June 2015

MARINE BIOPHYSICAL FIELD REPORT - SPRING AND SUMMER 2012

Biophysical Monitoring for Rich Passage Wave Energy Evaluation Study

Submitted to:
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REPORT

Report Number: 11393490-01-200-220

Golder Associates

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EXECUTIVE SUMMARY

This report documents the findings of nearshore biophysical field surveys conducted by Golder Associates Ltd. and Golder Associates Inc. (Golder) as part of the Rich Passage Wave Energy Evaluation Study. The study aims to evaluate the feasibility of providing Passenger Only Fast Ferry (POFF) service between the cities of Bremerton and Seattle, Washington, and to provide an assessment of potential shoreline response to fast ferry wake wash. The study scope includes collection and analysis of wave, wake, geomorphic, and biological data along the shorelines of Rich Passage prior to and during *in-situ* testing of the new low-wake, high speed POFF vessel, *Rich Passage 1* (RP1).

Nearshore biophysical surveys were conducted by Golder in fall (October) 2011 and in spring (May & June) 2012, prior to RP1 in-situ testing. Additionally surveys were conducted in summer (August) 2012, during RP1 in-situ testing. Data were collected from six study sites located along the Seattle to Bremerton transportation route and two reference sites situated outside Rich Passage, in Puget Sound. The nearshore biophysical data presented in this report supplements work initiated in 2004 to assess the inter-annual changes in the biophysical shoreline characteristics of Rich Passage. The biophysical field investigations and analyses included analysis of substrate, sediments, macroalgae, eelgrass, benthic infauna, and benthic epifauna.

Substrate and Sediments

Data from the biophysical surveys conducted in 2011 and 2012 indicate that the predominant substrate types observed at the study and reference sites include a mixture of silt/sand, gravel, cobble, boulder, bedrock, and hard clay. There were minimal changes in substrate types between spring and summer surveys. In summer, there was a slight increase in fine sand observed at seven of the eight sites. The accretion of fine sands between spring and summer is likely a function of reduced wind-wave energy during the summer and is consistent with seasonal trends observed along these beaches since 2004.

Macroalgae

The dominant macroalgae taxa observed during 2011 and 2012 surveys include: green algae (predominantly *Ulva* sp.); brown algae (e.g., rockweed [*Fucus* sp.], *Laminaria* spp., *Agarum* sp., non-native wireweed [*Sargassum* sp.]); and red algae (mostly *Gracilaria* sp. and Turkish towel [*Chondracanthus exasperatus*]). No bull kelp (*Nereocystis luetkeana*) was observed during the 2012 biophysical field surveys. There were no detectable changes in algal assemblages prior to and during RP1 testing.

Eelgrass

Several eelgrass beds were identified during shoreline towed video surveys within Rich Passage. Two eelgrass monitoring sites (Point Glover and Fort Ward) were identified and surveyed in 2012. Eelgrass monitoring surveys included bed perimeter mapping and eelgrass density surveys prior to and during RP1 testing. Eelgrass bed density at Point Glover and Fort Ward was shown to increase in August, likely related to normal seasonal growth. The results of these surveys indicate that the areal coverage and size of these beds was consistent prior to and during RP1 testing at both monitoring sites. Measurements of turbidity within the Fort Ward eelgrass bed showed a correlation with tidal currents. Fluctuations in turbidity during the passage of RP1 were not observed.

Benthic Infauna and Epifauna

The relative distribution of epibenthic and infaunal invertebrate species was shown to be highly variable amongst sampling sites and between sampling periods, with crustaceans generally representing the most abundant taxonomic group at all sites. The variability of species assemblages between seasons is likely due to differences in shoreline energy, grain size, and tidal elevation. Changes in benthic infauna and epifauna are not directly attributed to RP1 testing.

Recommendations

Though results from Golder's biophysical monitoring program of the Rich Passage Wave Energy Evaluation Study indicate ranges in biological assemblages between all sampling sites and sampling periods in 2011 and 2012, there were no systematic changes in biological communities at study sites when exposed to wake wash from RP1 operation. Given the high degree of inherent natural variability in biological communities in Puget Sound, having comparable data over extended periods is essential for detecting, measuring, and understanding ecological change in complex environments. Golder recommends continuation of data collection in August 2013 and 2014 include transect/quadrat sampling at all study sites, eelgrass monitoring at Point Glover and Fort Ward, and eelgrass reconnaissance in the bay west of the Point Glover eelgrass site. Data collection in 2013 and 2014 will provide a three year time-series and more comprehensive data set for addressing the objectives of this study.

1.0 INTRODUCTION

Golder Associates Ltd. and Golder Associates Inc. (Golder) were retained by Kitsap Transit (Kitsap) to collect intertidal and shallow subtidal biophysical data at Passenger Only Fast Ferry (POFF) study sites in Puget Sound near Bremerton, Washington (Figures 1 and 2). Biophysical survey data were collected as part of an ongoing study to understand the potential effects of POFF wakes on the physical and biological characteristics of nearshore systems. This monitoring report presents results from biophysical surveys conducted at the POFF study and reference sites during fall 2011, spring (May & June) 2012, and summer (August) 2012.

Golder conducted biophysical surveys prior to and during *in-situ* testing of the new low-wake, high-speed POFF vessel, *Rich Passage 1* (RP1). Results from fall 2011 surveys are included in Golder's 2011 Marine Biophysical Field Report (Golder 2012). The surveys were conducted to assess potential wake effects on nearshore biological communities present in the study area. Data presented in this report supplements work initiated in 2004[1] to assess the inter-annual changes in the biophysical shoreline characteristics of Rich Passage. The combined 2011 and 2012 dataset includes three distinct seasons (fall, spring, and summer) of biophysical data. Fall 2011 and spring 2012 data were collected prior to POFF *in-situ* testing and summer 2012 data were collected during active RP1 testing

The objective of the 2011 and 2012 field surveys was to investigate the following:

1) Have changes in the biophysical environment (fauna, macrophytes, and substrate) occurred at the study sites over the observed study period?

2) If changes have occurred, are they consistent with changes observed at POFF reference sites (i.e., are changes considered to be within seasonal/natural variability at the sites)?

3) Is there evidence of disturbance to biological communities at the study sites that is directly attributable to RP1 operations?

4) If a disturbance from RP1 is detected, what are the potential effects on the marine ecosystem locally and regionally?

To address these questions, Golder conducted biological monitoring at six study sites located along the Bremerton to Seattle transportation route. Field surveys were also conducted at two reference sites located outside of Rich Passage (Figure 2).

The biological monitoring program included the following field investigations:

- Quadrat and transect sampling (intertidal and shallow subtidal) to characterize macrophyte (eelgrass and algae) and faunal (macro invertebrate) communities;

- Infaunal community (invertebrates living in the substrate) and sediment grain size sampling at each site;

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[1] For a complete list and review of previous investigations and other available resources related to the Project, please refer to Golder 2012.

- Towed underwater video surveys along the northern and southern shorelines of Rich Passage to identify eelgrass presence/absence in the nearshore environment (Figures 3 and 4); and
- Targeted dive surveys of two eelgrass beds in Rich Passage to collect detailed information on bed size and shoot density, supplemented by *in-situ* turbidity monitoring (at one eelgrass bed).

Methods used for data collection and analyses are described in Section 3.0. Section 4.0 summarizes the results from each sampling program with detailed results presented as Appendices. Section 5.0 provides an interpretation of the results to date, and includes a review of several previous studies that provide additional insight on the potential effects of RP1 wakes on the physical and biological aspects of the study area's shoreline. Section 6.0 summarizes notable findings from the 2011/2012 field surveys, as well as recommendations for field survey efforts in 2013. Appendix L provides a background on bull kelp (*Nereocystis luetkeana*) in Rich Passage and the surrounding Puget Sound area. This technical memorandum includes information on morphology and development, ecological function, historical distribution, and potential environmental effects on bull kelp survivorship.

2.0 BACKGROUND

Rich Passage is a narrow channel located between Bremerton and Seattle Washington within Puget Sound that separates Bainbridge Island from the Kitsap Peninsula (Figure 1). This channel ranges in width from 0.3 to 1 mile (mi) with an average depth of 70 feet (ft) and a maximum depth of 120 ft. The waters of Rich Passage are biologically productive due to the shallow channel depth and tidal constriction. Tidal constriction and the obstructed tidal flows associated within the narrow passage between Point White and Point Glover result in localized upwelling, enhanced vertical flux of nutrients and consequently elevated primary production (Kruckeberg 1991). Nearshore biological communities in Puget Sound have been historically influenced by many natural (e.g. climate) and anthropogenic (e.g. shoreline structures, vessel traffic) factors (Shipman et al. 2010). Key anthropogenic and environmental factors thought to influence marine ecosystems within Rich Passage and surrounding shorelines are discussed below.

Human Development

Coastal development and the natural ecosystem are linked by complex biotic and abiotic interactions. In coastal areas, the processes and patterns associated with land development can have profound effects on natural systems. Puget Sound has been the site of industrial and residential development for over a century leading to recreational and economic pressures on the nearshore coastal environment and estuaries (Phillips 1984). In Puget Sound, like other areas of the United States, rapid expansion and urban development is occurring in areas that contain much of the country’s remaining natural aquatic ecosystems. These developments can lead to changes in hydrologic regime and shoreline morphological features in coastal ecosystems (May et al. 1997).

Within East Kitsap County, which includes Rich Passage, the shoreline represents a microcosm of anthropogenic modifications found in Puget Sound (Williams et al. 2004), with examples of low, moderate, and high levels of effects to nearshore resources. Osborne et al. (2010) suggest that the presence of bulkheads or seawalls has a long-term (decadal) effect on sediment supply which contributes to passive erosion in the local area. Additionally, the interaction of waves can result in variable beach response depending on the source of the wave (i.e., generated by a fast vessel, a slow vessel, or wind) (Osborne et al. 2006). Preliminary biological studies suggest that high levels of shoreline disturbance are often correlated with reduced habitat structure and ecological function (Borde et al. 2009).

Sediments and Armoring in the Study Area

Sediment distribution within Puget Sound is relatively complex, with beaches consisting of hard bottom, sand, gravel, cobble, shell, or a combination of these grain size classifications. The major source of sediment to Puget Sound beaches is the erosion and reworking of coastal bluff exposures of till, outwash sediments, and glacialmarine and glaciolacustrine deposits. These deposits often exhibit a variety of sedimentary rock types including clay, silt, sand, and gravel. Consequently, the beach sediments derived from these sources are similarly complex, with heterogeneous mixtures of pebble gravels and coarse-grained sands being the most prevalent (Finlayson 2006).

Sediment transport is an ongoing process in Rich Passage with wind and wave forces acting as the dominant transport mechanism in the area; during the winter storm interval, wind waves result in net alongshore transport of mixed sand and gravel to the northeast at Point White and Point Glover. Wakes from large vessels and a strong tidal current asymmetry dominate sediment transport during non-storm conditions (Osborne et al. 2011).

The natural functions of the beaches in Rich Passage and other shoreline segments in the greater Puget Sound area have been affected by various shoreline modifications (e.g., bulkheads, docks, breakwaters). These types of modifications can interrupt both the natural supply of new substrate material to beaches and reflect, resist, or block the wave energy that drives normal shoreline processes (Golder 2013; RPWAST 2001; Williams and Thom 2001a). In East Kitsap County, 84% of the County's armouring structures (primarily rip-rap and vertical structures) encroach into the intertidal zone and 40% of structures within Rich Passage are located below the OHWM (Borde et al. 2009).

Supratidal modifications (modifications above the high tide line) affect the energy exchange between marine and terrestrial ecosystems; however, the extent to which shoreline modifications directly or indirectly affect flora and fauna is relatively unknown (Sobocinski et al. 2010). Many shoreline modifications affect physical and biological resources similarly, which may result in permanent loss or structural change of native habitats (Williams and Thom 2001a). Shoreline modifications may also decrease the contribution of organic material entering the nearshore ecosystem and the availability of prey resources for fish and wildlife (Sobocinski et al. 2010). For juvenile salmon, general movement and schooling behavior is found to be altered by the presence of bulkheads and breakwaters. For example, studies have demonstrated that small (35 millimeter [mm] to 45 mm) pink and chum salmon fry were reluctant to leave the shoreline and venture along bulkheads or connected breakwaters until they reached a larger size (50 mm to 70 mm). These behaviors were attributed to higher observed rates of fry predation by coho smolts (*Onchorynchus kisutch*) and cutthroat trout (*Oncorhynchus clarkii*) in deeper water (Williams and Thom 2001a).

Macrophytes (Eelgrass and Macroalgae)

Macrophytes (eelgrass and macroalgae) are a valuable biological resource, providing shelter and food to a wide variety of fish and invertebrates and shorebirds (Carney et al. 2005). Macrophytes help promote re-establishment of intertidal and nearshore faunal communities and favorable habitat characteristics following physical perturbation of beaches (Berry et al. 2004; Borde et al. 2009).

Sunlight is the major factor controlling the distribution of marine grasses and submerged aquatic vegetation (Sand-Jensen 1975) and is the most easily affected from anthropogenic activities (Zimmerman 2006). Limited light penetration caused by high sediment loads in the water column can prevent phytoplankton and eelgrass growth. Parameters that alter light availability (e.g., water turbidity, sediment characteristics, wave action, and tidal amplitude) have known effects on submerged aquatic vegetation. Anthropogenic activities (e.g., alteration of shorelines) can elevate natural levels of suspended solids (Berry et al. 2004) and affect the availability and quality of light (Zimmerman 2006). Woodruff et al. (2001) noted that breaking waves can impact eelgrass by causing physical damage to eelgrass blades, increasing turbidity, reducing light availability, and redistributing surface sediment exposing rhizomes and uprooting plants.

Benthic Infauna and Epifauna

Organisms occupying the seafloor (benthic infauna[2] and epifauna[3]) are an important food source for fish, including many fish species fished recreationally and commercially (USEPA 2012). In addition benthic

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[2] Organisms living within seafloor sediments

[3] Organisms living on the seafloor sediments

organisms are an important component of global carbon and geochemical cycling, secondary production, filtration and sediment stability. Benthic infauna typically respond to environmental disturbance and thus provides a useful proxy for monitoring changes in marine ecosystems (Dethier and Schoch 2006). Processes known to affect the ecology of nearshore marine communities include a broad range of physical and biological factors. Key physical processes controlling the distributions of benthic populations in estuaries, such as Puget Sound, include salinity, wave action, and sediment grain size (Schoch and Dethier 2001). In a study conducted by Bishop on the effects of boat-generated waves on macroinfauna along the Parramatta River in Australia, shifts in macroinfauna community assemblages were directly associated with vessel wake exposure, suggesting that infaunal taxa could serve as useful indicators for monitoring vessel wake associated change in coastal ecosystems (Bishop 2007).

3.0 FIELD SURVEY METHODOLOGY

With the exception to benthic infauna and sediment grain size sampling, field surveys were conducted during spring (May) 2012 prior to RP1 test operations, and during summer (August) when RP1 *in-situ* test operations[4] were underway. Benthic infauna and grain size sampling occurred in June 2012 (shortly after RP1 *in-situ* test operations commenced) and again in August 2012. Field data were collected by a four-person field team (comprising marine biologists James Mortimor, Andrew Rippington and Michelle Spani and environmental scientist Traci Sanderson)[5]. A 7.6-meter (m) chartered jet boat, the *Office,* and a 10.4-m motor vessel, the *Venture,* were used to access survey sites (study sites and reference sites)[6] and to conduct towed video surveys. The spring and summer field surveys included the following studies:

- Transect and quadrat surveys (subtidal and intertidal) at the following locations (Figure 2);
    - Five POFF study sites (3B, 5D, 9B, 9D and 10B) located within Rich Passage;
    - One POFF study site (1B) located outside of Rich Passage at Manette Beach; and
    - Two reference sites at Illahee North (11B) and Crystal Springs (12B).
- Benthic infaunal sampling and sediment grain size analysis at the above locations;
- Towed underwater video surveys; and
- Eelgrass dive surveys.

3.1 Intertidal and Subtidal Transect / Quadrat Surveys

Transect and quadrat sampling were conducted at all study and reference sites during both spring and summer 2012 to characterize the macrophyte and epifaunal community in the nearshore (intertidal and shallow subtidal) environment, as well as associated habitat features (e.g. substrate type).

Spring surveys were conducted between May 18 and 23, prior to RP1 test operations. Summer surveys were conducted between August 26 and 30, during RP1 test operations. At each study and reference site, transect/quadrat surveying took place along a single transect line oriented perpendicular to the shore, commencing at the OHWM[7] (transect start) and extending offshore to approximately 1.5 m (5 ft) below Mean Lower Low Water (MLLW) level (transect end). Transects line locations corresponded with those previously surveyed by Golder in 2011. Surveys were conducted on foot in exposed intertidal areas and by divers in the lower intertidal/shallow subtidal zone.

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[4] RP1 operated scheduled trips (four round trips daily) along the Bremerton Seattle route from June 25, 2012 to November 2, 2012.

[5] Divers (J. Mortimor and M. Spani) are certified in accordance with internationally acceptable standards for occupational SCUBA diving (Canadian Standard Association Z275:4-97 and WorkSafe BC Regulations Part 24).

[6] Diving was planned in accordance with local current & tide tables as Rich Passage is subject to high currents (Appendix A).

[7] The OHWM was determined by the presence of soil or vegetation as a character distinct to the abutting land or in areas of upland hard substrate where the presence and action of waters were usual leading to visual differences in substrate and composition. Differences could include, but were not limited to substrate colour, presence of or algal attachment, and presence of woody debris.

[8] Start elevations were measured using a Real Time Kinetic (RTK) global position system (GPS) to optimize accuracy.

Quantitative data were collected within 0.25 square meters (m^2) quadrats placed every 5 m along each transect. General biophysical observations were also made along the full transect length (within 1 m on either side of the transect). Data recorded during quadrat/transect sampling included:

- Slope of exposed portion of transect segments (measured with a hand-held inclinometer) and elevation[8] (referenced to MLLW level)[9] of exposed and underwater quadrats;
- Substrate type/composition[10] along transect segments and within quadrats. Data along transect segments measured by visual estimate of area percent cover category[11]; quadrat data measured as area percent cover (e.g., 80% eelgrass);
- Presence and cover of macrophytes (macroalgae and eelgrass) along transect segments and within quadrats. Data along transect segments measured by visual estimate of area percent cover category. Quadrat data recorded as area percent cover and/or counts of individuals;
- Presence and abundance of macro-invertebrates along transect segments and within quadrats. Data along transect segments measured by visual estimate of area percent cover for sessile invertebrates (e.g., <1%, <5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%) and counts of individuals for motile invertebrates (e.g., single 1; few 2 to 10, many 11 to 100, and abundant >100). Within quadrats, data was recorded as areal percent cover for sessile invertebrates (e.g., X%) and/or counts for other macro-invertebrates; and,
- Photographs showing representative biological features and aiding in species identification[12].

Transect/Quadrat Sampling - Data Analyses

Data collected during transect and quadrat surveys were tabulated and quantitatively analyzed using biodiversity metrics including mean taxonomic richness, mean diversity (Shannon Diversity Index), and frequency of occurrence of each taxa. Mean taxonomic richness and mean diversity of faunal and macrophyte communities were determined for the following periods: fall 2011 (October), spring 2012 (May), and summer 2012 (August). Graphs were produced using SigmaPlot™ software. The above metrics provide biodiversity estimates for each site that can be compared over time. The methods for each calculation are described below.

Taxonomic Richness

Taxonomic richness provides a measure of overall diversity of the biological community sampled. For this study, taxonomic richness was expressed as the total number of taxa recorded per transect sample and the mean number of taxa per quadrat.

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[8] Start elevations were measured using a Real Time Kinetic (RTK) global position system (GPS) to optimize accuracy.

[9] Using predicted tidal heights from National Oceanic and Atmospheric Administration (NOAA) tide tables for Clam Bay (Rich Passage) provided by Nobeltec Nautical Software Tides & Currents Pro.

[10] Bedrock, boulder (>25 centimeters [cm]), cobble (6.5 to 25 cm), gravel, (0.2 to 6.5 cm) sand (0.06 to 0.2 mm) and silt/mud/clay (<0.06 mm).

[11] Areal percent cover was visually estimated and categorized into ranges for substrate and macrophytes within transect segments (e.g. <1 %,< 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%).

[12] Whenever possible, identification of species was made on site. To confirm species identification, or in cases where on-site identification was not possible, subsequent identification was undertaken by photograph (or in a limited number of cases by sample). Identification was made to the lowest practical taxonomic level.

Shannon Diversity Index

The Shannon Diversity Index provides a measure of both species richness (number of taxa) and abundance. To provide an estimate of diversity at each site, the Shannon Diversity Index (*H*) was calculated using the equation presented below:

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

Where *S* is the total number of taxa in each quadrat (richness) and p_i is the proportion of *S* made up of the i^{th} taxa (Krebs 2009; Zar 1999). Shannon Diversity Indices were calculated for each quadrat, then averaged, providing one estimate of diversity for each transect. For the purposes of this study, abundance data used to calculate Shannon Diversity Indices included both total counts (used for most species) and percent cover estimates (used for vegetation [algae and eelgrass], barnacles and pink-tipped anemones).

Frequency of Occurrence

Frequency of occurrence (i.e., likelihood of a species or species group occurring at a site) is a useful index for identifying the most commonly encountered taxa at each survey site during each sampling event. Frequency of occurrence was calculated for each taxa recorded during quadrat sampling at each site, using the following equation:

$$\text{Frequency of occurrence} = \frac{n \text{ (the number of quadrats in which the taxa was observed)}}{N \text{ (the total number of quadrats)}}$$

3.2 Benthic (Infauna) and Grain Size Sampling

Benthic sediment samples were collected at all study and reference sites during spring (June 18 to 20) and summer (August 26 to 30) 2012 to characterize the benthic infaunal community in the nearshore environment. Intertidal sediment samples (surface area = 0.025 m^2; sample depth = 10 to15 cm) were collected in triplicate at the 0 m contour (MLLW). Dependant on substrate type, the upper layer of rock armoring (cobble) was removed and the underlying sediments were sampled. Sediments were extracted using a stainless steel spoon and stored in labelled plastic bags.

Replicates were sieved in the field through a 500-micrometer (µm) mesh sieve then transferred to pre-labelled plastic jars using filtered sea water. Samples were preserved with 10% buffered formalin and submitted to Marine Taxonomic Services (MTS) for taxonomic analysis. Taxonomic identification was carried out to the lowest practical taxonomic level. Quality Assurance and Quality Control procedures for MTS are provided in Appendix B.

Taxonomic Diversity, Richness, and Abundance

Mean abundance (average number of individuals per m^2), mean taxonomic richness, and mean taxonomic diversity were calculated for each sampling station (three replicates per station) in June and August. The mean relative abundance of major taxonomic groups (crustaceans, molluscs, polychaetes and other taxa) was calculated and the dominant species at each sampling station was identified. Non-metric multi-dimensional scaling (NMDS) was used for analysis of the benthic infauna data (methods described below). Mean taxonomic richness and taxonomic diversity were calculated using the formulas provided in Section 3.1.1.

Multivariate Analysis

Non-metric multidimensional scaling (NMDS), a multivariate ordination technique, will be used to investigate differences in invertebrate community structure among survey sites and between sampling events. The purpose of this analysis was to identify taxa or groups of taxa that respond to environmental change that could serve as indicators for identifying changes associated with wake energy at survey sites. The NMDS takes the original taxonomic data (species abundance by station and month sampled), calculates a pair-wise matrix of similarities among cases, and then reduces that similarity matrix to a small number of underlying dimensions of variation among cases. In this way, NMDS can visually simplify a complex, multidimensional data set into two or three dimensions that captures the major patterns of spatial and temporal variation in the composition of the benthic communities sampled at the POFF survey sites.

To satisfy the assumptions of the multivariate analysis, species abundance values were $\log_{10}(x+1)$ transformed prior to analysis to reduce the influence of numerically dominant taxa and thereby to allow the NMDS to produce a more balanced representation of the community as a whole. A Bray-Curtis distance matrix was constructed and used as the input for the NMDS procedure. Two dimensions were selected for the NMDS after confirming that the final stress value of the two-dimensional configuration was sufficiently low to produce a reliable representation of the original data set (i.e., less than 0.2 [Clarke 1993]). The resulting NMDS dimensions were interpreted by calculating Spearman rank correlations between dimension scores and the abundances of individual species in the original data set. The NMDS was performed using Systat^{TM} version 11.0 (SSI 2004). Similar approaches for infauna data analysis were used in a study by Bishop to determine the effects of vessel generated waves on intertidal infauna along the Parramatta River, Sydney, Australia (Bishop 2007) and by the United States Geological Survey (USGS) to assess differences in macro invertebrate assemblages in samples collected from the northern and southern Colorado plateaus (USGS 2010).

Grain Size Analysis

In conjunction with benthic infaunal sampling, sediment samples were collected for grain size analysis (% composition by size class). Sediment samples (0.04 m^2; 20 cm x 20 cm) were collected to a depth of approximately 15 cm from the shoreline (0 m MLLW) at each site during June and August sampling events. Due to the coarse nature of the intertidal sites, cobble/boulder armouring was removed prior to sample collection. Extracted sediments were stored in labelled plastic bags and were submitted to Golder's Redmond, Washington office for ASTM D422 grain size analysis (Appendix I). Samples were split in the laboratory prior to analysis to produce a subsample representative of the entire sediment sample. Grain size data were tabulated and graphed using Microsoft Excel^{TM} (Appendix I).

3.3 Towed Video Survey

During spring and summer 2012, towed underwater video transect surveys were conducted along select depth contours in Rich Passage to identify presence/absence of eelgrass and bull kelp in the nearshore environment. Spring surveys included two transects along the northern shoreline (-5 ft/-1.5 m and -15 ft/-4.5 m MLLW) and one transect along the southern shoreline (-10 ft/-3 m MLLW) (Figure 3). Summer surveys included one transect along the northern shoreline and one along the southern shoreline (both at -5 ft/-1.5 m MLLW) (Figure 4). The underwater towed video system consisted of a high resolution video camera with an integrated WAAS-enabled GPS video overlay. Tracking of the vessel and video system was conducted using on-board Nobeltec^{TM} navigational software (Nobeltec). Underwater video was viewed in real-time on a monitor set-up on deck of the vessel, Eelgrass occurrence was qualitatively defined as either i) absent, ii) patchy (low density - occurring in small patches), or (iii) an eelgrass bed (moderate to high density - continuous). Positional information for all eelgrass sightings was post-processed using Global Information Systems (GIS) software and plotted on a base map

3.4 Eelgrass Surveys

Eelgrass surveys were conducted at two locations during spring (May 23 and 24) and summer (August 25 and 26) 2012. The Point Glover survey area was located adjacent to site 9B and the Fort Ward survey area was located offshore of Fort Ward State Park[13] (Figures 3, 4, and 5). Survey methods included mapping the perimeter of each observed eelgrass bed and estimating eelgrass density within each bed. The perimeter of each bed was delineated using Golder's Aquatic Mapping System (AMS), an integrated geo-referencing system for documenting submarine features. Using this system, divers swam the perimeter of the bed towing a surface float equipped with a WAAS enabled GPS[14] that recorded diver position (±3 m) at 30 second intervals. Track data were subsequently plotted on a base map identifying the shore-parallel boundaries of the eelgrass bed.

Divers also conducted transect and quadrat sampling within established eelgrass beds to quantify eelgrass bed density. Three shore-perpendicular line transects were surveyed (Figure 5) in which shoot densities (number of eelgrass rhizomes per 0.25 m^2 quadrat) were recorded within 30 randomly selected quadrats[15] (10 quadrats per transect). Transects extended from the inshore extent of the bed to the offshore edge of the bed. Quadrat samples were collected on alternating sides of each transect. A reconnaissance survey (towed video and diver spot-checks) was conducted in May 2012 to locate an eelgrass bed that would serve as a suitable reference site for the Point Glover and Fort Ward study sites, however, efforts to identify a representative site were unsuccessful.

Turbidity data was recorded at the Fort Ward eelgrass monitoring site during active RP1 vessel operations from September 24 to October 11, 2012. Sampling locations are shown in Figure 4. Turbidity data was collected using a YSI$^{©}$ 600 OMS equipped with a 6156 turbidity sensor programmed to sample at 5-minute intervals. The YSI was deployed with a Coastal Leasing MacroWave wave and pressure gauge at a depth of approximately -1 m MLLW. The MacroWave was used to measure water level and allowed for detection of RP1 wakes at the sampling site, thus turbidity changes due to RP1 wakes could be identified.

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[13] Due to vast extent of the Fort Ward eelgrass bed and the continuation of eelgrass to the north, it was not feasible to map the entire bed perimeter. The northern reach of the bed was truncated at the same location for both surveys.

[14] Accuracy within ± 3 to 5 m

[15] Quadrat sample locations were randomly selected along the transect using a Microsoft ExcelTM random number generator.

4.0 RESULTS

4.1 Transect / Quadrat Surveys

A general summary of the transect/quadrat sampling data collected during spring and summer 2012 is provided below, with detailed results presented in tabulated format in Appendix C. Representative photographs taken during the survey are provided in Appendix D. Changes in beach slope and transect elevation over the study period are described in the Rich Passage Wave Energy Evaluation, Beach Response to *in-situ* Testing of *Rich Passage 1* report (Golder 2013). Table 1 provides an overview of transect length and approximate end point elevations[16] at each site for spring and summer surveys.

Table 1: Site survey transect lengths and elevations for spring and summer 2012

Location	Transect Length Spring (m)	End Elevation Spring (m)	Transect Length Summer (m)	End Elevation Summer (m)
Transect 1B	80	- 2.2	80	- 2.4
Transect 3B	38	- 2.1	38	- 2.3
Transect 5D	37	- 2.1	35	- 1.6
Transect 9B	70	- 1.8	76	- 1.7
Transect 9D	50	- 2.4	52	- 2.3
Transect 10B	50	- 1.7	49	- 1.7
Transect 11B	65	- 3.0	65	- 2.6
Transect 12B	50	- 1.6	52	- 1.1

4.1.1 Transect 1B – Manette Beach

General Site Observations

Spring

Transect 1B, surveyed on May 18, 2012, extended approximately (~) 80 m seaward from the OHWM[17] (Figure 2). The transect was surveyed on foot from 0 to 38 m and by divers from 38 to 80 m. Adverse weather and wave conditions at the time of sampling resulted in poor visibility near the waterline within the shallow subtidal zone (between 40 and 55 m).

Summer

Transect 1B, surveyed on August 26, 2012, extended ~80 m seaward from the OHWM (Figure 2). Given tide levels at the time of the survey, the transect was surveyed on foot from 0 to 37 m and surveyed by divers from 37 to 80 m.

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[16] Transect end point elevations in the shallow subtidal were acquired during the dive survey using the diver's depth gauge (wrist mounted dive computer). Elevations are accurate to approximately +/- 0.3 m (1 foot).

[17] The Ordinary High Water Mark (OHM) is described as the tidal water mark where the presence and action of waters are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland (Ecology 2010). The elevation of the OHM within Rich Passage is approximately 2.7 m (8.69 ft) above chart datum.

Substrate

Spring

Substrate along the transect transitioned from gravel with shell (<5%) (0 to 10 m), to cobble (10 to 45 m with mixed silt/sand at the ~35 m mark), to well-mixed gravel/cobble/sand (40 m to 70 m), to gravel/sand (70 m to end of transect). Cobble occurred continuously along the full transect length (at varying levels of coverage). Gravel occurred along the majority of the transect length (0 to 20 m; 35 to 80 m) with the highest coverage occurring at the start and end of transect. Finer substrate (silt/sand/shell) occurred from ~25 m to the end of the transect, with a distinct band of finer sediments observed from 25 to 35 m. Boulders were observed between 70 and 75 m.

Summer

Substrate along the transect transitioned from gravel with little shell (<5%) (0 to 10 m), to gravel/cobble (10 to 25 m), to mainly sand (25 to 40 m), to cobble (45 to 60 m) with an increasing proportion to mixed gravel/sand/silt towards the offshore extent of the transect. Cobble occurred continuously along the full transect length beyond 15 m (at varying levels of coverage). Gravel occurred along the entire transect length (0 to 80 m) with the highest coverage occurring at the start and end of transect. Finer substrate (silt/sand/shell) occurred from ~25 m to the offshore extent of the transect with a distinct band of finer sediments observed from 25 to 35 m. Boulders occurred from 70 to 75 m. Substrate characterization near the waterline was impeded by extensive macroalgae cover (*Ulva* spp.) at the time of sampling.

Macrophytes

Spring

Green algae, specifically sea lettuce (*Ulva spp.*), was present at varying levels of coverage from ~20 m to the offshore extent of transect, with highest concentrations recorded near MLLW, including *Ulva intestinalis* (formerly *Enteromorpha intestinalis*) and *Acrosiphonia* sp. Brown algae observed included rockweed (*Fucus* sp.; lower intertidal near MLLW), non-native wireweed (*Sargassum muticum*; shallow subtidal in dense patches), *Laminaria saccharina* (observed near the offshore extent of transect at ~80 m) and one filamentous brown algae (sp. unidentified). Red algae was observed at varying levels of coverage from ~20 m to the end of transect. *Porphyra* spp. was the most common species above MLLW, and *Sarcodiotheca gaudichaudii* and *Chondracanthus exasperates* (Turkish towel) the most common species below MLLW. Other red algae species observed included *Gracilaria* spp., *Mazzaella splendens*, *Prionitis lanceolata*, and encrusting corallines.

Summer

Green algae, specifically sea lettuce, was present at varying levels of coverage from ~20 m to the offshore extent of transect, with highest concentrations recorded near MLLW. Brown algae observed included rockweed (lower intertidal), non-native wireweed (shallow subtidal), and *L. saccharina* (near the offshore end of the transect ~ 80 m). Red algae was observed at varying levels of coverage from ~20 m to the end of transect, with *S. gaudichaudii, Gracilaria* spp., *Prionitis* sp., and *C. exasperates* as the most commonly observed species

Invertebrates

Spring

Crustaceans recorded during transect/quadrat sampling included barnacles (suborder Balanomorpha), helmet crabs (*Telmessus cheiragonus*), a decorator crab (*Chorilia longipes*), kelp crabs (*Pugettia* sp.) and an amphipod (*Gammarus* sp.). Areas of highest barnacle coverage were in the mid- to low- intertidal zone (between ~20 and 35 m). Molluscs observed included limpets (Family Lottidae), mussels (*Mytilus* sp.), and periwinkles (*Littorina* spp.), chitons, false jingles, nudibranches and snails (unidentified sp.). Echinoderms were documented between 45 and 80 m, including sunflower stars (*Pycnopodia helianthoides*), spiny pink stars (*Pisaster brevispinus*), mottled stars (*Evasterias troschelii*), a morning sun star (*Solaster dawsonii*), and brittle stars (Family Ophiodermatidae). Cnidarians observed included a stubby anemone (*Urticina* sp.) and pink-tipped anemones (*Anthopleura elegantissima*), the latter mainly located between 25 and 40 m. Jointed tube worms (*Spiochaetopterus costarum*) were observed within the band of finer sediment located between 30 and 35 m. A slime-tubed feather duster worm (*Myxicola infundibulum*) was observed in the most offshore transect segment.

Summer

Crustaceans recorded during transect/quadrat sampling included barnacles, graceful crabs (*Cancer gracilis*), a red rock crab (*Cancer productus*), helmet crabs, hermit crabs, a kelp crab and shrimps (*Crangon* spp. and *Pandalus* spp.). Areas of highest barnacle coverage were in the mid-intertidal zone (between ~15 and 25 m). Molluscs observed included abundant limpets, mussels, periwinkles whelks, false jingle shells and snails (unidentified sp.). Echinoderms observed included sunflower stars, an ochre star (*Pisaster ochraceus*), a spiny pink star, and brittle stars. Cnidarians observed included a stubby anemone (*Urticina* sp.) and pink-tipped anemones (*Anthopleura elegantissima*), the latter mainly located between 25 and 40 m. Jointed tube worms (*Spiochaetopterus costarum*) were observed within the band of finer sediment located between 30 and 40 m.

4.1.2 Transect 3B – Point White West

General Site Observations

Spring

Transect 3B, surveyed on May 19, 2012, extended ~38 m seaward from the base of a rip-rap and bulkhead retaining wall (Figure 2). Given tide levels at the time of the survey, the transect was surveyed on foot from 0 to 25 m and surveyed by divers from 25 to 38 m. Adverse weather and wave conditions at the time of sampling resulted in poor visibility in the shallow subtidal zone (between 20 and 30 m) and a reduced ability to identify flora and fauna in this area.

Summer

Transect 3B, surveyed on August 27, 2012, extended ~38 m seaward from the base of a rip-rap and bulkhead wall (Figure 2). Given tide levels at the time of the survey, the transect was surveyed on foot from 0 to 22 m and surveyed by divers from 22 to 38 m. Adverse weather and wave conditions at the time of sampling resulted in poor visibility in the shallow subtidal zone (between 22 and 30 m) and a reduced ability to identify flora and fauna in this area.

Substrate

Spring

Substrate along the transect transitioned from gravel (0 to 10 m), to cobble (10 to 25 m), to boulder/cobble (25 m to end of transect). Areas of finer substrate (silt/sand/shell) occurred in 'pockets' along the transect and in higher proportions below 25 m. Hard clay 'bedrock'[18] substrate was observed in the shallow subtidal zone (30 to 38 m).

Summer

Substrate along the transect transitioned from gravel/sand/shell (0 to 5 m), to mainly gravel (5 to 15 m), to cobble/gravel (15 to 25 m), to mixed cobble/gravel/sand (25 to 38 m). Areas of finer substrate (silt/sand/shell) occurred in 'pockets' along the transect and in higher proportions between 0 and 5 m, and below 25 m. Hard clay 'bedrock' substrate was observed in the shallow subtidal zone (30 to 38 m).

Macrophytes

Spring

Green algae, specifically sea lettuce, was present in low densities (<5% cover) along two transect segments (15 to 20 m; 25 to 30 m). Brown algae observed included wireweed just below MLLW and acid-weed (*Desmarestia* sp.) near the end of transect. Red algae were present from ~25 m (MLLW) to the end of transect, with the most commonly observed species being *C. exasperates*, *S. gaudichaudii*, and *Mazzaella* sp., and the highest proportional cover (30 to 35 % cover) occurring at ~30 m. Other red algae species identified were *Microcladia* spp., encrusting corallines, *Palmaria* sp., *Rhodymenia* sp., filamentous red alga (sp. unidentified) and an outcrop of *Plocamium* sp. at 35 m.

Summer

Green algae, specifically sea lettuce, was present from ~15 m to the end of transect (38 m), and in highest proportional coverage near the end of transect. Brown algae observed included wireweed just below MLLW and acid-weed (*Desmarestia* sp.) near the end of transect. Red algae were present from ~20 m (MLLW) to the end of transect, with the most commonly observed species being *C. exasperates*. *Porphyra* spp. and *Mastocarpus* sp. were the only red algal species recorded above MLLW. *S. gaudichaudii*, *Mazzaella* sp., *Plocamium* sp., and *Polyneura* sp. were recorded at 30 m. Other red algae species identified were *Hymenena* spp., *Microcladia* spp., encrusting corallines, red cups (*Constantine* sp.) and iodine weed (*Prionitis lanceolata*).

Invertebrates

Spring

Crustaceans recorded during transect/quadrat sampling included barnacles (mainly between 0 and 20 m), kelp crabs, a helmet crab, and one shrimp (*Pandalus* sp.). Molluscs observed included mussels, periwinkles (near MLLW), limpets (near MLLW), one chiton, one whelk, false jingle shells, piddock clams (*Zirphaea* sp.) and horse clams (*Tresus* sp.). Echinoderms observed included leather stars (*Dermasterias imbricata*), an ochre star (*P. ochraceus*), a six-legged sea star (*Leptasterias hexactis*) and a sea cucumber (*Cucumaria miniata*). Cnidarians

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[18] Hard clay 'bedrock' substrate has been described as hard pan or bedrock in previous studies on the site.

observed included pink-tipped anemones near MLLW and one hydroid (Class Hydrozoa) in the shallow subtidal. A calcareous tube-worm (Family Serpulidae) was observed in the shallow subtidal.

Summer

Crustaceans recorded during transect/quadrat sampling included barnacles (mainly between 10 m and 25 m), a kelp crab, a red rock crab, shore crabs (*Hemigrapsus* spp.), a decorator crab, helmet crabs, hermit crabs and shrimps (*Crangon* sp.). Molluscs observed included mussels, periwinkles, limpets (between 10 and 20 m), chitons (*Mopalia* sp.), whelks, piddock clams and horse clams. The piddock clams occurred in the shallow subtidal (burrowed in hard clay substrate with siphons exposed) and the horse clams occurred at MLLW. Echinoderms observed included a sunflower star, leather star and ochre stars. Bryozoan colonies (phylum Bryozoa) and sponges (Phylum Porifera) were also observed in the shallow subtidal.

4.1.3 Transect 5D – Point White East

General Site Observations

Spring

Transect 5D, surveyed on May 21, 2012, extended ~37 m seaward from the base of a rip-rap wall at OHWM (Figure 2). Given tide levels at the time of the survey, the transect was surveyed on foot from 0 to 20 m and surveyed by divers from 20 to 37 m. Adverse weather and wave conditions at the time of sampling resulted in poor visibility in the shallow subtidal zone (between 25 and 37 m) and a reduced ability to identify flora and fauna in this area.

Summer

Transect 5D, surveyed on August 27, 2012, extended ~35 m seaward from the base of a rip-rap wall at OHWM (Figure 2). Given tide levels at the time of the survey, the transect was surveyed on foot from 0 to 23 m and surveyed by divers from 23 to 35 m.

Substrate

Spring

Substrate along the transect transitioned from gravel (0 to 15 m), to cobble and gravel (15 to 30 m), to mixed boulder/cobble/gravel (30 to 37 m). Percent cover of boulder remained relatively consistent along the transect (20% to 40%). Finer substrate (silt/sand/shell) was observed from 15 m to 37 m (transect end).

Summer

Substrate along the transect transitioned from gravel (0 to 15 m), to a 50/50 cobble/gravel mix (15 to 20 m), to mixed cobble with gravel and some boulder (20 to 35 m). Boulders were only recorded below 15 m. The percentage of gravel coverage decreased from 20 to 35 m (transect end). Finer substrate (silt/sand/shell) was observed from 30 to 35 m. Substrate characterization near the waterline was impeded by a high percent cover of *Ulva* spp. and *C. exasperates*.

Macrophytes

Spring

Green algae, specifically sea lettuce, were present from 25 to 37 m. Brown algae were present below MLLW; with wireweed representing the most commonly observed species (occurring in a band between 25 and 30 m).

Other brown algae observed included rockweed, sea cauliflower (*Leathesia difformis*), *Scytosiphon lomentaria* and filamentous brown algae (unidentified sp.), all in relatively low densities. Red algae were present from 25 m to 37 m. *C. exasperates* (Turkish towel) had the highest percent cover of any red algae species. Other red algae present included *Microcladia borealis, Mazzaella* sp., *Sarcodiotheca* sp., *Hymenena* sp., *Palmaria* spp., *Delesseria decipiens*, and *P. lanceolata.*

Summer

Green algae, specifically sea lettuce, were present continuously from MLLW to 35 m (transect end). Brown algae were present below MLLW, with wireweed representing the most commonly observed species (occurring in a band at ~25 m). Other brown algae observed included rockweed and *Agarum* sp. Red algae were present continuously beyond 20 m with *Porphyra* spp. being the only red algae species present above MLLW (between 5 and 20 m). *C. exasperates* had the highest percent cover of any red algae species.

Invertebrates

Spring

Crustaceans observed during transect/quadrat sampling included barnacles (between the upper intertidal and 25 m), hermit crabs, shore crabs and helmet crabs. Barnacle coverage increased from ~15 to 25 m. Molluscs present included false jingle shells, nudibranchs, whelks, and relatively high abundances of limpets, periwinkles and mussels. Three species of sea star were observed near the end of transect: sunflower stars, a mottled star, and an ochre star. Anemones, sponges, and calcareous tube-worms were also observed in the shallow subtidal zone.

Summer

Crustaceans observed during transect/quadrat sampling included barnacles (between 5 and 20 m), red rock crabs, helmet crabs, kelp crabs and coonstripe shrimps (*Pandalus danae*). Barnacle coverage increased from ~15 to 20 m. Molluscs included limpets, periwinkles and mussels (all relatively abundant at and near MLLW), and false jingle shells near the end of transect (35 m). Three species of sea star were observed near the end of transect: sunflower stars, mottled stars, and an ochre star. Plumose anemones (*Metridium* spp.) and sponges were also observed in the same subtidal zone.

4.1.4 Transect 9B – Point Glover East

General Site Observations

Spring

Transect 9B, surveyed on May 21, 2012, extended ~70 m seaward from the base of a steep grassy embankment which terminated at OHWM (Figure 2). Given tidal levels at the time of survey, the transect was surveyed on foot from 0 to 30 m and by divers from 30 to 70 m.

Summer

Transect 9B, surveyed on August 30, 2012, extended ~76 m seaward from the base of a steep grassy embankment which terminated at OHWM (Figure 2). Given tidal levels at the time of survey, the transect was surveyed on foot from 0 to 33 m and by divers from 33 to 76 m. Adverse weather and wave conditions at the time of sampling resulted in poor visibility in the shallow subtidal zone (between 35 and 50 m) and a reduced ability to identify flora and fauna in this area.

Substrate

Spring

Substrate along the transect transitioned from gravel (0 to 15 m), to gravel/sand (15 to 25 m) to sand/silt (25 to 70 m). Silt/sand was consistently the most dominant substrate observed from 25 to 70 m (transect end).

Summer

Substrate along the transect transitioned from gravel with little cobble (0 to 15 m), to sand/silt (15 to 76 m). The sand and silt was well-mixed with relatively even coverage. Percent cover of cobble was <5% along the full length of the transect. Few boulders occurred along the transect. Percent cover of gravel remained relatively consistent (between 2 and 12%) beyond the 20 m mark.

Macrophytes

Spring

Green algae, specifically sea lettuce, were observed from the upper-mid intertidal through to the shallow subtidal, occurring in highest densities from ~15 to 35 m. Other green algae species observed included *U. intestinalis*, *Acrosiphonia* sp., and encrusting green algae. Brown algae observed included rockweed (from mid-intertidal to MLLW), sea cauliflower (mid-intertidal), wireweed (near MLLW), *Laminaria* spp. (~1.2 m below MLLW), *S. lomentaria*, and *Desmarestia ligulata*. Red algae were found from the mid-intertidal to ~70 m (transect offshore extent); no single species was dominant. Red algae species observed included *M. borealis, Sarcodiotheca* sp., *Gracilaria* sp., *C. exasperates*, encrusting corallines, *Porphyra* sp.*, Mazzaella* sp., and *Plocamium* sp. A bed of eelgrass (*Zostera marina*) was recorded at and below MLLW, beginning at ~35 m and continuing beyond the offshore extent of the transect.

Summer

Green algae, specifically sea lettuce, were observed from the upper-mid intertidal through to the shallow subtidal, occurring in highest densities from ~15 to 35 m. Brown algae observed included rockweed (from mid-intertidal to MLLW), wireweed (near MLLW), *Agarum* sp. and *Laminaria* spp. (~-0.9 m below MLLW). Red algae were present from the mid-intertidal to 76 m (transect end). *S. gaudichaudii* and eelgrass epiphyte *Smithora naiadum* were the most dominant red algae species recorded. Other red algae species observed included *Ahnfeltia* sp.*, Gracilaria* sp., encrusting corallines, *Porphyra* sp., *Mazzaella* sp.*,* and *C. exasperates*. A bed of eelgrass was recorded at and below MLLW, beginning at ~35 m and continuing beyond the offshore extent of the transect.

Invertebrates

Spring

Crustaceans observed during transect/quadrat sampling included barnacles (mainly between 5 and 30 m), a kelp crab, graceful crabs, a hermit crab, a red rock crab, and sand fleas (Order Amphipoda). Molluscs observed included mussels (~15 to 25 m), limpets and periwinkles in the lower intertidal, and a moon snail (*Euspira lewisii*). Cnidarians observed included pink-tipped anemones near MLLW. Echinoderms observed included brittle stars near the end of the transect (~70 m) and two sunflower stars at the waterline, near MLLW.

Summer

Crustaceans observed during transect/quadrat sampling included barnacles (between ~5 and 30 m), kelp crabs, graceful crabs, a hermit crab, and shrimp. Molluscs observed included mussels (~15 to 25 m), limpets, periwinkles, chitons and a false jingle-shell (*Pododesmus macrochisma*). Cnidarians observed included pink-tipped anemones, in high abundances between 15 and 30 m. Echinoderms observed included brittle stars was near the end of transect (~76 m).

4.1.5 Transect 9D – Point Glover Mid

General Site Observations

Spring

Transect 9D, surveyed on May 22, 2012, extended ~50 m seaward from the base of a rip-rap wall which terminated at OHWM (Figure 2). Given tidal levels at the time of survey, the transect was surveyed on foot from 0 to ~30 m and surveyed by divers from 30 to 52 m. Adverse weather and wave conditions at the time of sampling resulted in poor visibility in the shallow subtidal zone (between 40 and 50 m) and a reduced ability to identify flora and fauna in this area. Characterization of substrate and epifauna was also impeded between 40 and 52 m due to extensive cover of green algae (*Ulva* spp.) and kelp (*Agarum* sp. and *Laminaria* spp.) along the transect at the time of sampling.

Summer

Transect 9D, surveyed on August 28, 2012, extended ~52 m seaward from the base of a rip-rap wall which terminated at OHWM (Figure 2). Given tidal levels at the time of survey, the transect was surveyed on foot from 0 to ~30 m and surveyed by divers from 30 to 52 m. Characterization of substrate and epifauna was impeded between 40 and 52 m by extensive cover of green algae (*Ulva* spp.) and kelp (*Agarum* sp. and *Laminaria* spp.) at the time of sampling.

Substrate

Spring

Substrate along the transect transitioned from gravel/shell (0 to 20 m) to well-mixed cobble/gravel/sand. Hard clay was recorded beyond the 20 m mark. In places, a thin silt veneer was apparent over underlying bedrock.

Summer

Substrate along the transect transitioned from sand with little shell and gravel (0 to 5 m) to gravel/shell (5 to 10 m), to mainly gravel with some cobble and sand/silt (10 to 25 m). From 25 to 52 m (transect end), the substrate consisted of well-mixed cobble/gravel with pockets of sand and silt with little shell. Hard clay was recorded beyond the 20 m mark. In places, a thin silt veneer was apparent over underlying bedrock.

Macrophytes

Spring

Green algae, specifically sea lettuce (including *U. enteromorpha)*, were present from ~10 to 40 m along the transect. Brown algae observed included rockweed (<5% cover), wireweed (below MLLW), sea cauliflower, kelp (*Agarum* sp. and *Laminaria* spp. in the shallow subtidal), and *Desmarestia* spp. At least 13 red algae species were identified along the transect, all in relatively low densities (<25%). S. *gaudichaudii* and *C. exasperates* were the most commonly observed red algae species. The highest diversity of red algae occurred at ~40 m along the transect.

Summer

Green algae, specifically sea lettuce (including *U. enteromorpha)*, were observed from ~10 to 45 m along the transect. Brown algae observed included rockweed (<5% cover), wireweed (below MLLW), and kelp (*Agarum* sp. and *Laminaria* spp. in the shallow subtidal). Red algae were recorded from the upper-mid intertidal to the seaward end of the transect (52 m). At least 17 species of red algae were identified along the transect, with S. *gaudichaudii* and *C. exasperates* being the most common. The highest diversity of red algae occurred towards the distal end of the transect.

Invertebrates

Spring

Red mites (*Neomolgus littoralis*) were observed at the start of the transect (near the OHWM) and crustaceans including, barnacles (mainly in the mid-intertidal zone), isopods (*Idotea* spp.), helmet crabs, a hermit crab, decorator crabs, flat porcelain crab (*Petrolisthes cinctipes*), and a red rock crab were documented during transect/quadrat surveys. Molluscs observed included mussels, periwinkles and limpets (all between ~10 and 30 m), false jingle shells, a whelk, as well as several piddock clams buried in the hard pan from ~25 m (just below MLLW) to 50 m (transect end). Pink-tipped anemones were observed between 15 and 35 m. A spaghetti worm (Family Terebellidae) was observed in the shallow subtidal. Echinoderms observed included an ochre star, a sunflower star, mottled stars, a leather star and brittle stars.

Summer

Crustaceans observed during transect/quadrat sampling included barnacles (mainly in the intertidal zone), kelp crabs, a helmet crab, a hermit crab, and several isopods. Molluscs observed included mussels and limpets (between 10 and 30 m along the transect), a pacific oyster (*Crassostrea gigas*), a false jingle shell, periwinkles in the lower intertidal, several nudibranchs, and several piddock clams buried in the hard pan from ~25 m (just below MLLW) to 52 m (transect end). Many clam squirts were observed at low-tide near MLLW. Abundant pink-tipped anemones were observed between 15 and 35 m along the transect. A spaghetti worm was observed in the shallow subtidal. Echinoderms observed included a sunflower star and brittle stars.

4.1.6 Transect 10B – Point Glover West

General Site Observations

Spring

Transect 10B, surveyed on May 20, 2012, extended ~50 m seaward from OHWM (Figure 2). Given tidal levels at the time of survey, the transect was surveyed on foot from 0 to 35 m and surveyed by divers from 35 to 50 m. Adverse weather and wave conditions at the time of sampling resulted in poor visibility in the shallow subtidal zone (between 35 and 50 m) and a reduced ability to identify flora and fauna in this area.

Summer

Transect 10B, surveyed on August 28, 2012, extended ~49 m seaward from OHWM (Figure 2). Given tidal levels at the time of survey, the transect was surveyed on foot from 0 to 35 m and surveyed by divers from 35 to 49 m.

Substrate

Spring

Substrate along the transect transitioned from gravel/cobble/sand (0 to 15 m) to bedrock with overlying smaller sediments including cobble, gravel, and silt/sand (15 to 50 m). Substrate characterization was impeded between 45 and 50 m due to a high percent cover of *Agarum* sp.

Summer

Substrate along the transect transitioned from gravel/cobble with pockets of shell (0 to 15 m) to bedrock with overlying smaller sediments including cobble, gravel, and silt/sand) (15 to 49 m). A large pocket of sand was recorded near ~49 m (transect end). Substrate characterization was impeded between 45 and 49 m by a high percent cover of *Agarum* sp.

Macrophytes

Spring

Green algae, specifically sea lettuce, were present in the mid to lower intertidal, with the highest percent cover occurring from ~15 to 40 m. Brown algae observed included rockweed (from 10 to 35 m with greatest coverage at 30 m), wireweed (shallow subtidal), sea cauliflower (between ~15 and 30 m), and *Agarum* sp. (at ~45 m). Red algae were present from the mid intertidal to the shallow subtidal. A number of red algae species were identified, with *M. borealis*, *C. exasperates* and *Sarcodiotheca* sp. being the most common. Other red algae species observed included *Rhodymenia* sp., *Hymenena* sp., *Mazzaella* sp., coralline algae, *Polysiphonia* sp., *Porphyra* spp., and *Plocamium* spp.

Summer

Green algae, specifically sea lettuce, were present in the lower intertidal and shallow subtidal, occurring continuously from ~15 to 45 m. Brown algae observed included rockweed (from 10 to 40 m with greatest coverage at 30 m), wireweed (shallow subtidal), sea cauliflower, and kelp (*Agarum* sp. and *Laminaria* spp*.;* from 35 m to the end of the transect at 49 m). Red algae were present from the mid intertidal to the shallow subtidal. A number of red algae species were identified, with *C. exasperates* and *Ahnfeltia* spp. being the most common. Other red algae species observed included Turkish washcloth, coralline algae, *Sarcodiotheca gaudichaudii, Gracilaria* spp., *Endocladia* spp., *Palmaria* spp., and *Porphyra* spp.

Invertebrates

Spring

Crustaceans observed during transect/quadrat sampling included barnacles, hermit crabs, a kelp crab, isopods and amphipods. Molluscs observed included mussels and limpets (between 10 and 30 m), piddock clams, cone-shaped snails, false jingle shells, nudibranchs and periwinkles. Pink-tipped anemones were observed between 10 and 30 m. Echinoderms observed in the shallow subtidal included a sunflower star and ochre stars. A single nereid worm was observed along the transect.

Summer

Crustaceans observed during transect/quadrat sampling included barnacles, a red rock crab, shore crabs, helmet crabs, kelp crabs, isopods and shrimp. Molluscs observed included mussels and limpets (between 10 and 35 m along the transect), piddock clams, whelks, false jingle shells, and periwinkles. Pink-tipped anemones were observed between 10 and 35 m. Echinoderms observed in the shallow subtidal included a mottled star, sunflower stars, and ochre stars.

4.1.7 Transect 11B – Illahee Beach (Reference Site)

General Site Observations

Spring

Transect 11B, surveyed on May 23, 2012, extended ~65 m seaward from the base of a small concrete seawall which terminated at OHWM (Figure 2). Given tidal levels at the time of survey, the transect was surveyed on foot from 0 to 33 m and surveyed by divers from 33 to 65 m. Adverse weather and wave conditions at the time of sampling resulted in poor visibility in the shallow subtidal zone (between 35 and 65 m), and reduced the ability to identify flora and fauna in this area. Characterization of substrate and epifauna was also impeded between 45 and 65 m due to extensive cover of green algae (*Ulva* spp.) and detrital *Laminaria* spp. at the time of sampling.

Summer

Transect 11B, surveyed on August 29, 2012, extended ~65 m seaward from the base of a small concrete seawall which terminated at OHWM (Figure 2). Given tidal levels at the time of survey, the transect was surveyed on foot from 0 to ~34 m and surveyed by divers from 35 to 65 m. Characterization of substrate and epifauna was impeded between 40 and 65 m due to extensive cover of green algae (*Ulva* spp.) at the time of sampling.

Substrate

Spring

Substrate along the transect transitioned from cobble/gravel (0 to 40 m) (with higher proportional cover of gravel; approximately 4:1) to well-mixed cobble/gravel/sand (40 to 50 m), to mainly finer sediments (50 m to end of transect at 65 m). Few boulders were observed along the transect. Shell was observed along the majority of the transect.

Summer

Substrate transitioned from well-mixed cobble/gravel/sand with some shell fragments from the OHWM to 30 m along the transect. Between 30 and 40 m, cobble cover was greater than gravel cover, which in turn was greater than sand cover. Beyond 40 m, percent cover of sand/silt steadily increased towards the end of the transect (65 m) with cobble cover dropping dramatically beyond the 45 m mark. Few boulders were observed along the transect. Shells were observed along the majority of the transect.

Macrophytes

Spring

Green algae, specifically sea lettuce, were observed continuously from 30 m (near MLLW) to the end of transect (65 m). *U. intestinalis* was also present. Brown algae observed included *Laminaria* spp. below ~40 m and *D. ligulata* in two transect segments in the shallow subtidal. Red algae were present in the mid to lower intertidal segments of the transect, including *Mazzaella* sp. and *Porphyra* spp. Below MLLW, *Gracilaria* spp. and *Sarcodiotheca* sp. were the most common red algae species observed.

Summer

Green algae, specifically sea lettuce, were observed continuously from ~25 m (near MLLW) to the end of transect (65 m). Kelp (*Laminaria* spp.) was observed below ~40 m. Red algae were present in the mid to lower intertidal segments of the transect, including *Mastocarpus* spp. and *Polysiphonia* spp. Below MLLW, *Gracilaria* spp. was the most dominant red species with *Palmaria* spp. and *Rhodymenia* spp. also present.

Invertebrates

Spring

Crustaceans observed during transect/quadrat sampling included barnacles, shore crabs, hermit crabs, dungeness crab (*Cancer magister*) and helmet crabs (below MLLW). Molluscs observed included mussels (lower intertidal), periwinkles (throughout intertidal), limpets, whelks (at the waterline), nudibranchs and false jingle shells. Jointed tube worms were present in softer substrates between ~60 and 65 m (transect end). Echinoderms observed included ochre stars towards the end of transect.

Summer

Crustaceans observed during transect/quadrat sampling included barnacles, shore crabs, hermit crabs and graceful crabs (below MLLW,) three helmet crabs, two kelp crabs, several amphipods, and two species of shrimp (*Pandalus* spp. and *Crangon* spp.). Molluscs observed included mussels (lower intertidal), chitons, limpets and snails (sp. unidentified) in the shallow subtidal, periwinkles throughout the intertidal, whelks (at the waterline) and false jingle shells (near MLLW). Jointed tube worms were present in softer substrates between 50 and 60 m along the transect. Echinoderms observed included mottled stars at and just below the waterline.

4.1.8 Transect 12B – Crystal Springs (Reference Site)

General Site Observations

Spring

Transect 12B, surveyed on May 22, 2012 extended ~50 m seaward from the base of a rip-rap wall which terminated at OHWM (Figure 2). Given tidal levels at the time of survey, the transect was surveyed on foot from 0 to 30 m and by divers from 30 to 50 m. Adverse weather and wave conditions at the time of sampling resulted in fair to poor visibility in the shallow subtidal zone (between 30 and 50 m) resulting in reduced ability to identify flora and fauna in this area.

Summer

Transect 12B, surveyed on August 29, 2012, extended ~52 m seaward from the base of a rip-rap wall which terminated at OHWM (Figure 2). Given tidal levels at the time of survey, the transect was surveyed on foot from 0 to ~32 m and by divers from 32 to 52 m. Characterization of substrate and epifauna was impeded at the time of sampling between 40 and 52 m by extensive cover of green algae (*Ulva* spp./ *Ulvaria* spp.).

Substrate

Spring

Substrate along the transect transitioned from sand/silt (0 to 5 m) to gravel with little cobble and shell (5 to 30 m), to cobble (30 m to end of transect at 50 m mark).

Summer

Substrate along the transect transitioned from sand with little gravel (0 to 5 m), to gravel with little cobble and shell (5 to 30 m). Cobble cover increased towards the 35 m mark (to a maximum percent cover of 50%), then decreased towards the offshore extent of the transect (52 m). From 35 to 52 m, the percent cover of sand increased and became finer at depth. Beyond 50 m, substrate consisted of cobble, gravel, silt, sand, and shell.

Macrophytes

Spring

Green algae, specifically sea lettuce, were present continuously from ~25 to 50 m (transect end), with *Acrosiphonia* sp. and *U. intestinalis* observed in low densities near the water line. No brown algae (kelp) and limited red algae were observed along the transect. Red algae species observed included *Mazzaella* sp., *Mastocarpus* spp., *C. exasperates*, and *Porphyra* spp.

Summer

Green algae, specifically sea lettuce, were present continuously from ~25 to 52 m (transect end). Brown algae (*Laminaria* spp.) were observed below 35 m (~1.5 m below MLLW). Limited red algae were observed along the transect, with *Gracilaria* spp. and *Mastocarpus* spp. representing the most dominant red species.

Invertebrates

Spring

Crustaceans observed during transect/quadrat sampling included barnacles (from 5 to 50 m), shore crabs (mid to low-intertidal), hermit crabs and a red rock crab. Molluscs observed included mussels (between 15 and 25 m), periwinkles (mid- to low-intertidal), limpets (mid- to low-intertidal), a chiton, false jingle shells (near and below MLLW), and dogwinkles (Nucella spp.). A single stubby anemone was observed in the 40 to 45 m segment.

Summer

Crustaceans observed during transect/quadrat sampling included barnacles (from 5 to 52 m), shore crabs, a red rock crab, hermit crabs, a helmet crab, kelp crabs and a graceful crab. Molluscs observed included mussels (between 15 and 30 m), periwinkles (most abundant in mid-intertidal), limpets (most abundant in mid- to low-intertidal), whelks and false jingle shells (near MLLW). Two slime-tubed feather duster worms and one spaghetti worm were observed in the shallow subtidal. Echinoderms observed included brittle stars and mottled stars.

4.1.9 Summary Statistics[19] - Quadrat Sampling

Taxonomic Richness and Diversity

Detailed results on the number of taxa observed at each site, as well as taxonomic richness and diversity values recorded at each site, are provided in Appendix E. Figures 7 through 11 illustrate changes in mean taxonomic richness and diversity across survey sites over the three study periods. It is important to note that the taxonomic richness and diversity values identified represent a mean value based on all quadrats surveyed along a single

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[19] Calculated values are based on field and analytical methods described within this report. Comparing these values to other reports or studies, where different methods have been employed, may result in poor agreement.

transect at each site. This approach does not take into account seasonality and shore-gradient effects that may be present at each site (i.e., it assumes that marine biota are evenly distributed across the entire transect). Bearing this in mind, the following points concerning these data are noteworthy:

- In general, mean taxonomic richness and mean diversity of marine fauna were highly variable across study sites and sampling periods. Taxonomic richness of fauna was shown to increase at all study sites in 2012 compared to values recorded in fall (October 2011) (Figure 7). For study sites, taxonomic richness was highest at Site 3B in May 2012 and lowest at Site 9B in October 2011 (Figure 7). When comparing taxonomic richness between spring (May 2012) and summer (August 2012), mean faunal richness was shown to decrease in summer at sites 10B and 5D, increase in summer at Site 1B, and show little variation between seasons at Sites 9B, 9D and 3B. Taxonomic diversity at study sites showed similar trends for the three seasons, with the highest diversity observed at Site 3B in August 2012 and the lowest diversity observed at Site 9B (Figure 9). When comparing species diversity between spring and summer of 2012, mean faunal diversity was shown to increase in summer at Sites 1B, 3B, 9B, 9D; decrease in summer at Site 10B; and show little variation at Site 5D.

- Overall, mean taxonomic richness of macrophytes was variable across study sites and sampling periods (Figure 9). Taxonomic richness for study sites was highest at Site 9D during all sampling periods. Taxonomic diversity for macrophytes was highest at Site 9D during both fall and summer and highest at Site 10B during spring (followed by Site 9D). When comparing taxonomic richness of macrophytes between spring and summer, richness was shown to increase in summer at Sites 3B and 1B; decrease in summer at Sites 9B, 9D and 10B; and show little variation at Site 5D (Figure 11). With the exception of Site 3B, mean macrophyte diversity decreased at all sites in summer (Figure 11).

- Mean taxonomic richness and diversity of fauna and macrophytes at reference site 12B (Crystal Springs) were variable over the study period. Comparison of spring and summer 2012 data suggests a slight increase in fauna richness during summer, coupled with a moderate decrease in fauna diversity, macrophyte richness and macrophyte diversity (Figure 11). Reference site 11B (Illahee North) was added as an additional reference site for the 2012 surveys; therefore no survey data was collected at this location in October 2011. Site 11B exhibited higher richness and diversity values for fauna during summer of 2012, although little change in richness and diversity of macrophytes between spring and summer 2012 (Figure 11).

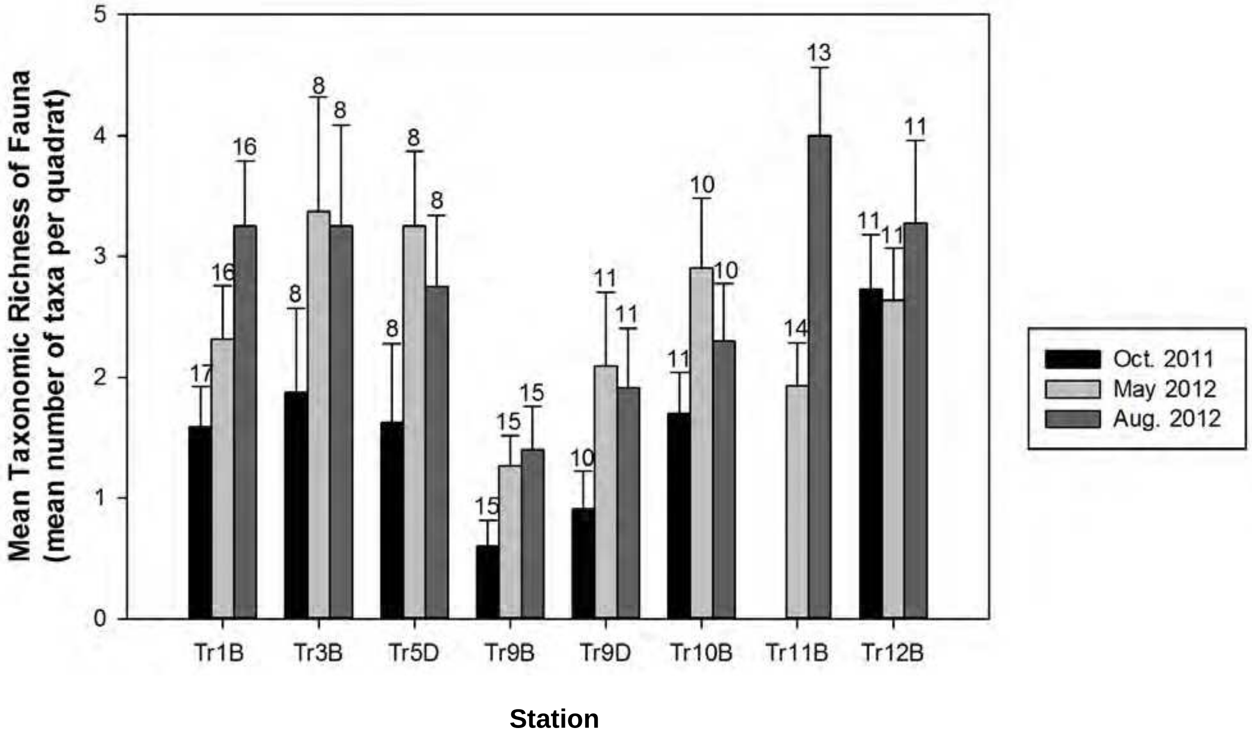

Figure 7: Mean taxonomic richness of fauna across sites - Transect/quadrat sampling data: October 2011, May 2012, and August 2012. Means were calculated for quadrat data; the number of samples/ quadrats (n) is displayed above the error bars (standard error).

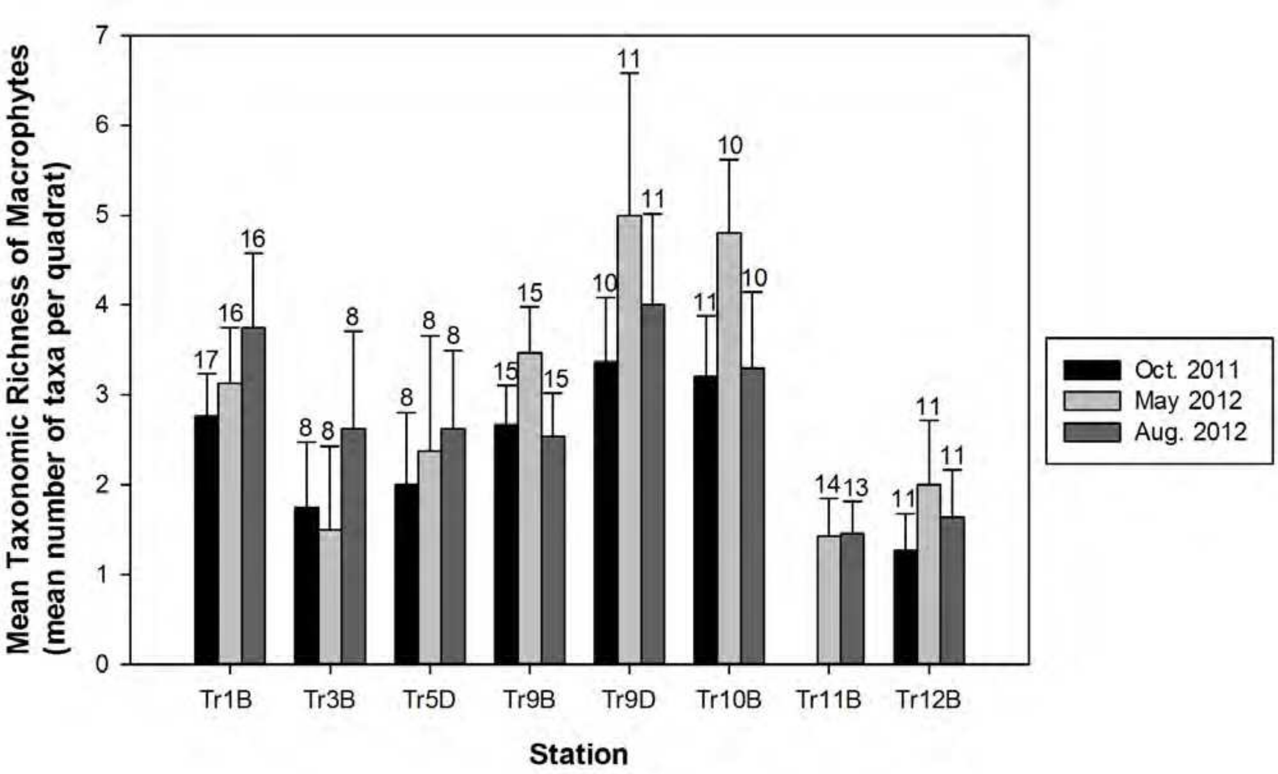

Figure 8: Mean taxonomic richness of macrophytes across sites - Transect/quadrat sampling data: October 2011, May 2012, and August 2012. Means were calculated for quadrat data; the number of samples/ quadrats (n) is displayed above the error bars (standard error).

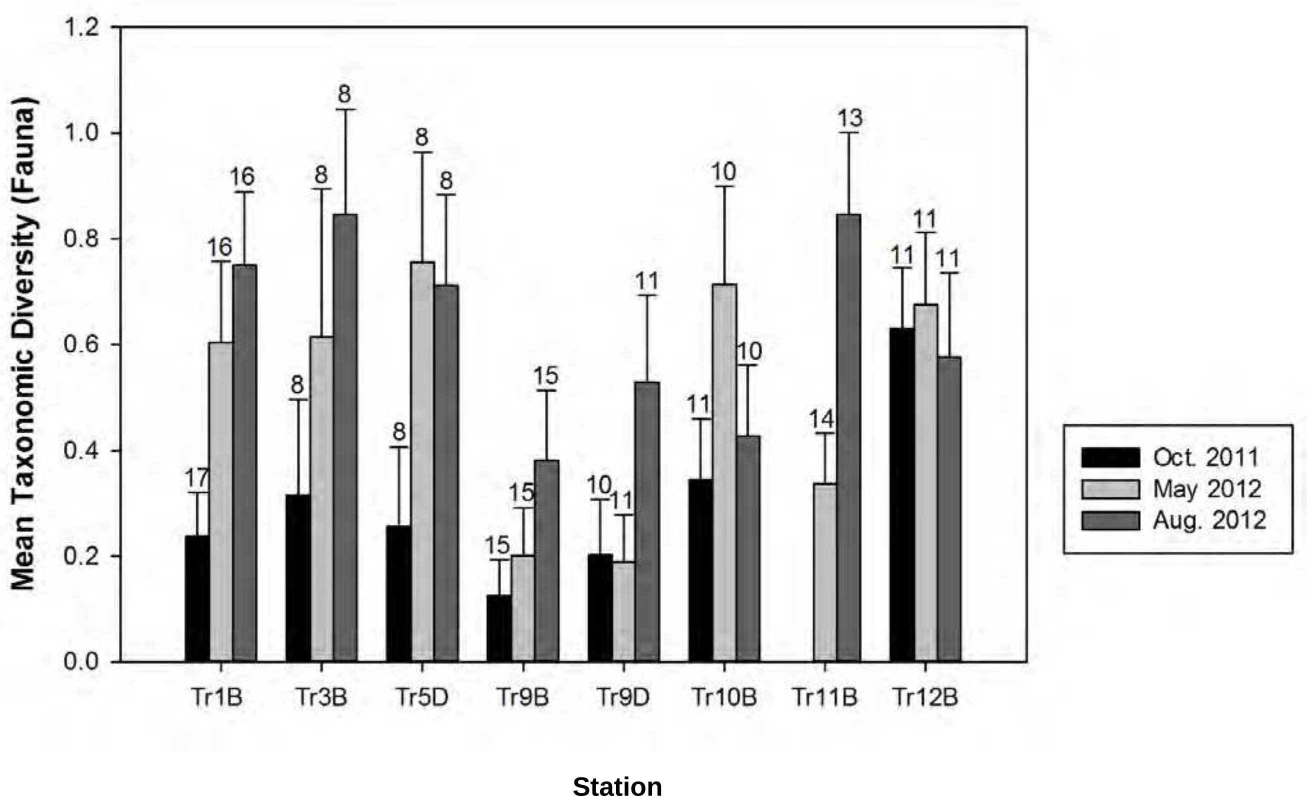

Figure 9: Mean taxonomic diversity of fauna - Transect/quadrat sampling data: October 2011, May 2012, and August 2012. Means were calculated for quadrat data; the number of samples/ quadrats (n) is displayed above the error bars (standard error).

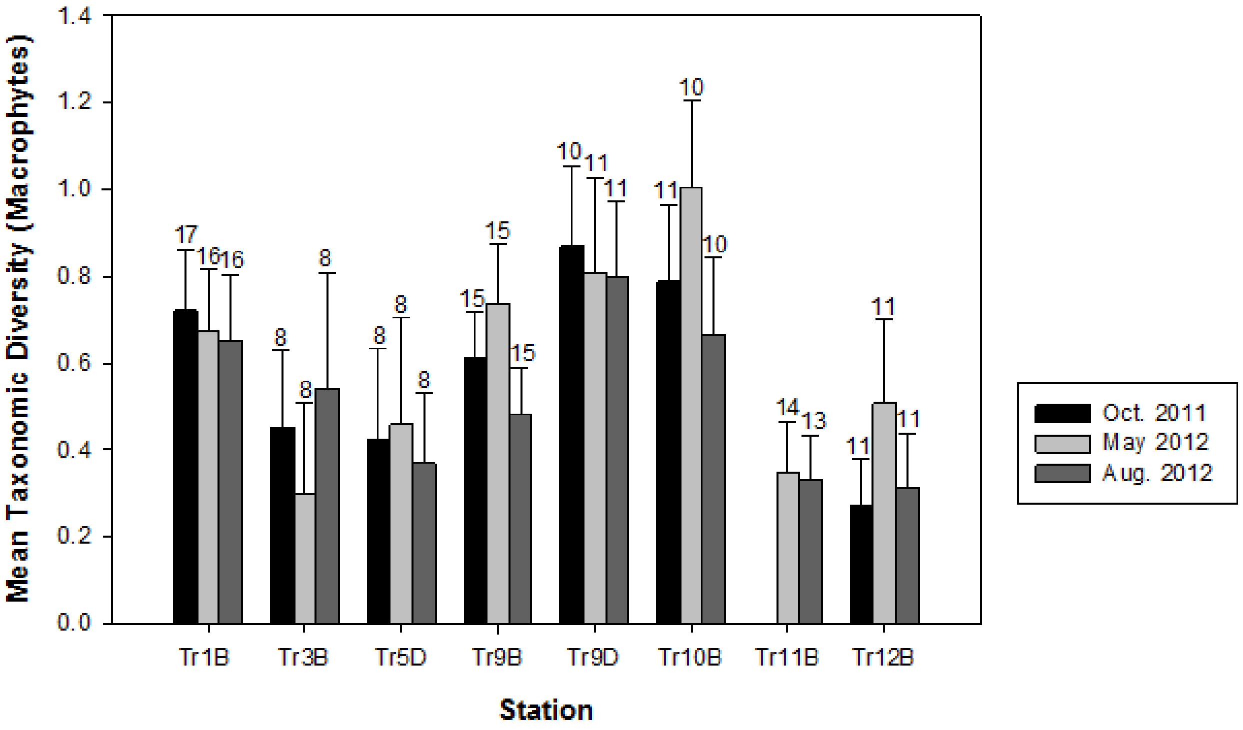

Figure 10: Mean taxonomic diversity of macrophytes - Transect/quadrat sampling data: October 2011, May 2012, and August 2012. Means were calculated for quadrat data; the number of samples/ quadrats (n) is displayed above the error bars (standard error).

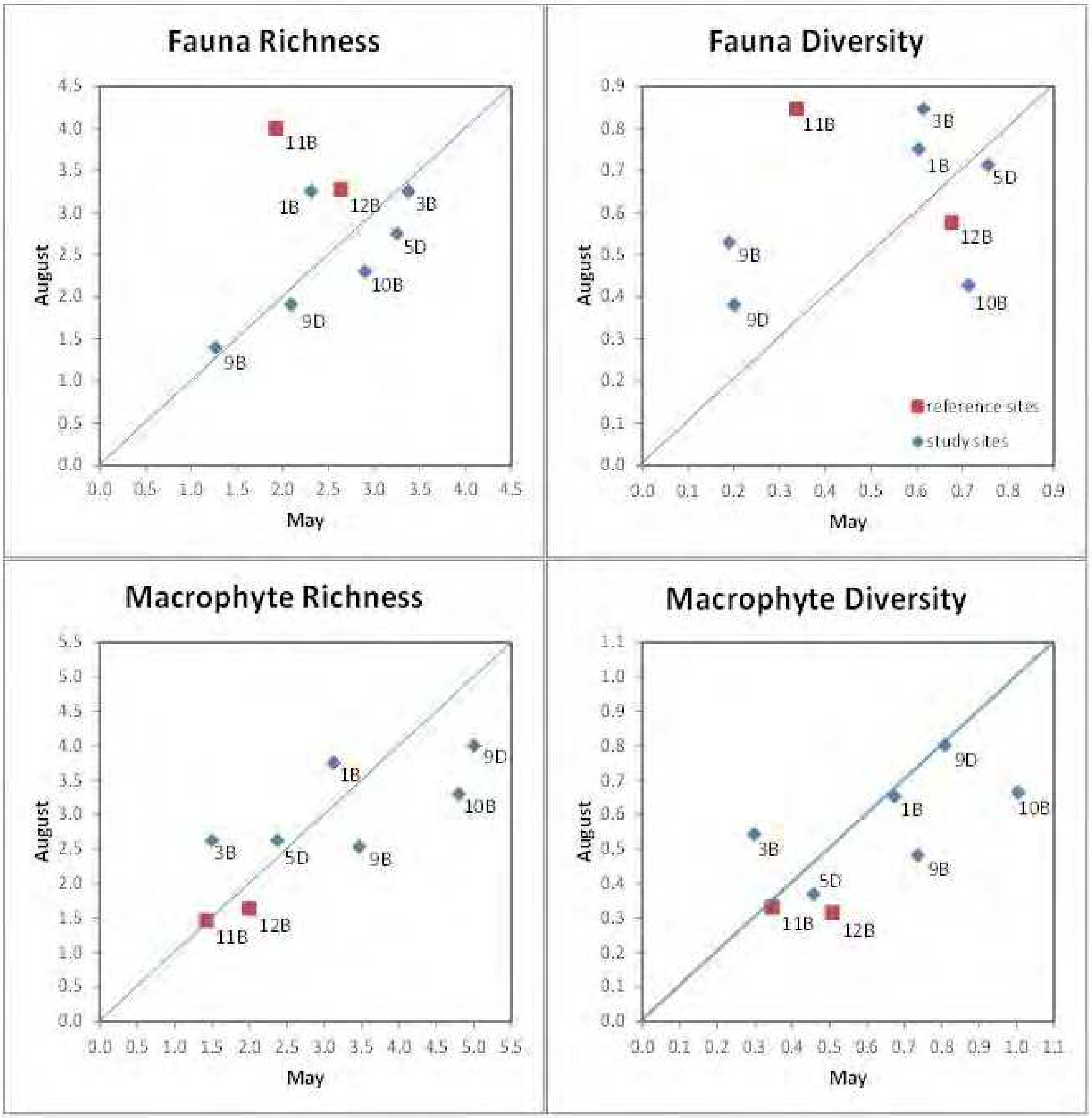

Figure 11: Changes in taxonomic richness and diversity in macrophyte and faunal communities between sampling seasons – (May and August 2012) transect quadrat sampling data. Stations located on the line indicates no change between seasons, stations located below the line indicates a higher diversity/richness in May and stations located above the line indicate higher diversity/ richness in August.

Frequency of Occurrence

Frequency of occurrence indicates the likelihood of a species occurring at a site. As the frequency-of-occurrence value approaches 1, a species is more commonly observed. Appendix E contains a summary table for frequency of occurrence metrics in May and August 2012. Results from fall 2011 surveys are included in Golder's 2011 Marine Biophysical Field Report (Golder 2012).

During spring sampling (May 2012), the most frequently encountered macroalgae and invertebrate species recorded during quadrat sampling included the following:

- Green algae:
  - *Ulva*/*Ulvaria* (maximum frequency of 0.75 [Site 1B])
  - *U. intestinalis* (maximum frequency of 0.67 [Site 9B])
- Brown algae:
  - Sea cauliflower (maximum frequency of 0.6 [Site 10B])
  - Rockweed (maximum frequency of 0.4 [Site 10B])
  - *Laminaria spp.* (maximum frequency of 0.3 [Site 1B])
- Red algae:
  - *Mazzaella spp.* (maximum frequency of 0.7 [Site 10B])
  - *C. exasperates* (Turkish towel) (maximum frequency of 0.6 [Site 10B])
  - *M. borealis/Microcladia coulteri* (maximum frequency of 0.4 [Site 10B])
  - *Gracilaria* spp. (maximum frequency of 0.36 [Site 9D])
  - *Sarcodiotheca* sp. (maximum frequency of 0.31 [Site 1B])
  - Encrusting coralline algae (maximum frequency of 0.3 [Site 9D])
- Crustaceans:
  - Barnacles (maximum frequency of 0.88 [Site 3B])
  - Kelp crabs (maximum frequency of 0.25 [Site 3B])
- Molluscs:
  - Limpets (maximum frequency of 0.5 [Site 10B])
  - Periwinkles (maximum frequency of 0.36 [Site 12B])
  - Mussels (maximum frequency of 0.3 [Site 10B])
- Cnidarians:
  - Pink-tipped anemones (maximum frequency of 0.3 [Site 10B])

During summer sampling (August 2012), the most frequently encountered macroalgae and invertebrate species recorded during quadrat sampling included the following:

- Green algae:

  - *Ulva*/*Ulvaria* (maximum frequency of 0.67 [Site 1B])
- Brown algae:
  - Rockweed (maximum frequency of 0.4 [Site 10B])
  - *Laminaria* spp. (maximum frequency of 0.27 [Site 9D])
- Red algae:
  - *Sarcodiotheca* sp. (maximum frequency of 0.5 [Site 1B])
  - *Porphyra spp.* (maximum frequency of 0.5 [Site 5D])
  - *C. exasperates* (Turkish towel) (maximum frequency of 0.4 [Site 10B])
  - *Mastocarpus spp.* (maximum frequency of 0.4 [Site 10B])
  - Encrusting coralline algae (maximum frequency of 0.38 [Site 9D])
  - *Gracilaria* spp. (maximum frequency of 0.27 [Site 12B])
  - Red cup (maximum frequency of 0.25 [Site 3B])
- Crustaceans:
  - Barnacles (maximum frequency of 0.92 [Site 11B])
  - Shrimp (*Pandalus sp*.) (maximum frequency of 0.31 [Site 1B])
- Molluscs:
  - Limpets (maximum frequency of 0.62 [Site 3B])
  - Periwinkles (maximum frequency of 0.46 [Site 11B])
  - False jingle shell (maximum frequency of 0.45 [Site 1B])
  - Mussels (maximum frequency of 0.4 [Site 10B])
- Cnidarians:
  - Pink-tipped anemones (maximum frequency of 0.3 [Site 10B])

4.1.10 Benthic (Infauna) and Grain Size Sampling

Taxonomic Diversity, Richness and Abundance

Benthic data collected during June and August 2012 was used to calculate mean taxonomic diversity (Figure 12), mean taxonomic richness (Figure 13), and abundance by taxonomic group (Figure 14). Detailed taxonomic data for the benthic samples are provided in Appendix G. Detailed tables for the benthic data statistics are provided in Appendix H.

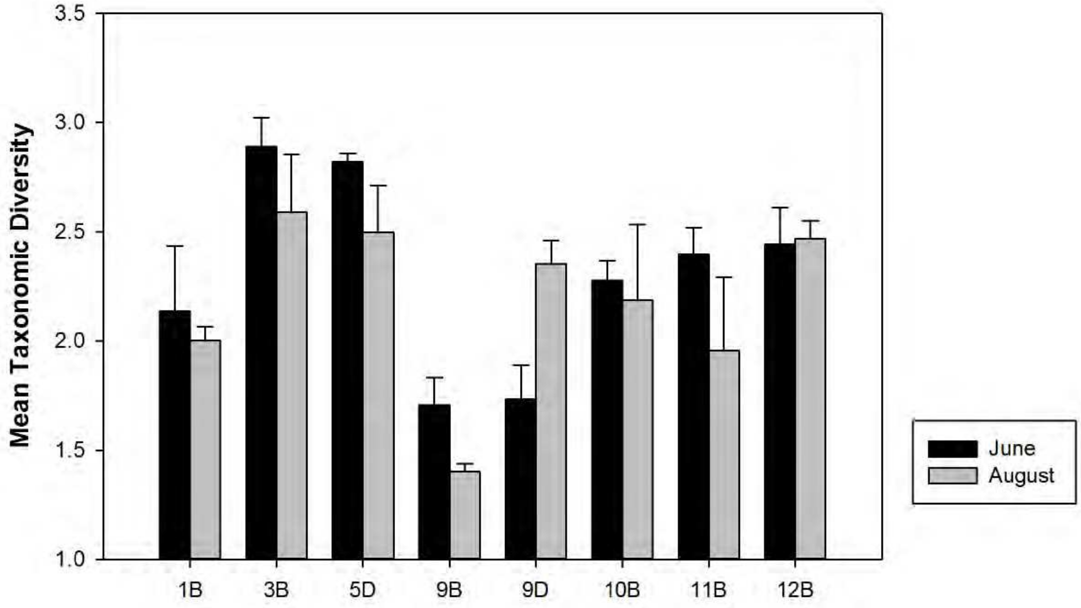

Figure 12: Mean taxonomic diversity for benthic infauna - June and August 2012. Samples were collected at ~0 m MLLW. Means were based on three replicate samples (n = 3). Error bars indicate standard error.

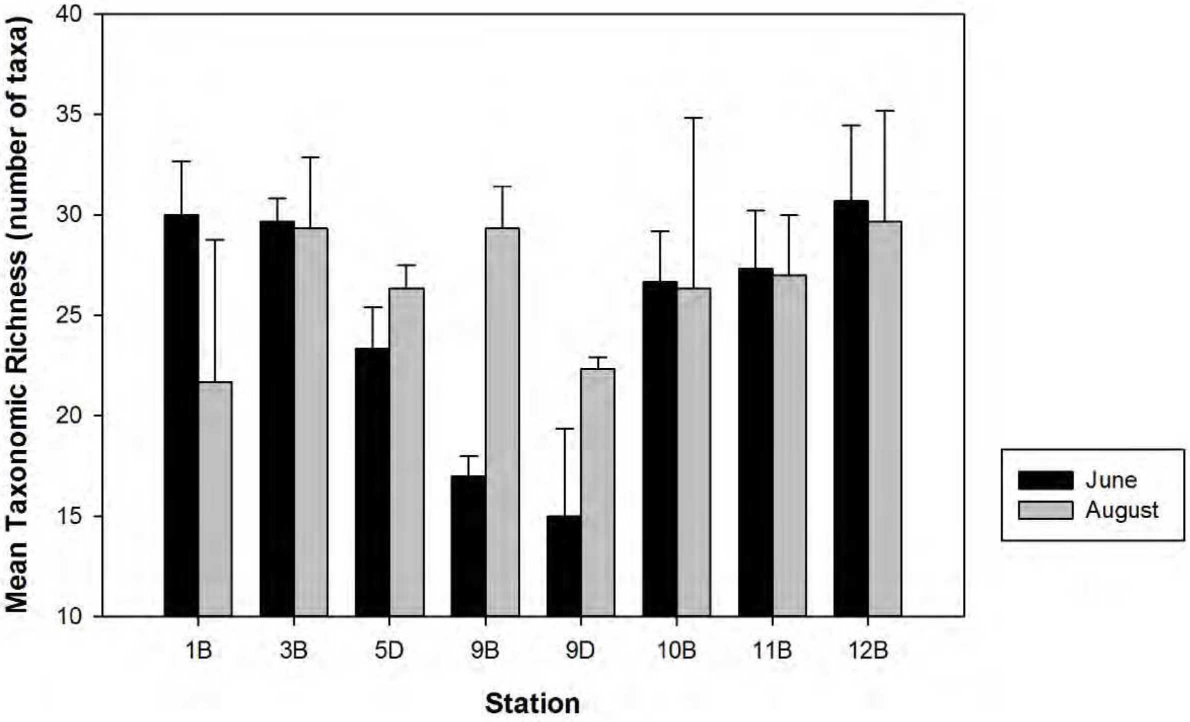

Figure 13: Mean taxonomic richness for benthic infauna - June and August 2012. Samples were collected at ~0 m MLLW. Means were based on three replicate samples (n = 3). Error bars indicate standard error.

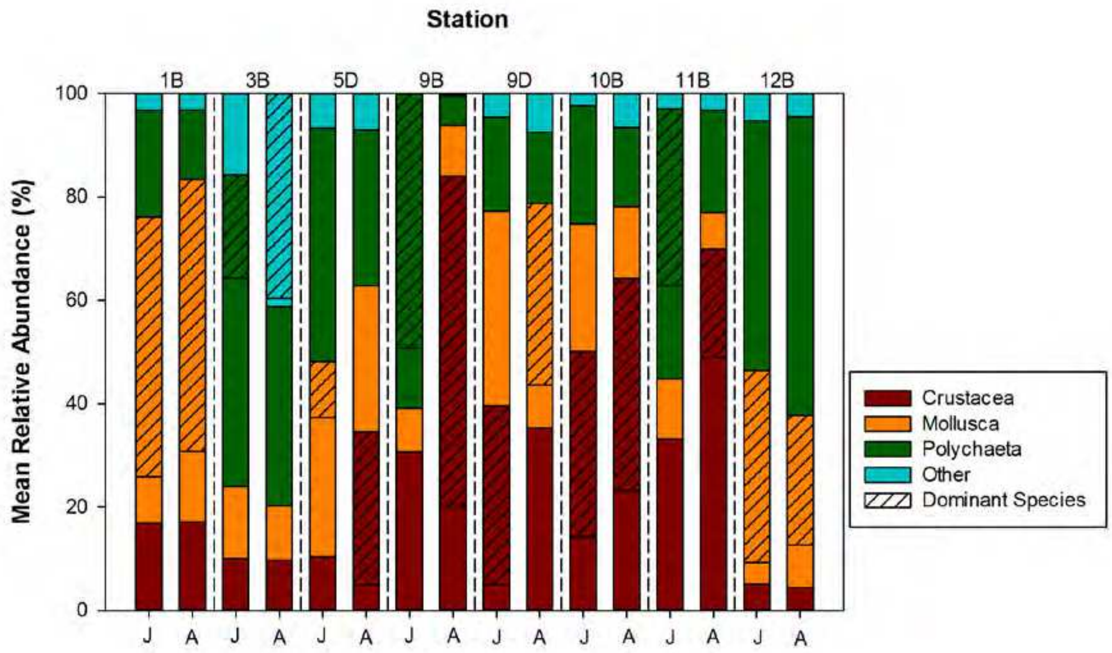

Figure 14: Mean relative abundance of benthic infauna - June and August 2012. Samples were collected from study sites at ~0 m MLLW. The abundance of the dominant species within each group is indicated with cross hatching. Means were based on three replicate samples (n = 3).

Mean taxonomic diversity and mean taxonomic richness of benthic infauna were shown to be variable across study sites and across the two sampling periods (June and August). The highest diversity occurred at sites 3B during both June and August 2012 sampling periods (Figure 12). The lowest diversity occurred at Site 9B during August. The highest species richness values for benthic infauna occurred at Site 12B during both sampling periods (Figure 13). The lowest species richness values occurred at site 9D during June and at site 1B during August.

Changes in the relative abundance of taxa in samples collected during June and August sampling events were observed. Figure 14 illustrates the proportions of organisms observed in each taxonomic group, and the abundance of the dominant species. Detailed results are provided in Appendix H, and a general summary of the 2012 findings is provided below:

- Site 1B: Molluscs were the most abundant taxonomic group in both June and August, with the most dominant species being *Rochefortia* sp.;
- Site 3B: Polychaetes were the most abundant group in June (dominant species *Armandia* sp.); however, nemerteans (categorized as other taxa) were the dominant taxa in August;

- Site 5D: Polychaetes were abundant in both June and August (dominant taxa in June were molluscs – *Rochefortia* sp.). An increase in crustaceans, particularly barnacles (Infraclass Cirripedia) was observed in August;
- Site 9B: Polychaetes were the most abundant taxa in June (dominant species *Eteone* sp.); however, crustaceans were more abundant in August (dominant species *Leptochelia* sp.);
- Site 9D: Molluscs and crustaceans were abundant in both June and August. *Gnorimosphaeroma* sp. (subphylum Crustacea) was the dominant species recorded in June and *Rochefortia* sp. (phylum Mollusca) was the dominant species recorded in August;
- Site 10D: Crustaceans (dominant taxa *Gnorimosphaeroma* sp.) were the most abundant taxa recorded in both June and August;
- Reference Site 11B: Polychaetes (dominant taxa *Armandia* sp.) were the most abundant taxa recorded in June; however, crustaceans (infraclass Cirripedia) were the most dominant taxa recorded during August; and
- Reference Site 12B: Polychaetes were the most abundant taxa in June and August; however, *Rochefortia* sp. (subphylum Crustacea) was the dominant species at this site during both sampling periods.

Multivariate Analysis

Two NMDS dimensions were derived from the benthic community data, which together accounted for 86% of the variance in the original Bray-Curtis matrix. The stress value of the final configuration was 0.18, which represents a good fit of the ordination results to the input data (Clarke 1993). The NMDS ordination of the station-month combinations (Figure 15) illustrates the degree of similarity in community composition between sampling events. Station-month events that appear close together on this plot had relatively similar benthic communities, whereas station-month events that are far apart were relatively dissimilar. Spearman's rank-order correlations between species' abundances and the NMDS dimensions indicate which taxa were most closely associated with each of the dimension variables. Spearman's rank-order correlation coefficient[20] data are provided in Appendix K; taxa with relatively strong correlations are shown on the axes of Figure 15.

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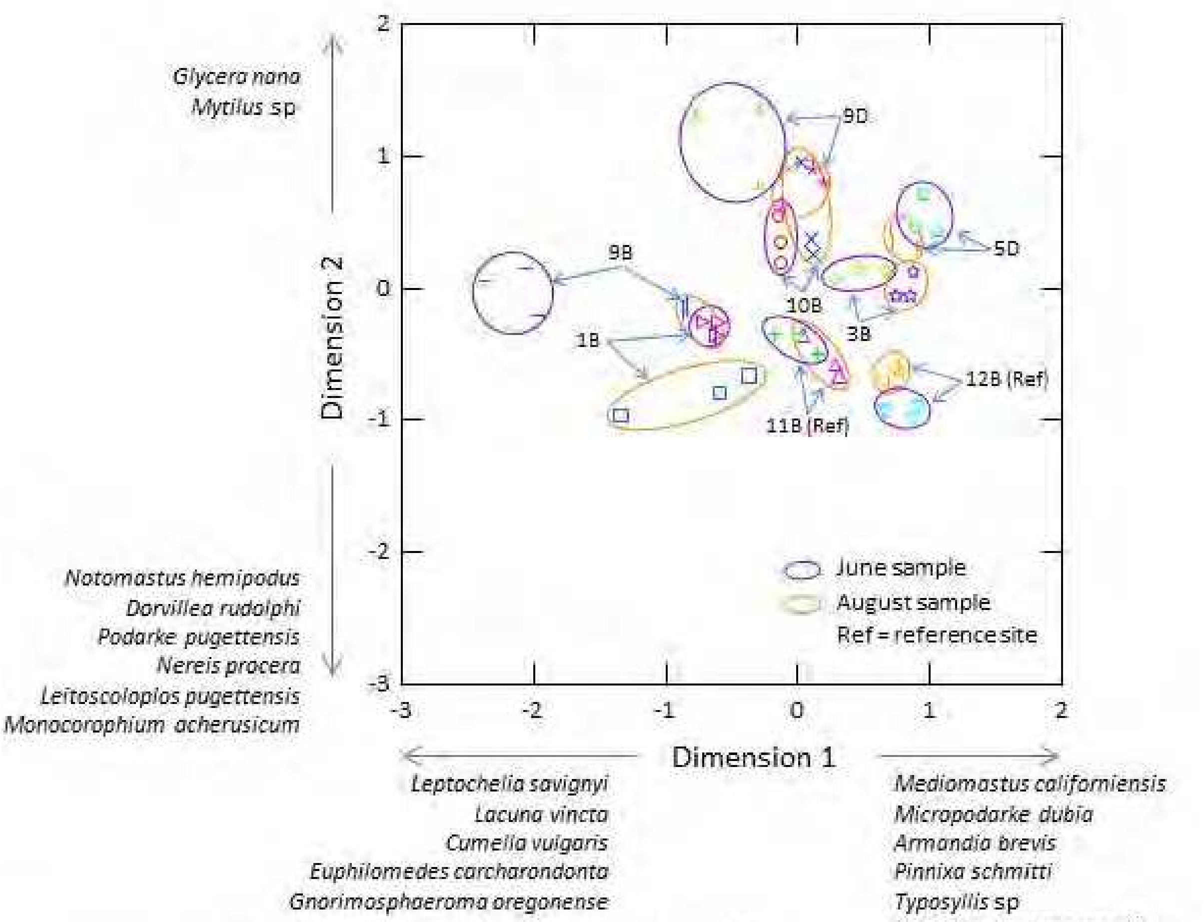
[20] The Spearman's rank-order correlation coefficient measures the strength of association between two ranked variables.



Note: Taxa shown had moderate to strong correlations (*i.e.*, $|r_i| > 0.5$)

Figure 15: NMDS ordination of the station-month combinations for benthic infauna samples. The degree of similarity in community composition is shown between the three replicates collected at each site along with the shifts in community composition between sampling events where closely clustered samples indicates high similarity between replicate samples and sampling events. Samples are represented with symbols and the coloured polygons indicate samples collected during June and August sampling events. Samples were collected from approximately 0 m MLLW in June and August 2012.

NMDS Dimension 1 was negatively correlated with four crustacean species (*Leptochelia savignyi, Cumella vulgaris, Euphilomedes carcharondonta* and *Gnorimosphaeroma oregonense*) and sea snails (*Lacuna vincta*). Thus, as Dimension 1 scores increase (to the right of Figure 15), abundances of these taxa decrease and as Dimension 1 scores decrease, abundances of these taxa increase. Species that were positively correlated to Dimension 1 were three polychaetes (*Mediomastus californiensis, Micropodarke dubia, and Armandia brevis)* and three crustaceans (*Hemigrapsus oregonensis*, *Pinnixa schmitti* and *Typosyllis* sp.). Dimension 2 was positively correlated with a polychaete species (*Glycera nana*) and a mollusc species (*Mytilus* spp.) and negatively correlated with five polychaete species (*Notomastus hemipodus, Dorvillea rudolphi, Podarke pugettensis*, *Nereis procera* and *Leitoscoloplos pugettensis*) and a mollusc (*Monocorophium acherusicum).*

For the majority of sample locations, replicates were tightly clustered (indicating high similarity) and sampling events were relatively close together (indicating little change between months). Exceptions were sites 9B, 9D and 1B. This analysis suggests that sites 9B and 9D exhibited lower Dimension 1 scores in June compared to August, indicating a shift in community composition between the sampling events related to the taxa correlated to Dimension 1. In contrast, the dimension scores from sample location 1B indicated a change between June and August related to the abundance of taxa correlated to Dimension 2, with lower Dimension 2 scores in August.

The purpose of this analysis was to identify key taxonomic assemblages that could serve as indicators for environmental change at survey sites. Although change in the abundance of taxa correlating with Dimension 1 and Dimension 2 were evident at some survey sites over the study period, additional analysis (a longer-term data series) are required to examine if changes relate to RP1 operations or other contributing factors.

Grain Size

Grain size data collected from survey sites in June and August 2012 is provided in Appendix I with the overall results presented in Figure 16.

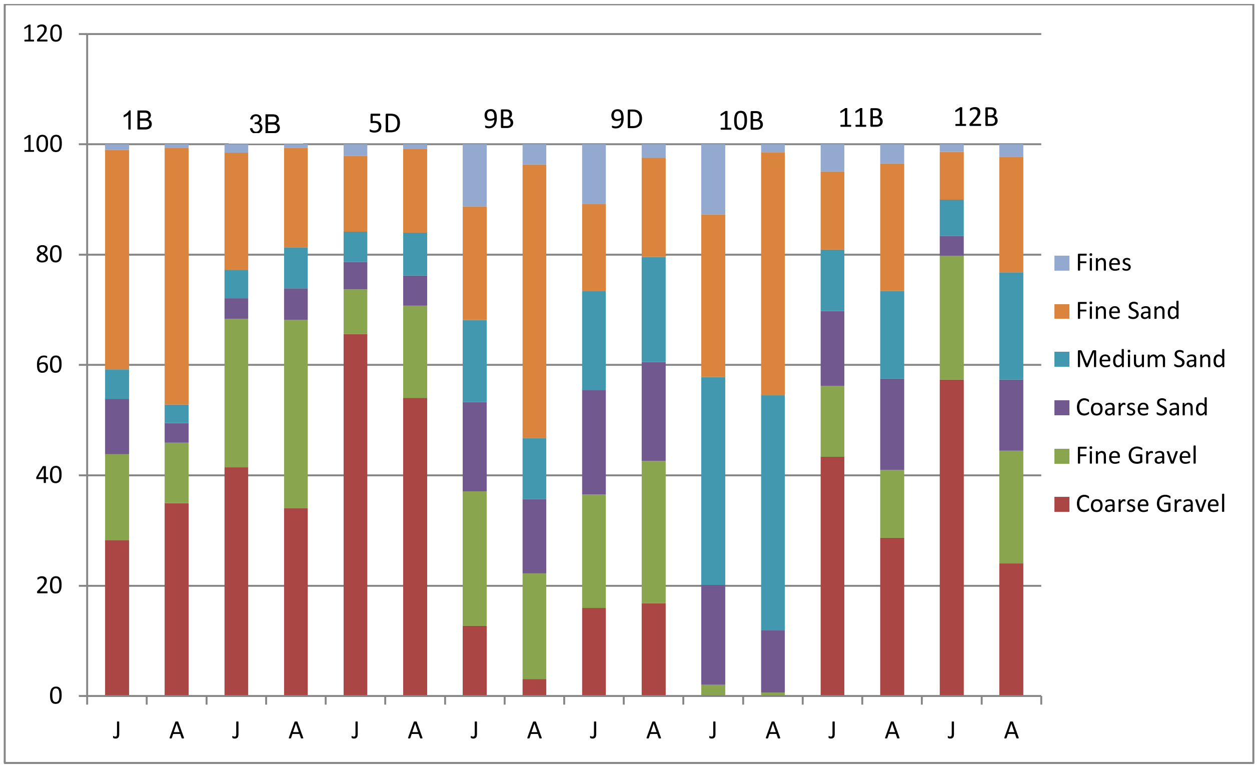


Figure 16: Grain size data collected from approximately 0 m MLLW - June and August 2012. Values presented are based on data from one grain size sample (n = 1) collected from each site during each sampling event.

In general, grain size distributions for sampling locations at survey sites were similar in June and August. The most notable differences were observed at sites 9B and 12B. Grain size data collected from Site 9B in August suggests a decrease in coarse gravel and an increase in fine sand compared to June data (Figure 16). Grain size data collected from Site 12B in August suggests a decrease in coarse gravel and an increase in sand.

4.2 Towed Video Surveys

Underwater videography was useful in documenting areas where eelgrass beds were present or absent, in addition to documenting other key biological features such as clam and sea pen beds. Survey methodology and selected target depths for the 2012 survey were based on survey results from fall of 2011 (Golder 2012). Spring surveys conducted May 18 to 20 included two shore-parallel transects along the northern shoreline (-5 ft/-1.5 m and -15 ft/-4.5 m MLLW) and one shore-parallel transect along the southern shoreline (-10 ft/-3 m MLLW) (Figure 3). Summer surveys conducted on August 24 included one shore-parallel transect along the northern shoreline and one along the southern shoreline (both at -5 ft/-1.5 m MLLW) (Figure 4).

Eelgrass beds and patchy eelgrass (*Z. marina*) were observed along both shorelines during May and August 2012 surveys, with more extensive eelgrass beds occurring along the Bainbridge Island shoreline. Clam beds were observed (demarcated by the presence of large siphons) along both shorelines during both spring and summer survey periods. Areas of sea pen aggregations (*Ptilosarcus* spp.) were also recorded during both seasons in the subtidal zone of the bay located to the east of Point White. No bull kelp was observed in the subtidal zone of either shoreline during the towed video surveys. Appendix F includes a DVD with all towed video footage collected during the underwater towed video survey. Detailed information on the historical presence and distribution of bull kelp (*Nereocystis luetkeana*) in Rich Passage is provided in Appendix L.

4.3 Eelgrass Monitoring Surveys

Eelgrass beds at Point Glover and Fort Ward were mapped following field survey efforts in 2012 (spring and summer data presented in Figures 3 and 4 respectively). To investigate potential changes in the size of these eelgrass beds over a wider time-scale, the 2012 mapping data were overlaid with historical mapping information for the same eelgrass beds surveyed during summer of 2000 by Battelle Marine Sciences Laboratory (Battelle) using aerial and boat survey techniques (Woodruff et al. 2001). Figure 5 compares the size and location of these beds between different survey years; with results suggesting that eelgrass beds at both sites appear to have shifted moderately shoreward since the survey completed by Battelle in summer of 2000 (Figure 5).

Detailed survey information on eelgrass shoot density and average bed density at both sites in May and August 2012 are provided in tabular format in Appendix I. In general, higher shoot densities were recorded in August when compared to May surveys. Average shoot density at the Point Glover eelgrass site ranged from 22.93 shoots per 0.25 m^2 (SE = 2.43) in May to 24.79 shoots per 0.25 m^2 (SE = 2.53) in August. Average shoot density at the Fort Ward eelgrass site ranged from 19.86 shoots per 0.25 m^2 (SE = 2.31) in May to 41.07 shoots per 0.25 m^2 (SE = 3.52) in August.

A reconnaissance survey was conducted to identify a suitable reference site for eelgrass monitoring. Surveys were conducted outside Rich Passage (Figure 6) using towed video and diver spot checks to locate an eelgrass bed that would serve as a suitable reference site for the Point Glover and Fort Ward study sites. Eelgrass was not noted in any of locations surveyed and a suitable reference could not be identified within practicable distance to the study areas.

To measure changes in water clarity, turbidity data were recorded at the Fort Ward eelgrass monitoring site during vessel test operations between September 24 and October 11, 2012. A time series of turbidity data, the occurrence of RP1 vessel wake wash (POFF run) and water surface elevations within the eelgrass bed along with tidal fluctuations are presented in Figures 17 and 18. These data indicate that increased turbidity was often correlated with increased tidal currents on the flood tide. Turbidity changes potentially associated with RP1 wakes were not detectable over natural turbidity fluctuations attributed to tidal currents.

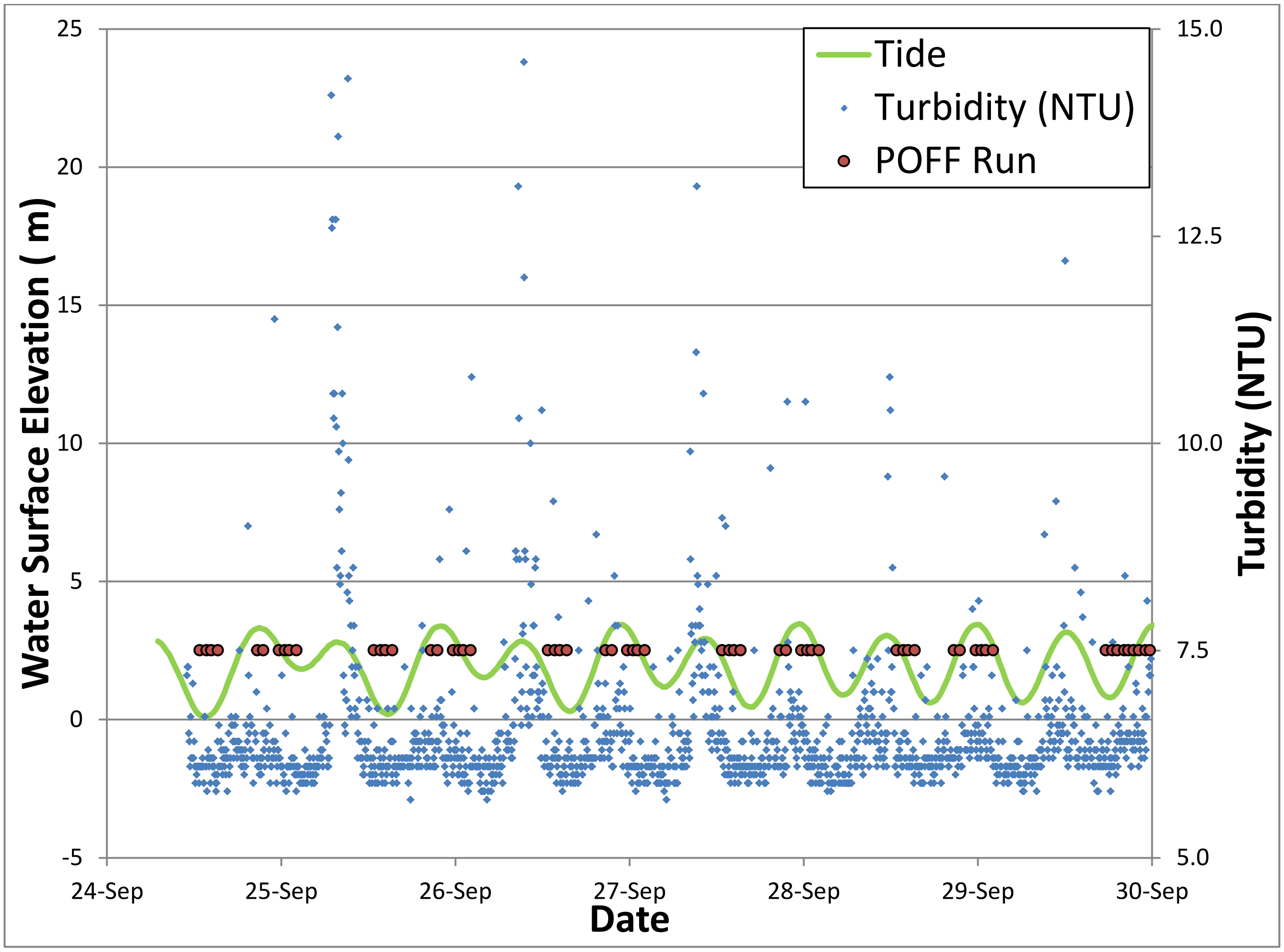


Figure 17: Turbidity monitoring in Fort Ward eelgrass bed - September 24 to September 30' 2012 in relation to RP1 vessel transits and daily tide levels. Turbidity, a measure of water clarity, is presented as Nephelometric Turbidity Units (NTU). Water surface elevation indicates tidal height in meters.

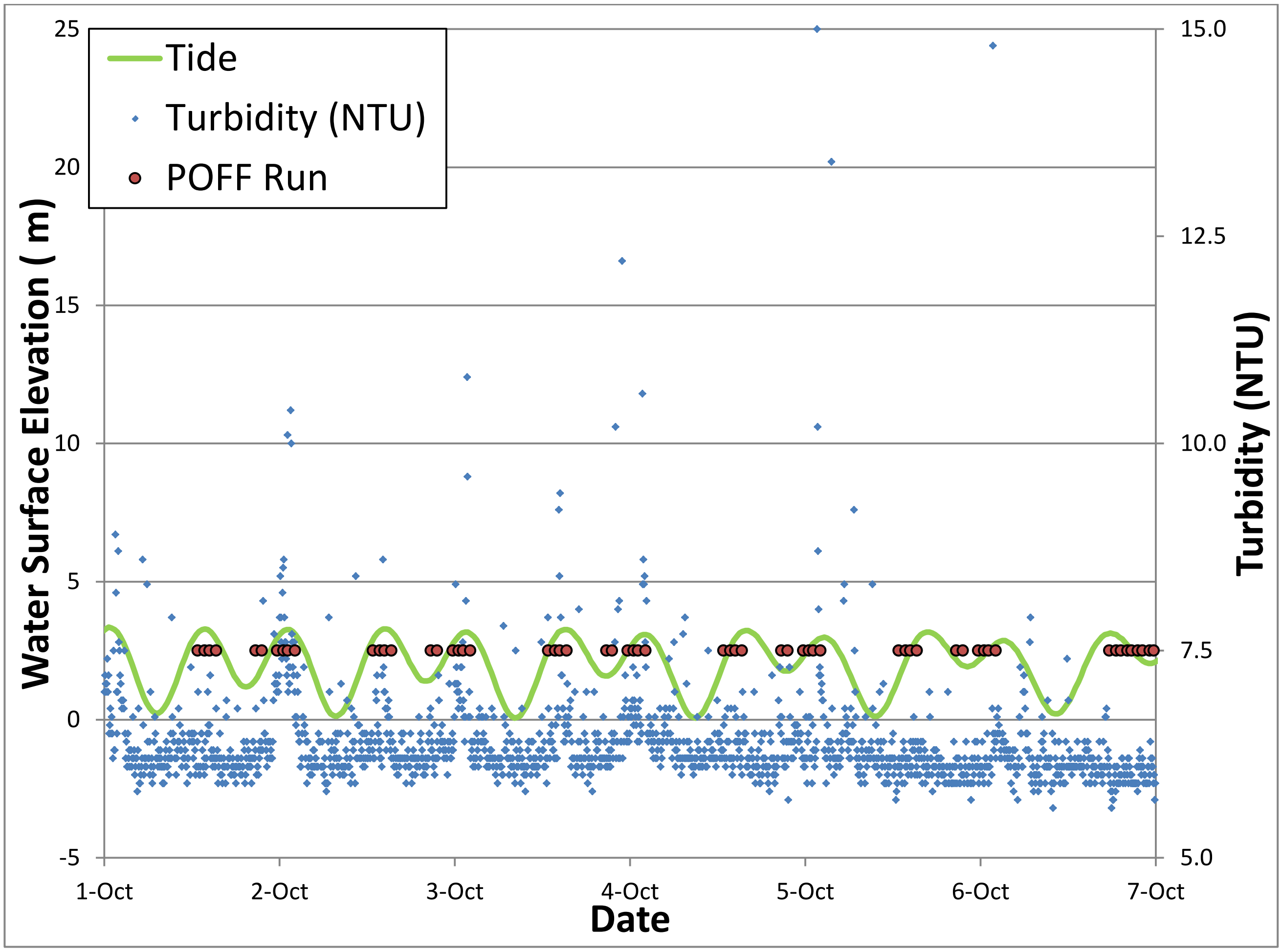


Figure 18: Turbidity monitoring in Fort Ward eelgrass bed - October 1 to October 7, 2012 in relation to RP1 vessel transits and daily tide levels. Turbidity, a measure of water clarity, is presented as Nephelometric Turbidity Units (NTU). Water surface elevation indicates tidal height in meters.

5.0 DISCUSSION

This section describes the study results along with natural and anthropogenic factors collectively influencing the biophysical environment (substrate and sediments, macrophytes, benthic infauna and epifauna) at Rich Passage study sites and reference sites.

5.1 Substrate and Sediments

Understanding the geomorphological setting of each survey site is critical when comparing sediment data between sites, as the shoreline type may influence the effects of POFF wakes on the site's sediments and fauna. Several beach types occur in the Project area, varying in substrate type, slope, exposure, orientation, and shoreline form. Four of the study sites are low bank (Site 3B, 5D and 9B); three are spit/barrier/backshore (Sites 1B, 11B and 12B); and two are rocky shore (Sites 9D and 10B). Each of the survey sites had some form of shoreline modification at or below the OHWM. Wind-waves and wake wash may interact with shoreline armouring structures causing wave reflection, increasing the total net energy acting on the beach and affecting the physical and biological systems (Shipman et al. 2010).

In general, grain size distributions at survey sites were similar before and after RP1 testing. The amount of fine sand increased slightly in samples collected from survey sites in August at all but one site (3B). The accretion of finer sands between spring and summer may be a function of wind-wave energy in the area. Beaches within Rich Passage have a mixed sediment regime that generally includes lots of coarse sediment. The cobble and gravel distribution on beaches within Rich Passage are generally reverse graded due to winnowing and gravity sorting. Site 3B is exposed to the highest speed tidal currents of any of the survey sites and finer sediment could be suspended and transported from the area seasonally.

Increased turbidity resulting from the re-suspension of fine sediments and suspended solids in shallow nearshore ecosystems may occur in conjunction with vessel wake wash. Measurements of turbidity within the Fort Ward eelgrass bed were primarily attributed to tidal currents. Fluctuations in turbidity during the passage of RP1 were not observed (Figures 17 and 18).

5.2 Macrophytes (Macroalgae and Eelgrass)

Several studies have shown that algal communities in Puget Sound can vary considerably with seasons (DNR 2012; Hodgson and Waaland 1979; Neushul 1967). Variability in macroalgae assemblages and abundance (percent cover) within seasons and among seasons could be attributed to a number of factors including microtopography, wave and wake exposure. Eckman et al. (2003) documented that microtopography in the intertidal zone alters the exposure of plants and animals to waves and hydrodynamic forces; they studied how subtle differences in microtopography determine the exposure of understory kelps (*Agarum* sp. and *Laminaria* spp.) to waves and strong tidal currents. The degree of water movement at a given site can exclude the colonization of certain algae, lead to morphological adaptations in certain species (Stewart and Carpenter 2003) and alter interactions among species (Gabel et al. 2011). Annual differences in algal growth have also been noted (Neushul 1967), not only due to environmental conditions but also related to grazing pressure from epibenthic invertebrates. The abundance and relative species composition of algal and faunal communities has been shown to vary with exposure to waves and wakes (Eckman et al 2003; Demes et al. 2012). In particular, the increased overall water movement from frequent and proximate ferry traffic can stimulate primary production in marine seaweeds in nearby rocky intertidal areas by improving nutrient transfer and supporting the removal of metabolic wastes (Demes et al. 2012).

Macrophyte data collected by Golder in October 2011, May 2012 and August 2012 in Rich Passage indicated variable mean species richness and diversity. In general, the fluctuations in macrophyte richness and diversity were within the variability (standard error) for the samples. There were no detectable changes in algal assemblages prior to and during RP1 testing. Additionally, macrophyte data could not be quantitatively compared to previous studies in Rich Passage because of differences in survey methods[21]. Macrophyte surveys conducted by Golder in 2011 and 2012 involved field identification of macroalgae to the lowest practical taxonomic level allowing for more accurate identification of taxa at each survey site than documented in previous studies.

5.3 Bull Kelp

Bull kelp (*Nereocystis luetkeana*) is considered a Valued Ecosystem Component (VEC) by many organizations including the Puget Sound Nearshore Partnership (PSNP). Bull kelp is known to provide a wide variety of ecological functions in nearshore ecosystems and is critically linked to other VECs including birds, fish, and other marine organisms (Leschine and Peterson 2007). Bull kelp was documented along Point White on Bainbridge Island in multiple surveys between 1852 and 1989, as well as in 1999 (Thom and Hallum 1990; RPWAST 2001). Bull kelp was not observed during 2011 and 2012 field studies and has not been documented in Rich Passage since 2000 (GeoEngineers 2006; Grette 2007). Potential causes for observed changes in bull kelp distribution in Rich Passage are currently unknown (Berry 2013 pers. comm.; Mumford 2013 pers. comm.).

In contrast to patterns observed in the Strait of Juan de Fuca, bull kelp distribution and abundance in Puget Sound has generally displayed a decreasing trend since the 1960s; with the majority of this loss occurring in the 1960s and 1970s (Berry 2013; Mumford 2013). Potential causes for observed changes in bull kelp distribution in Puget Sound are currently unknown. Since the widespread losses are not associated with any particular man-made structure, water quality or changes in herbivore density are likely causes (Mumford 2013).

Mumford (2013) suggests that direct adverse effects on bull kelp communities due to increased wave action by vessel wakes would require wave action sufficient to move the substrate and abrade the young sporophytes found attached to bedrock, boulders or large cobble in the subtidal zone (below tidal influenced water level). Rich Passage private property owners reported the loss of bull kelp beds after the operation of Chinook class vessels from 1998 to 2001. RP1 wakes were measured to be an order of magnitude less than the Chinook Class vessels (Golder 2013) and are likely insufficient to effect sporophytes through sediment transport.

Once bull kelp is removed it may be outcompeted by perennial Laminariales (e.g. *Agarum fimbriatum*) leading to a permanent shift in algal assemblages. Throughout Rich Passage, extensive mature beds of *A. fimbriatum* have been observed (Golder 2012) up to several hundred metres in length and tens of meters in width. These extensive beds may potentially impede the attachment of juvenile bull kelp (sporophytes) on local substrate.

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[21] Macroalgae studies conducted by Parametrix in 2008 used photograph documentation to identify macroalgae taxa and abundance in quadrats. Studies conducted by Golder in 2011 & 2012 identified macroalgae to the lowest practical taxonomic level in the field. If field identification was not possible, taxa were identified from photographs or from field samples. The abundance of macroalgae were also estimated in the field during Golder's 2011 and 2012 investigations.

When coupled with a potential shift in benthic faunal composition, conditions could become limited for the successful re-establishment of bull kelp along the Rich Passage shoreline. Appendix L provides more information on the historical presence of bull kelp in the Puget Sound area and presents possible explanations on recent changes in bull kelp distribution.

5.4 Towed Video Surveys

Towed video surveys were conducted in 2012 to document the occurrence of eelgrass and macroalgae throughout the study area. Stratified depths were selected for the video surveys to maximize detection of both eelgrass and bull kelp. Bull kelp was not identified within Rich Passage during video surveys conducted in October 2011 and May 2012 and given the documented absence of bull kelp in this area, the survey protocol was adjusted in August 2012 to focus on eelgrass presence. To gather a more accurate representation of eelgrass bed locations, the deeper towed video tracks (-3 m/-10 ft and -4.5 m/-15 ft MLLW) were abandoned and the summer 2012 surveys focused on a shallower target depth (-1.5 m/-5 ft MLLW). This change in study design improved the overall confidence in the data, as evidenced in Figures 3 and 4 where several stretches of shoreline were originally depicted as “patchy” eelgrass, but were re-classified as eelgrass beds following the shallower summer 2012 video surveys (Figure 4).

Several eelgrass beds were identified along both shorelines of Rich Passage during previous surveys (Golder 2012; RPWAST 2001; Williams et al. 2004; Woodruff et al. 2001). Eelgrass observed in the fall 2011, spring 2012 and summer 2012 video surveys[22] (Figures 3 and 4), while showing some differences, remained consistent within years and was similar to the distribution mapped by Battelle in the summer of 2000 (Figure 5) (Woodruff et al. 2001). Some differences among seasons were observed in the towed video surveys (Figures 3 and 4) and could be explained by seasonal variability and slight differences in video track location between seasons.

Woodruff et al. (2001) also studied eelgrass within Rich Passage, noting that eelgrass recorded near the Point White and Pleasant Beach on Bainbridge Island in the late 1970s had decreased significantly. The study also noted that this area experienced possible effects from vessel wakes. Similarly, eelgrass declines on the south side of Rich Passage, near Orchard Point and Manchester, were described by Woodruff et al. (2001). Due to the distance from the ferry sailing route and the sheltered shoreline orientation of this location, wake wash was not suspected to be a factor in past observed eelgrass declines in this area. The eelgrass bed area near Fort Ward State Park, on Bainbridge Island was exposed to ferry wake, however any potential effects associated with the ferry wake were predicted to be minor (Coldwater 2012). The overall change in the distribution of eelgrass in Rich Passage between 1979 and 2000 (Woodruff et al. 2001) along with Golder’s visual observations in 2011 and 2012 suggests that this region is highly dynamic and influenced by numerous natural and anthropogenic variability and stressors. These could include, but are not limited to storm events, current and wave action, increased turbidity, erosion and/or deposition of substrate, and increased eutrophication caused by upland development (Thom and Hallum 1990).

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[22] Limits to underwater towed videography include: water clarity, tow speed, the ability to maintain visual acuity, current, camera angle, position logging, and operation in shallow water.

5.5 Eelgrass Monitoring

Eelgrass (*Zostera marina*) is recognized globally as a valuable ecosystem component that provides many ecosystem services including nearshore habitat to ecologically and economically important species. *Z. marina* is considered a valuable indicator of ecosystem health because it responds quickly to anthropogenic stressors (Thom et al. 2003). In Puget Sound, eelgrass shoot densities are typically greatest at water depths between about +0.5 and −1.0 m MLLW (Thom et al. 2008). The preferred substrate for eelgrass is sand or a sand/silt combination (Woodruff et al. 2001).

Seagrass beds, including eelgrass, can be affected by many anthropogenic activities including vessel wake. The most common effects from vessel wake include increased suspended sediments, release of nutrients stored in sediments, and reduced light levels associated with elevated turbidity. These stresses are considered minimal when compared to natural fluctuations observed in seagrass habitats (Koch 2002). A study by Koch (2002) showed the greatest effect from the vessel-generated wakes was observed at low tide when sediments were re-suspended, then promptly re-deposited. Vessel operations at high tide reduce sediment re-suspension and minimize the effects of vessel-generated wakes on seagrass habitats. Additionally, at lower tides, vessel-generated waves can change the flow of pore water though eelgrass bed sediments, increasing the concentration of ammonia in the water column and negatively effecting seagrass beds over the long term. Turbidity data collected in 2012 from a monitoring station deployed in the Fort Ward eelgrass bed indicated that tide cycle and natural variables within the passage had greater influence on turbidity than the wake wash from RP1 operations at this location (Figures 17 and 18).

The two eelgrass monitoring sites within Rich Passage (Figures 3, 4, and 5) showed little to no change in bed size (m^2) between pre-vessel *in-situ* testing and measurements taken during RP1 operations. However, eelgrass survey results showed an increase in mean bed density at both Point Glover and Fort Ward, from 22.93 shoots/0.25 m^2 to 24.79 shoots/0.25 m^2 and 19.86 shoots/m^2 to 41.07 shoots/m^2. This increase in mean bed density is most likely related to seasonal growth and new plant establishment from rhizomes between the May and August surveys; however, shoreward quadrats for both sites exhibited increased shoot densities during the summer surveys (Appendix J). Furthermore, the increased shoot density at both sites in August is within regular seasonal biomass increases for *Z. marina* in settings where total photosynthetic radiation (sunlight) controls plant production (Sand-Jensen 1975).

Several eelgrass beds have been documented along both shorelines of Rich Passage (Golder 2012; RPWAST 2001; Williams et al. 2004; Woodruff et al. 2001). An eelgrass reconnaissance was conducted in May 2012 using towed video, diver and snorkel surveys at several locations to identify potential eelgrass reference sites; however a suitable reference eelgrass bed could not be identified during these surveys (Figure 6).

When comparing the eelgrass monitoring sites to sites surveyed by Woodruff et al. (2001) in August 2000 (Figures 3 and 4), "site 5" (the Point Glover eelgrass bed in this report) was similar in shape and size but the location shifted slightly southward (closer to shore). This may be a function of the different survey methods used in Woodruff et al. (2001)[23]. In Woodruff et al. (2001), the results for "site 3" (the Fort Ward eelgrass monitoring

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[23] The August 2000 the surveys conducted by Woodruff et al. (2001) were completed aerially and supplemented with boat observations and dive data.

site in this report) displayed some patchiness at the upper edge (the nearshore margin of the bed) and eelgrass was considered to be in poor to fair condition[24] at the upper edge and in relatively good condition at the lower limit (the offshore extent of the bed). In 2012, quadrats sampled by Golder at the upper edge of the Fort Ward eelgrass bed showed dense eelgrass cover and significant increases in shoot density at the upper edge during summer surveys (Appendix J). Additionally, the bed appears to have expanded to the southeast when compared to August 2000 surveys by Woodruff et al. (2001). Eelgrass observed in the fall 2011, spring 2012 and summer 2012 video surveys (Figures 3 and 4) remained relatively consistent and the distribution of eelgrass in Rich Passage during 2011 and 2012 surveys which were similar to the distribution mapped by Woodruff et al. (2001) in 2000 (Figure 5). The Woodruff et al. (2001) survey was not intended to be a comprehensive and high resolution mapping effort of eelgrass, but rather a survey to assess the general location of eelgrass beds and the health and condition of the selected beds. The level of potential error with relation to the accuracy of the eelgrass bed location is difficult to quantify.

5.6 Benthic Infauna and Epifauna

Benthic infauna data from spring and summer 2012 indicated some variability between sites and over seasons at three sites; however the majority of the samples showed little change over the sample period. Exceptions were locations 9B, 9D and 1B (see NMDS in Figure 15). Sample locations 9B and 9D indicated a shift in community composition between the sampling events related specifically to abundance of four crustacean species *(Leptochelia savignyi, Cumella vulgaris, Euphilomedes carcharondonta* and *Gnorimosphaeroma oregonense*). In contrast, Site 1B indicated a change between June and August in the abundance of five polychaete species (*Notomastus hemipodus, Dorvillea rudolphi, Podarke pugettensis*, *Nereis procera* and *Leitoscoloplos pugettensis*) and a mollusc (*Monocorophium acherusicum)*[25]. Shifts in infauna community composition at sites 9B, 9D and 1B were not mirrored in transect/quadrat data for epibenthic fauna.

Several factors are known to affect infauna and epifauna in nearshore ecosystems including, grain size composition, tidal elevation and sample timing (Williams and Thom 2001b; Weiser 1959). Studies by Weiser (1959) found that grain size composition had known implications on infaunal community structure. On Puget Sound beaches, grain size composition depends on exposure and energy regime. In general, upper elevations show coarser grade sediments and lower elevation in the intertidal zone have finer grades. Sediments with a median diameter of 200 µm constitute a barrier for a number of burrowing animals. For mechanical reasons, the grain size, shape and the type of burrowing species are known to influence the distribution of fauna. Furthermore, average infauna densities are higher at lower elevations and within fine, sandy substrates.

Williams and Thom (2001b) found that the density and diversity of epibenthic organisms was influenced by substrate composition, tidal elevation and sample timing. In addition, the presence of mobile sediment in

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[24] Woodruff et al. (2001) characterized the health of plants into three categories (poor, fair, good). An assessment of “good” indicated one or more of the following: no evidence of eroded sediment, sediment deposition, or exposed rhizomes; coverage of eelgrass was generally moderate to dense; and there was little evidence of additional macroalgae (Ulvoids) in the bed. An assessment of “fair” indicated occasional evidence of sediment erosion or deposition, partially exposed rhizomes; eelgrass coverage was moderate and/or patchy; occasional macroalgae. An assessment of “poor” indicated evidence of scouring, erosion or deposition of sediment, exposed rhizomes; extensive macroalgae (especially Ulvoids); and coverage of eelgrass was sparse and/or patchy.

[25] Due to the patchy nature of benthic communities and the limited sample size of the 2012 sampling efforts, samples cannot be inferred to represent the entire infaunal community for each site; the samples were collected from MLLW and represent communities at this tidal elevation during a specific sampling event.

nearshore ecosystems can lead to mortality or shell damage in stationary species (Shanks & Wright 1986). Shanks and Wright (1986) reported a significant relationship between the frequency of shell damage during seasonal periods of high surf and the faunal makeup of the community, as the rock damage contributes to the physical ‘boundaries” of the environment within which the inhabitants must survive.

Although the 2012 transects originated at the same location and were targeted to terminate at the same location as previous sampling events, slight differences in orientation, especially at site locations with bedrock reefs (10B and 9D), may have had large influences on species observed based on microfeatures within the sites. The variability of species assemblages between seasons is likely due to differences in shoreline energy, grain size, and tidal elevation. Changes in benthic infauna and epifauna are not directly attributed to RP1 testing.

6.0 SUMMARY AND RECOMMENDATIONS

This report documents the findings of nearshore biophysical monitoring conducted by Golder in 2012 as part of the Rich Passage Wave Evaluation Study. Data presented in this report supplements work initiated in 2004 to assess the inter-annual changes in the biophysical shoreline characteristics of Rich Passage. The following inferences and recommendations can be drawn from this study:

- Predominant substrates observed at the study sites included silt/sand, gravel, cobble, boulder, bedrock and hard clay. The transition of substrate types along transects differed between sites.
- There were minimal changes in substrate types in spring and summer, prior to and during RP1 testing. In summer, there was a slight increase in fine sand observed at seven of the eight sites. The accretion of fine sands between spring and summer is likely a function of wind-wave energy in the area.
- Macroalgae was documented at all of the study sites, including green algae (predominantly *Ulva* sp.), brown algae (e.g., rockweed, *Laminaria* spp., *Agarum* sp. and wireweed) and red algae (most commonly *Gracilaria* sp. and Turkish towel).
- No bull kelp (*Nereocystis luetkeana*) was observed in Rich Passage or surrounding study sites during 2011 and 2012 field surveys (Appendix L). Extensive mature beds of *A. fimbriatum* were observed and may out compete bull kelp by impeding the attachment of juvenile bull kelp (sporophytes) on local substrate.
- Two eelgrass monitoring sites (Point Glover and Fort Ward) were identified and surveyed in 2012. The size and distribution of eelgrass beds surveyed at Point Glover and Fort Ward showed little to no change between spring and summer. Eelgrass bed density at Point Glover and Fort Ward was shown to increase in August, likely related to normal seasonal growth.
- Eelgrass is considered a good indicator for environmental change because it responds quickly to anthropogenic stressors (Thom et al. 2003). Therefore, continued monitoring of eelgrass surveys at Fort Ward and Point Glover is recommended in 2013 with increased effort focused on shoreward portions of the beds where direct effects from wakes would be more apparent.
- At the conclusion of the 2012 biological field survey, there were no detectable changes in algal species assemblages prior to and during RP1 testing. Due to the complexity and dynamic nature of the algal community within Rich Passage, macroalgae are not considered a good independent indicator to detect changes associated with wake effects in this area.
- A shift in infaunal species assemblages was observed between June and August 2012 at sites 9B, 9D and 1B. No similar trends were observed for epibenthic species assemblages. The variability of species assemblages between seasons is likely due to differences in shoreline energy, grain size, and tidal elevation. Additional data collection is required to clearly determine the seasonal variability of infaunal species assemblages in Rich Passage.
- Annual infaunal surveys are recommended at all survey sites for at least two additional years to establish a baseline understanding of the interannual variability in infauna assemblages. Increasing the number of sample locations along each transect from one elevation (0 MLLW) to at least two elevations (0 and 1.5 m MLLW) along the northern and southern Rich Passage shorelines, specifically at areas considered to be

more exposed to wake wash (Point White and Point Glover), would assist in determining spatial variability in infaunal communities.

- Epibenthic data collected during quadrat sampling indicates that taxonomic richness and species diversity of marine fauna and macrophytes decreased at Site 10B during August 2012, compared to May 2012 data. Observed changes in epibenthic fauna may reflect seasonal variability at this specific site. Data collection for at least three consecutive years (2012 through 2014) is required to confirm this hypothesis and provide a baseline understanding in changes in epibenthic organisms at survey sites.
- Though results from the 2011 and 2012 biophysical sampling indicate changes in biological assemblages between all sampling sites and sampling periods, there were no systematic changes in biological communities at study sites when exposed to wake wash from RP1. Golder recommends continuation of data collection in August 2013 and 2014 to provide a three year time-series and more comprehensive data set for addressing the objectives of this study.
- Golder recommends biological surveys in 2013 and 2014 include transect/quadrat sampling at all study sites, eelgrass monitoring at Point Glover and Fort Ward, as well as eelgrass reconnaissance in the bay west of the Point Glover eelgrass site. Sampling is recommended in August of 2013 to provide an enhanced understanding of annual variability occurring at the study sites during the time of highest annual productivity. We further recommend an increased sampling effort for eelgrass monitoring at Point Glover and Fort Ward.

7.0 LIMITATIONS

This report has been prepared by Golder, on behalf of Kitsap Transit. The findings documented in this report have been prepared for discussion with regulatory agencies and have been developed in a manner consistent with that level of care normally exercised by environmental professionals currently practising under similar conditions. Golder makes no other warranty, expressed or implied. This report is intended for the sole and exclusive use of Kitsap Transit. Any use, reliance on, or decision made by any person other than Kitsap Transit based on this report is the sole responsibility of such other person. Golder makes no representation or warranty to any other person with regard to this report and the work referred to in this report and they accept no duty of care to any other person or any liability or responsibility whatsoever for any losses, expenses, damages, fines, penalties or other harm that may be suffered or incurred by any other person as a result of the use of, reliance on, any decision made, or any action taken based on this report or the work referred to in this report.

The investigation undertaken by Golder with respect to this report and any conclusions or recommendations made in this report reflect Golder's judgement based on the site conditions observed at the time of the site inspection on the dates set out in this report and on information available at the time of preparation of this report. This report has been prepared for specific application to this site; and, is based upon visual observation of the site during a specific time interval, all as described in this report. Unless otherwise stated, the findings cannot be extended to previous or future site conditions, or areas that were not investigated directly. Conditions different than those reported may exist in areas other than the locations investigated.

If site conditions or applicable standards change or if any additional information becomes available at a future date, modifications to the findings, conclusions and recommendations in this report may be necessary. Other than by Kitsap Transit copying or distribution of this report or use of or reliance on the information contained herein, in whole or in part, is not permitted without the express written permission of Golder. Nothing in this report is intended to constitute or provide a legal opinion.

8.0 CLOSURE

This report documents the findings of nearshore field surveys conducted by Golder in the Rich Passage area, and includes a review of other studies relevant to the biophysical conditions in the area. Should you have any questions or concerns, please do not hesitate to contact Michelle Spani or Andrew Rippington at 250-881-7372.

Report Signature Page

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061015jc_2012_marine_biophysical_richpassage_report.docx

FIGURES

LEGEND

🟨 Figure 2 Extents

🟥 Figure 3 & 4 Extents

🟧 Figure 6 Extents

– – Approximate Location of POFF Bremerton-Seattle Route

0 5 10

SCALE 1:150,000

KILOMETERS

REFERENCE

Base Map data provided by ESRI and USGS
DATUM: NAD83 PROJECTION: UTM ZONE 10

PROJECT

RICH PASSAGE POFF STUDY
WASHINGTON, U.S.A

TITLE

SITE LOCATIONS

Golder Associates

PROJECT 113-93490-200-220			FILE No.
DESIGN	MS	10DEC2011	SCALE AS SHOWN REV. 0
GIS	DH	16JUL2013	FIGURE: 1
CHECK	DM	27Nov2013	
REVIEW	AR	27Nov2013	

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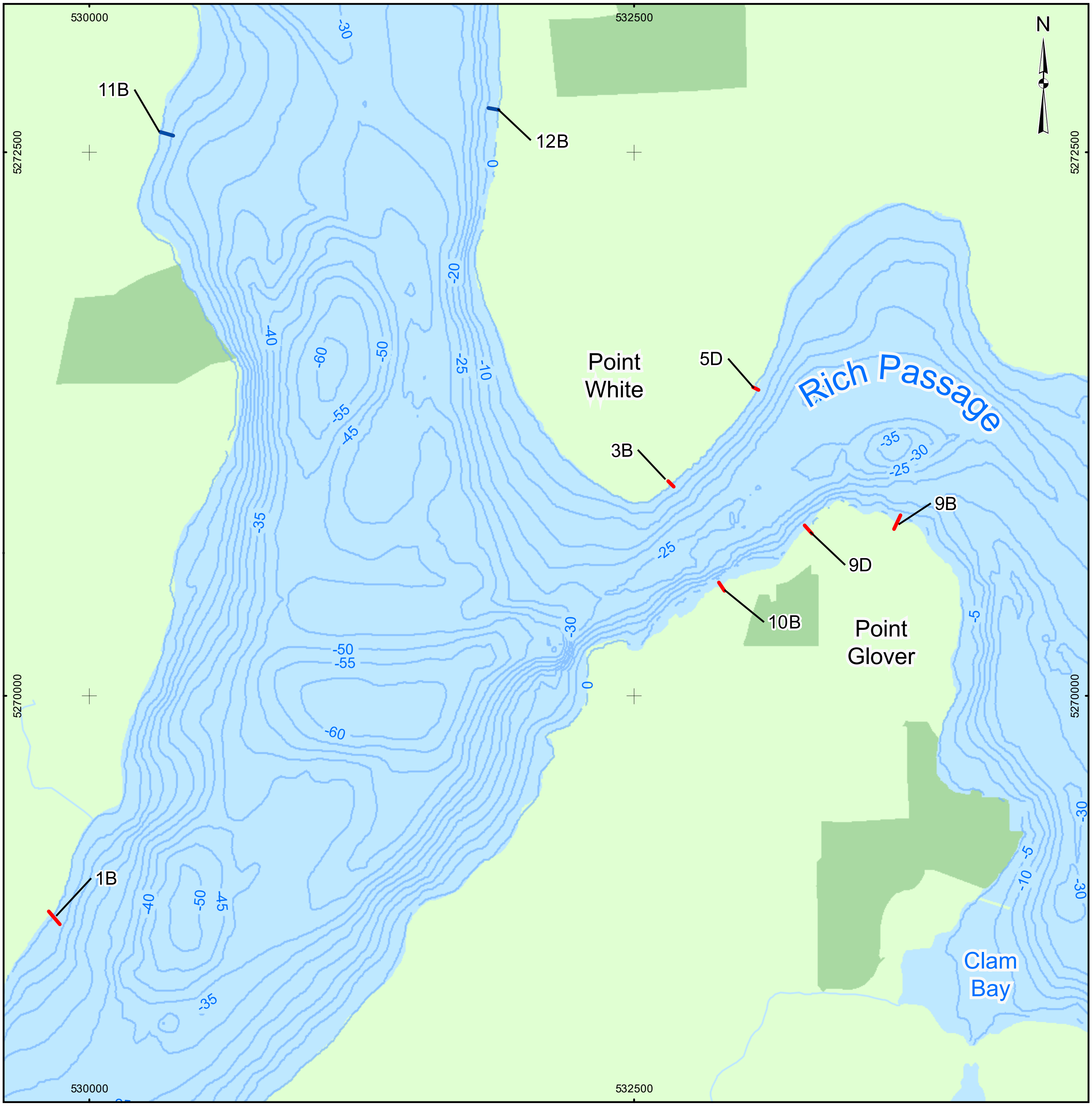

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SCALE 1:25,000 KILOMETERS

LEGEND

- ▬ POFF Reference Site
- ▬ POFF Study Site
- ─ 5m. Contour

REFERENCE

Base Map data provided by ESRI, USGS, and Washington State DNR
Bathymetric data provided by NOAA (1982)
DATUM: NAD83 PROJECTION: UTM ZONE 10

PROJECT

RICH PASSAGE POFF STUDY
WASHINGTON, U.S.A

TITLE

BIOPHYSICAL TRANSECT SURVEY LOCATIONS

Golder Associates
Victoria, BC

PROJECT 113-93490-200-220			FILE No.	
DESIGN	MS	10DEC2011	SCALE AS SHOWN	REV. 0
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REVIEW	DM	27NOV2013		

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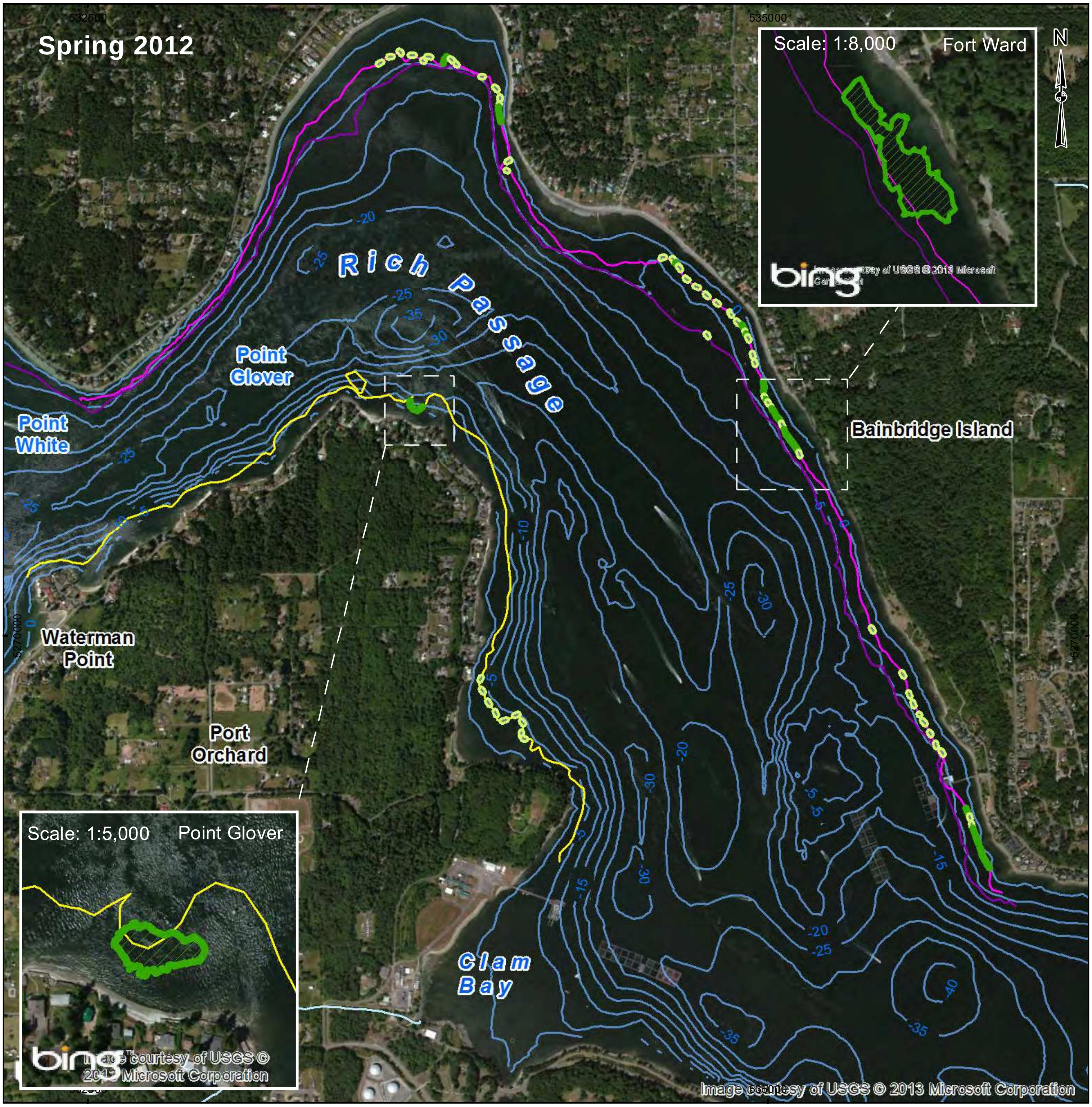

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SCALE 1:20,000

KILOMETERS

LEGEND

Towed Video Track
- Track PrtO B-10
- Track PtW B-5
- Track PtW B-15

Observations
- Eelgrass Bed
- Patchy Eelgrass

- 5m. Contour

Notes: B-5 = 1.5m/ 5ft, B-10 = 3m/ 10ft, B-15 = 4.5m/ 15ft

REFERENCE

Base Map data provided by ESRI, USGS, and Washington State DNR
Bathymetric data provided by NOAA (1982)
DATUM: NAD83 PROJECTION: UTM ZONE 10

PROJECT

RICH PASSAGE POFF STUDY
WASHINGTON, U.S.A

TITLE

EELGRASS BEDS OBSERVED DURING TOWED VIDEO SURVEYS

Golder Associates
Victoria, BC

PROJECT 113-93490-200-220			FILE No.	
DESIGN	MS	10DEC2011	SCALE AS SHOWN	REV. 0
GIS	DH	24JAN2013		
CHECK	AR	27AUG2013	FIGURE: 3	
REVIEW	PR	27AUG2013		

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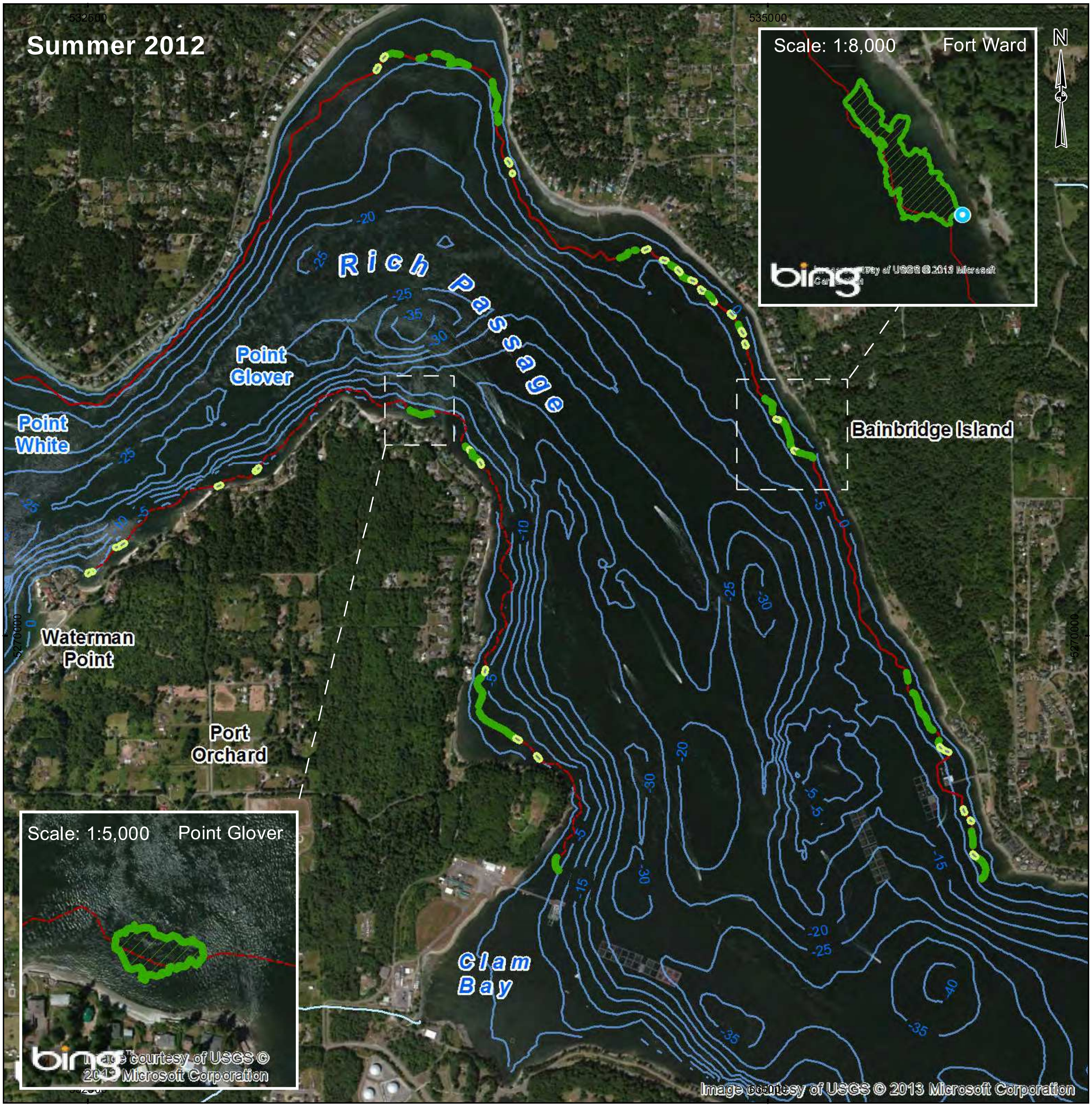

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LEGEND

Towed Video Track	Observations	
— Track PtW B-5	Eelgrass Bed	5m. Contour
--- Track PrtO B-5	Patchy Eelgrass	○ Turbidity and Wave Data Sensor

Notes: B-5 = 1.5m/ 5ft

REFERENCE

Base Map data provided by ESRI, USGS, and Washington State DNR
Bathymetric data provided by NOAA (1982)
DATUM: NAD83 PROJECTION: UTM ZONE 10

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SCALE 1:20,000 KILOMETERS

PROJECT

RICH PASSAGE POFF STUDY
WASHINGTON, U.S.A

TITLE

EELGRASS BEDS OBSERVED DURING TOWED VIDEO SURVEYS

Golder Associates
Victoria, BC

PROJECT 113-93490-200-220			FILE No.	
DESIGN	MS	10DEC2011	SCALE AS SHOWN	REV. 0
GIS	DH	24JAN2013	**FIGURE: 4**	
CHECK	AR	26AUG2013		
REVIEW	PR	26AUG2013		

LEGEND

- — Eelgrass Bed - Summer 2012
- — Eelgrass Bed - Spring 2012
- - - Transect - Spring 2012
- - - Transect - Summer 2012
- ▭ Batelle Dive Site*

REFERENCE

Imagery obtained from BING maps for ARCGIS published by Microsoft corporation and its data suppliers.
*Woodruff, D.L., Borde, A.B., Southard, J.A., Williams, G.D., Thom, R.M. 2001. Assessment of Eelgrass (Zostera marina) Presence and Condition in Rich Passage during Summer 2000. Prepared for the Washington State Department of Transportation, Olympia, Washington by Battelle Marine Sciences Laboratory, Sequim, WA. PNWD-3012. April 2001.
DATUM: NAD83 PROJECTION: UTM ZONE 10

PROJECT

RICH PASSAGE POFF STUDY
WASHINGTON, U.S.A

TITLE

PERIMETER AND DIVE TRANSECT LOCATIONS
FOR EELGRASS MONITORING SITES AT
FORT WARD AND POINT GLOVER

Golder Associates
Victoria, BC

PROJECT 113-93490-200-220			FILE No.	
DESIGN	MS	10DEC2011	SCALE AS SHOWN	REV. 0
GIS	DH	24JAN2013	FIGURE: 5	
CHECK	AR	27NOV2013		
REVIEW	DM	27NOV2013		

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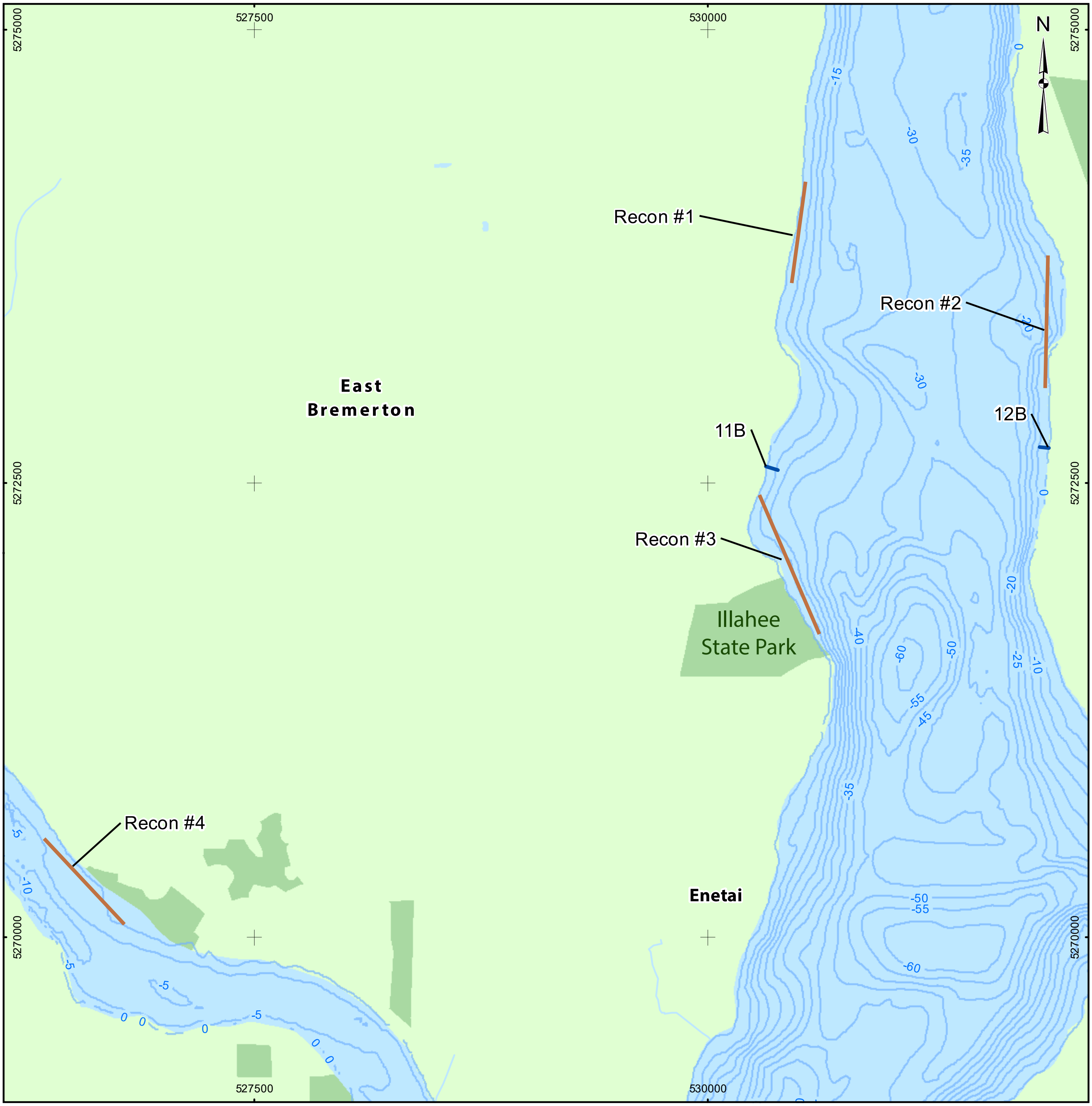

LEGEND

🟫	Reconnaissance Transect
🟦	POFF Reference Site
—	5m. Contour
—	Rivers
🟩	Parks

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SCALE 1:30,000 KILOMETERS

REFERENCE

Base Map data provided by ESRI, USGS, and Washington State DNR
Bathymetric data provided by NOAA (1982)
DATUM: NAD83 PROJECTION: UTM ZONE 10

PROJECT

RICH PASSAGE POFF STUDY
WASHINGTON, U.S.A

TITLE

BIOPHYSICAL
RECONNAISSANCE TRANSECT

Golder Associates
Victoria, BC

PROJECT 113-93490-200-220			FILE No.
DESIGN	MS	10DEC2011	SCALE AS SHOWN REV. 0
GIS	DH	24JAN2013	**FIGURE: 6**
CHECK	AR	27NOV2013	
REVIEW	DM	27NOV2013	

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APPENDIX A

Rich Passage Tide Tables

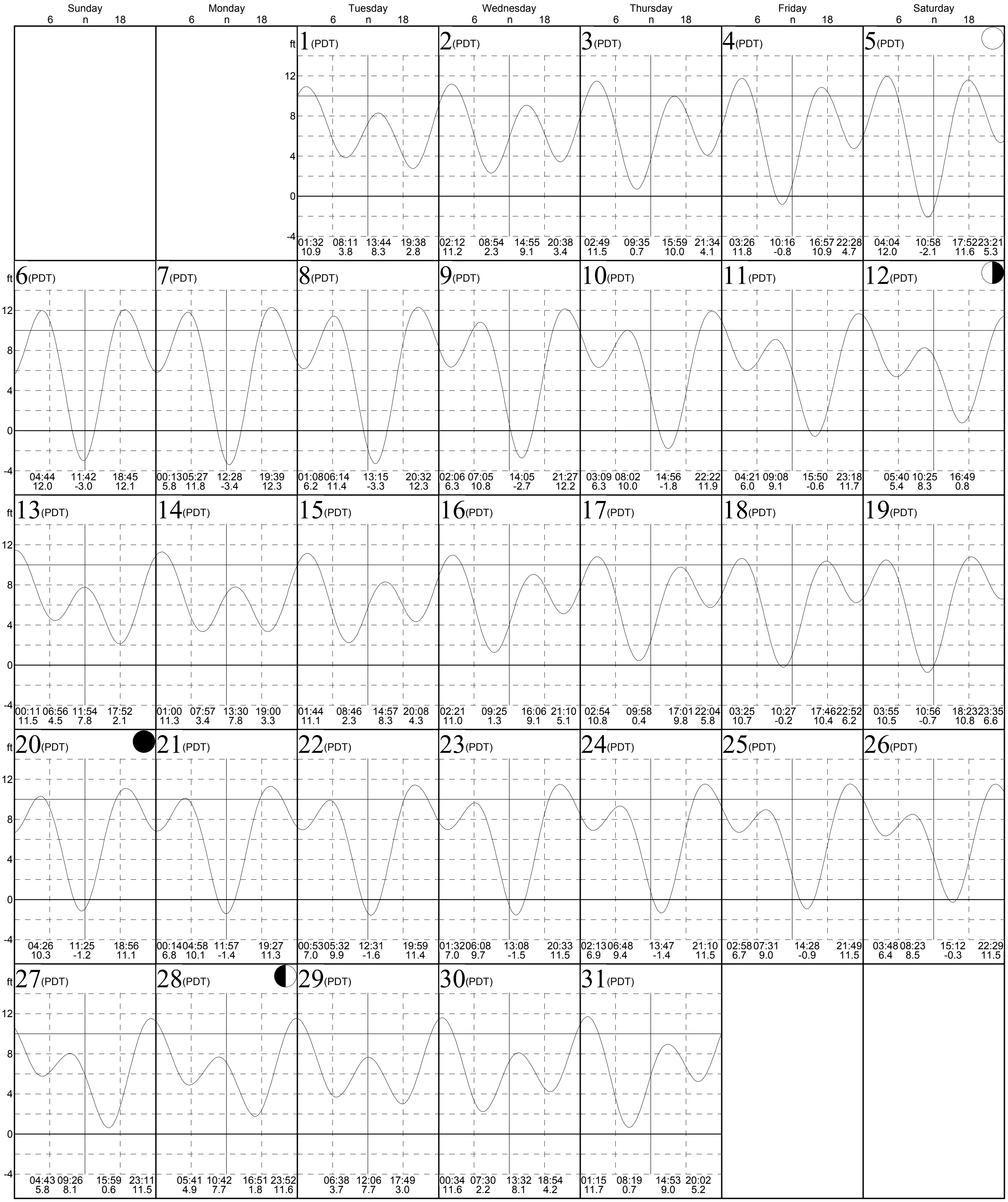
Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides
Mean Range: 7.8 ft
MHHW: 11.5 ft
Mean Tide: 6.7 ft

May 2012

Monthly High & Low
High May 8, 20:3212.3 ft
Low May 7, 12:28 -3.4 ft



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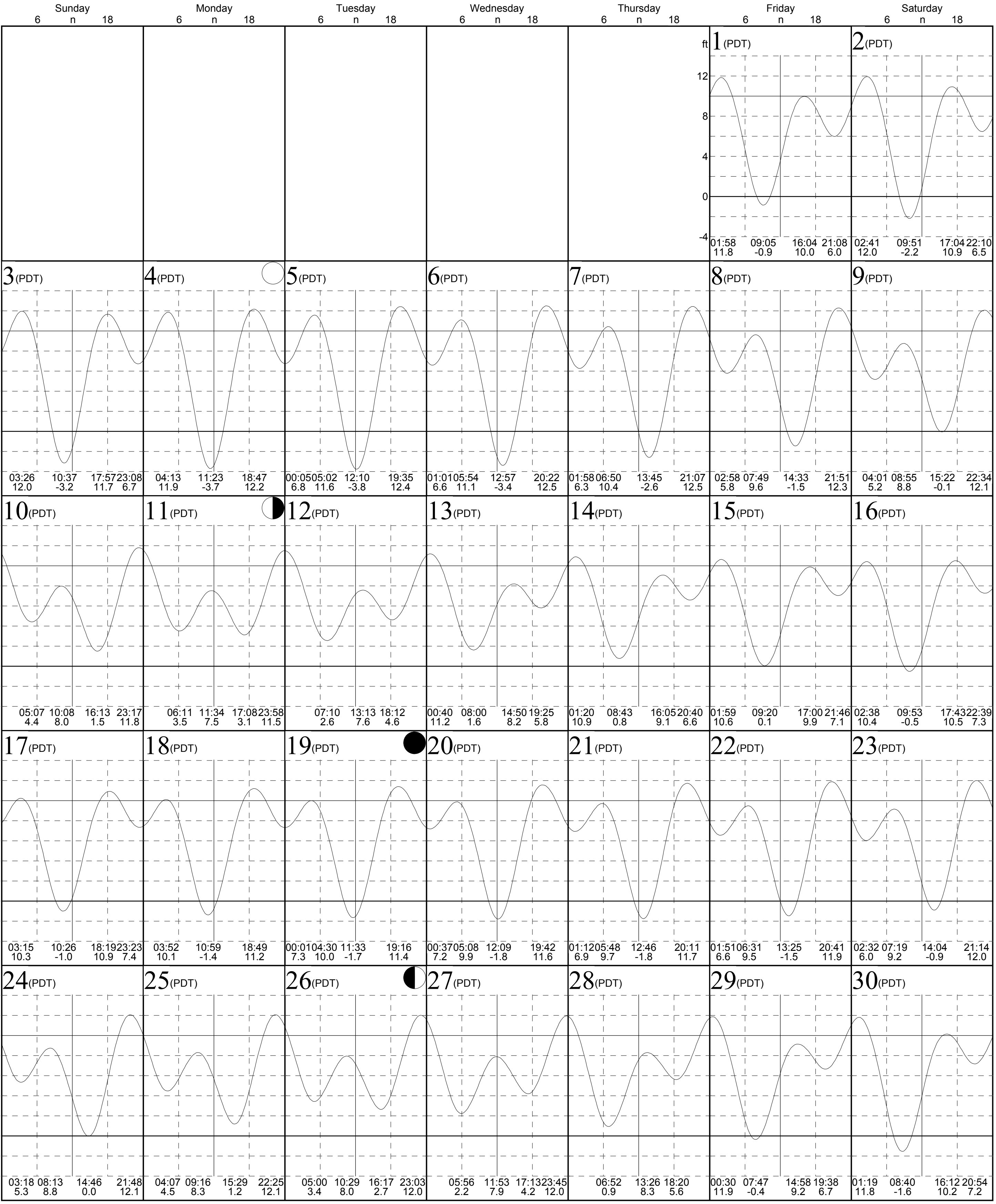
Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides
Mean Range: 7.8 ft
MHHW: 11.5 ft
Mean Tide: 6.7 ft

June 2012

Monthly High & Low
High June 6, 20:2212.5 ft
Low June 5, 12:10 -3.8 ft



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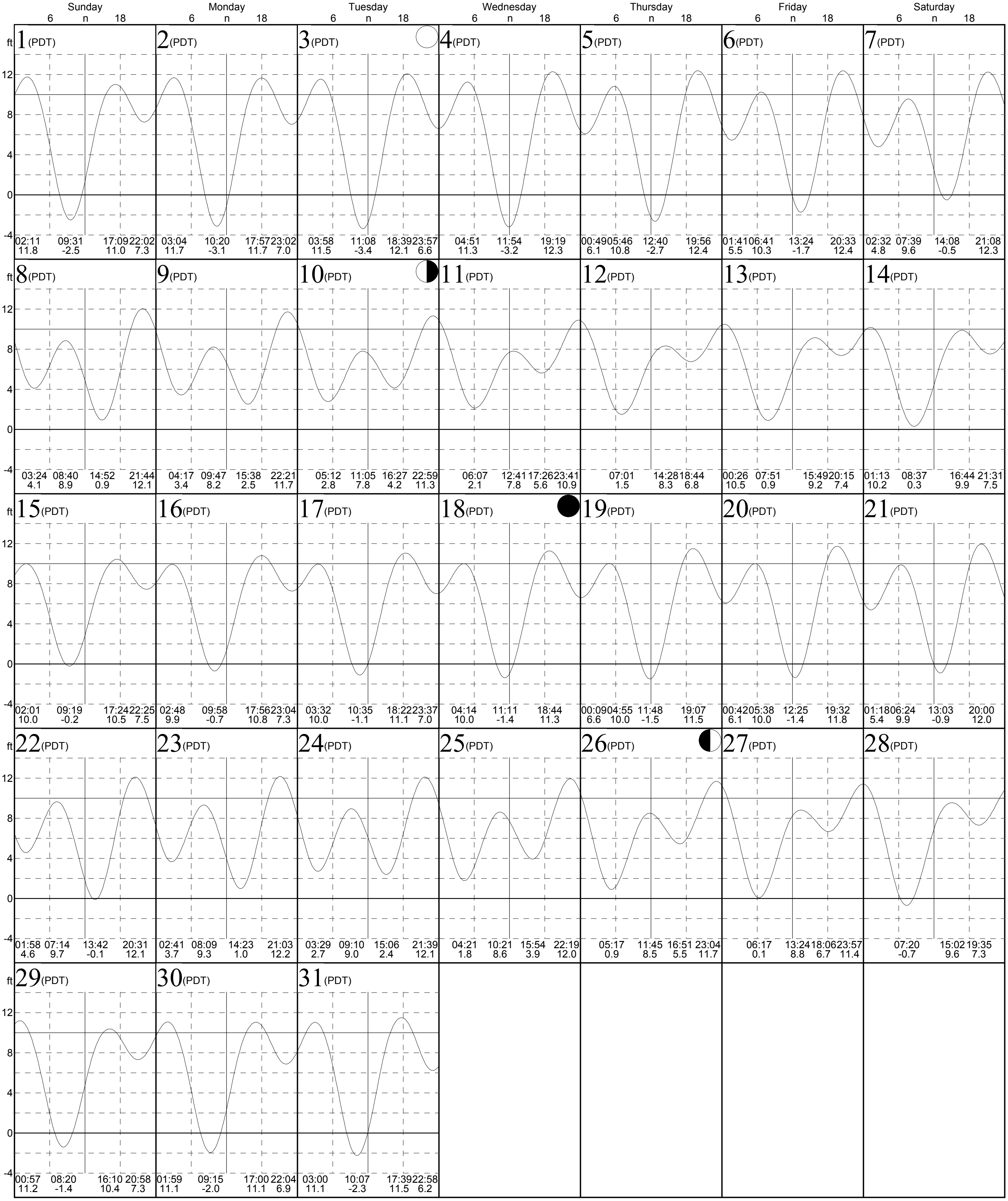
Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides
Mean Range: 7.8 ft
MHHW: 11.5 ft
Mean Tide: 6.7 ft

Monthly High & Low
High July 5, 19:5612.4 ft
Low July 3, 11:08 -3.4 ft

July 2012



Day				
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2 (PDT)	03:04 11.7	10:20 -3.1	17:57 11.7	23:02 7.0
3 (PDT)	03:58 11.5	11:08 -3.4	18:39 12.1	23:57 6.6
4 (PDT)	04:51 11.3	11:54 -3.2	19:19 12.3	
5 (PDT)	00:49 6.1	05:46 10.8	12:40 -2.7	19:56 12.4
6 (PDT)	01:41 5.5	06:41 10.3	13:24 -1.7	20:33 12.4
7 (PDT)	02:32 4.8	07:39 9.6	14:08 -0.5	21:08 12.3
8 (PDT)	03:24 4.1	08:40 8.9	14:52 0.9	21:44 12.1
9 (PDT)	04:17 3.4	09:47 8.2	15:38 2.5	22:21 11.7
10 (PDT)	05:12 2.8	11:05 7.8	16:27 4.2	22:59 11.3
11 (PDT)	06:07 2.1	12:41 7.8	17:26 5.6	23:41 10.9
12 (PDT)	07:01 1.5	14:28 8.3	18:44 6.8	
13 (PDT)	00:26 10.5	07:51 0.9	15:49 9.2	20:15 7.4
14 (PDT)	01:13 10.2	08:37 0.3	16:44 9.9	21:31 7.5
15 (PDT)	02:01 10.0	09:19 -0.2	17:24 10.5	22:25 7.5
16 (PDT)	02:48 9.9	09:58 -0.7	17:56 10.8	23:04 7.3
17 (PDT)	03:32 10.0	10:35 -1.1	18:22 11.1	23:37 7.0
18 (PDT)	04:14 10.0	11:11 -1.4	18:44 11.3	
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20 (PDT)	00:42 6.1	05:38 10.0	12:25 -1.4	19:32 11.8
21 (PDT)	01:18 5.4	06:24 9.9	13:03 -0.9	20:00 12.0
22 (PDT)	01:58 4.6	07:14 9.7	13:42 -0.1	20:31 12.1
23 (PDT)	02:41 3.7	08:09 9.3	14:23 1.0	21:03 12.2
24 (PDT)	03:29 2.7	09:10 9.0	15:06 2.4	21:39 12.1
25 (PDT)	04:21 1.8	10:21 8.6	15:54 3.9	22:19 12.0
26 (PDT)	05:17 0.9	11:45 8.5	16:51 5.5	23:04 11.7
27 (PDT)	06:17 0.1	13:24 8.8	18:06 6.7	23:57 11.4
28 (PDT)	07:20 -0.7	15:02 9.6	19:35 7.3	
29 (PDT)	00:57 11.2	08:20 -1.4	16:10 10.4	20:58 7.3
30 (PDT)	01:59 11.1	09:15 -2.0	17:00 11.1	22:04 6.9
31 (PDT)	03:00 11.1	10:07 -2.3	17:39 11.5	22:58 6.2

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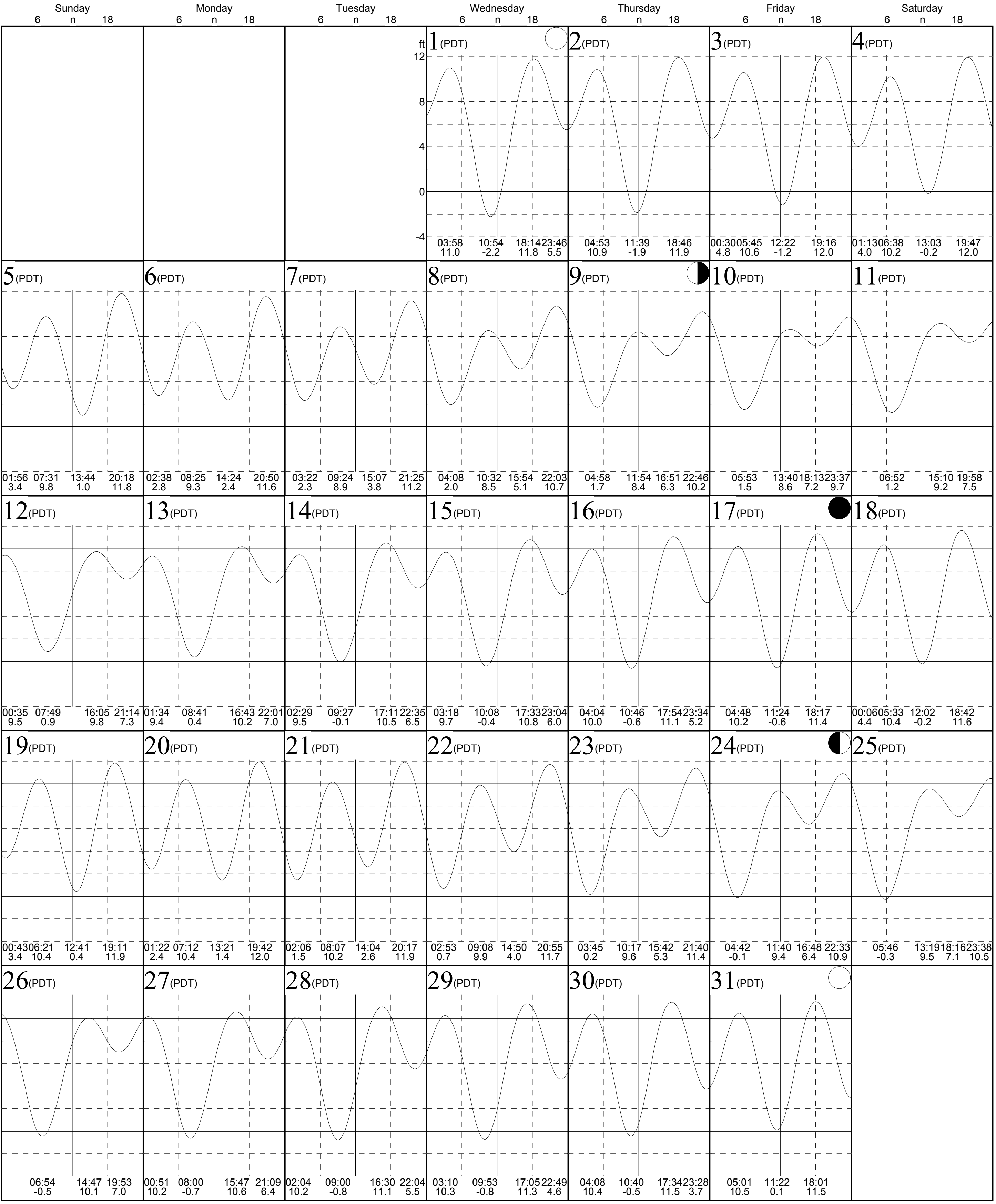
Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides	
Mean Range:	7.8 ft
MHHW:	11.5 ft
Mean Tide:	6.7 ft

August 2012

Monthly High & Low
High August 3, 19:1612.0 ft
Low August 1, 10:54 -2.2 ft



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Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides	
Mean Range:	7.8 ft
MHHW:	11.5 ft
Mean Tide:	6.7 ft

September 2012

Monthly High & Low
High September 18, 18:5411.8 ft
Low September 20, 02:22 -1.2 ft

Date	Time	ft	Time	ft	Time	ft	Time	ft
1 (PDT)	00:05	2.9	05:50	10.5	12:03	0.9	18:27	11.5
2 (PDT)	00:41	2.2	06:37	10.4	12:42	1.9	18:54	11.4
3 (PDT)	01:16	1.7	07:24	10.2	13:21	2.9	19:23	11.2
4 (PDT)	01:52	1.3	08:12	10.0	14:01	4.0	19:55	10.8
5 (PDT)	02:30	1.0	09:03	9.8	14:43	5.0	20:30	10.4
6 (PDT)	03:12	1.0	10:00	9.5	15:31	6.0	21:09	9.9
7 (PDT)	03:58	1.1	11:07	9.3	16:30	6.7	21:54	9.3
8 (PDT)	04:51	1.3	12:30	9.2	17:56	7.2	22:52	8.9
9 (PDT)	05:51	1.4	13:58	9.4	19:42	7.1		
10 (PDT)	00:00	8.6	06:55	1.4	14:59	9.7	20:49	6.7
11 (PDT)	01:09	8.6	07:56	1.1	15:38	10.1	21:28	6.0
12 (PDT)	02:12	8.9	08:48	0.9	16:06	10.4	21:58	5.3
13 (PDT)	03:06	9.4	09:35	0.7	16:30	10.7	22:27	4.3
14 (PDT)	03:55	9.9	10:17	0.8	16:53	11.1	22:58	3.2
15 (PDT)	04:43	10.4	10:57	1.1	17:19	11.4	23:32	2.1
16 (PDT)	05:31	10.8	11:38	1.6	17:48	11.6		
17 (PDT)	00:09	0.9	06:20	11.1	12:20	2.4	18:19	11.8
18 (PDT)	00:50	-0.1	07:12	11.2	13:03	3.4	18:54	11.8
19 (PDT)	01:34	-0.8	08:07	11.1	13:50	4.4	19:33	11.6
20 (PDT)	02:22	-1.2	09:07	10.9	14:42	5.4	20:16	11.2
21 (PDT)	03:14	-1.1	10:15	10.6	15:43	6.3	21:08	10.6
22 (PDT)	04:12	-0.8	11:33	10.4	17:01	6.8	22:12	9.9
23 (PDT)	05:17	-0.3	12:58	10.4	18:38	6.7	23:31	9.4
24 (PDT)	06:27	0.2	14:11	10.6	20:06	5.9		
25 (PDT)	00:57	9.1	07:38	0.5	15:05	10.9	21:07	4.8
26 (PDT)	02:17	9.3	08:41	0.9	15:46	11.1	21:53	3.7
27 (PDT)	03:26	9.7	09:35	1.3	16:18	11.3	22:32	2.7
28 (PDT)	04:23	10.0	10:23	1.8	16:45	11.3	23:06	1.8
29 (PDT)	05:13	10.4	11:05	2.5	17:10	11.2	23:37	1.1
30 (PDT)	05:58	10.6	11:45	3.3	17:35	11.1		

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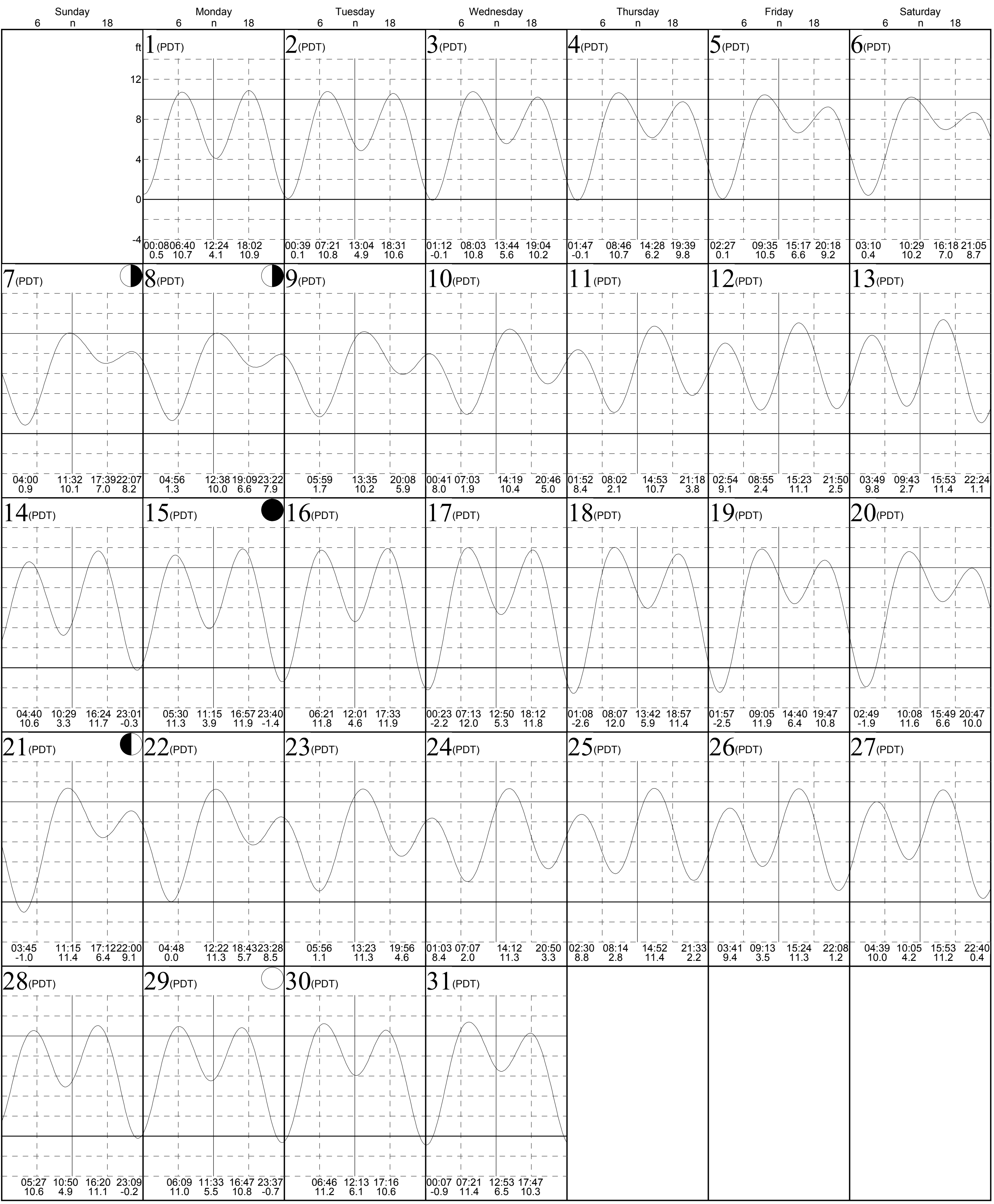
Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides
Mean Range: 7.8 ft
MHHW: 11.5 ft
Mean Tide: 6.7 ft

October 2012

Monthly High & Low
High October 18, 08:0712.0 ft
Low October 18, 01:08 -2.6 ft



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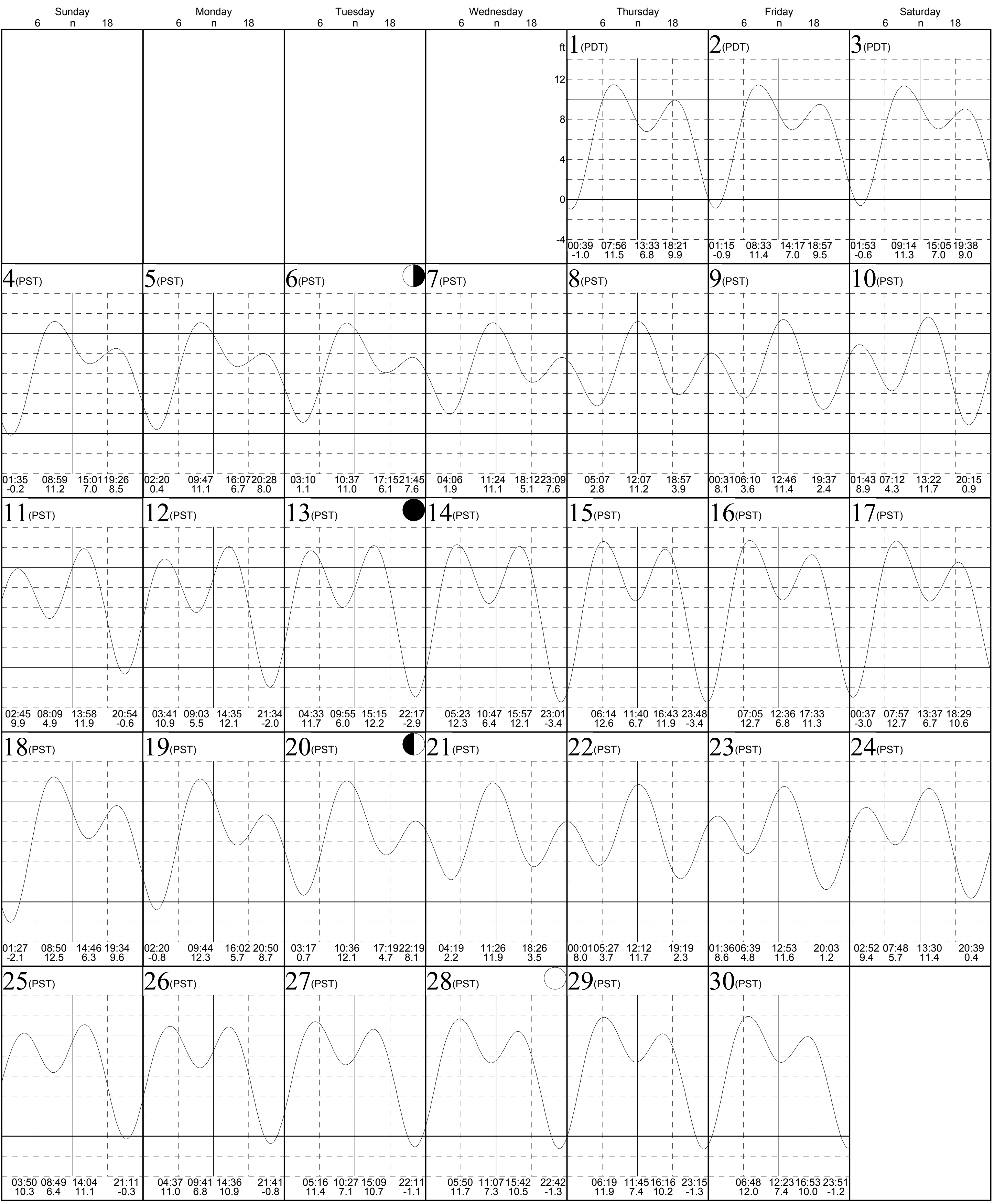
Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides
Mean Range: 7.8 ft
MHHW: 11.5 ft
Mean Tide: 6.7 ft

Monthly High & Low
High November 16, 07:0512.7 ft
Low November 15, 23:48 -3.4 ft

November 2012



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3	(PDT)	01:53 -0.6	09:14 11.3	15:05 7.0	19:38 9.0
4	(PST)	01:35 -0.2	08:59 11.2	15:01 7.0	19:26 8.5
5	(PST)	02:20 0.4	09:47 11.1	16:07 6.7	20:28 8.0
6	(PST)	03:10 1.1	10:37 11.0	17:15 6.1	21:45 7.6
7	(PST)	04:06 1.9	11:24 11.1	18:12 5.1	23:09 7.6
8	(PST)	05:07 2.8	12:07 11.2	18:57 3.9	
9	(PST)	00:31 8.1	06:10 3.6	12:46 11.4	19:37 2.4
10	(PST)	01:43 8.9	07:12 4.3	13:22 11.7	20:15 0.9
11	(PST)	02:45 9.9	08:09 4.9	13:58 11.9	20:54 -0.6
12	(PST)	03:41 10.9	09:03 5.5	14:35 12.1	21:34 -2.0
13	(PST)	04:33 11.7	09:55 6.0	15:15 12.2	22:17 -2.9
14	(PST)	05:23 12.3	10:47 6.4	15:57 12.1	23:01 -3.4
15	(PST)	06:14 12.6	11:40 6.7	16:43 11.9	23:48 -3.4
16	(PST)	07:05 12.7	12:36 6.8	17:33 11.3	
17	(PST)	00:37 -3.0	07:57 12.7	13:37 6.7	18:29 10.6
18	(PST)	01:27 -2.1	08:50 12.5	14:46 6.3	19:34 9.6
19	(PST)	02:20 -0.8	09:44 12.3	16:02 5.7	20:50 8.7
20	(PST)	03:17 0.7	10:36 12.1	17:19 4.7	22:19 8.1
21	(PST)	04:19 2.2	11:26 11.9	18:26 3.5	
22	(PST)	00:01 8.0	05:27 3.7	12:12 11.7	19:19 2.3
23	(PST)	01:36 8.6	06:39 4.8	12:53 11.6	20:03 1.2
24	(PST)	02:52 9.4	07:48 5.7	13:30 11.4	20:39 0.4
25	(PST)	03:50 10.3	08:49 6.4	14:04 11.1	21:11 -0.3
26	(PST)	04:37 11.0	09:41 6.8	14:36 10.9	21:41 -0.8
27	(PST)	05:16 11.4	10:27 7.1	15:09 10.7	22:11 -1.1
28	(PST)	05:50 11.7	11:07 7.3	15:42 10.5	22:42 -1.3
29	(PST)	06:19 11.9	11:45 7.4	16:16 10.2	23:15 -1.3
30	(PST)	06:48 12.0	12:23 7.4	16:53 10.0	23:51 -1.2

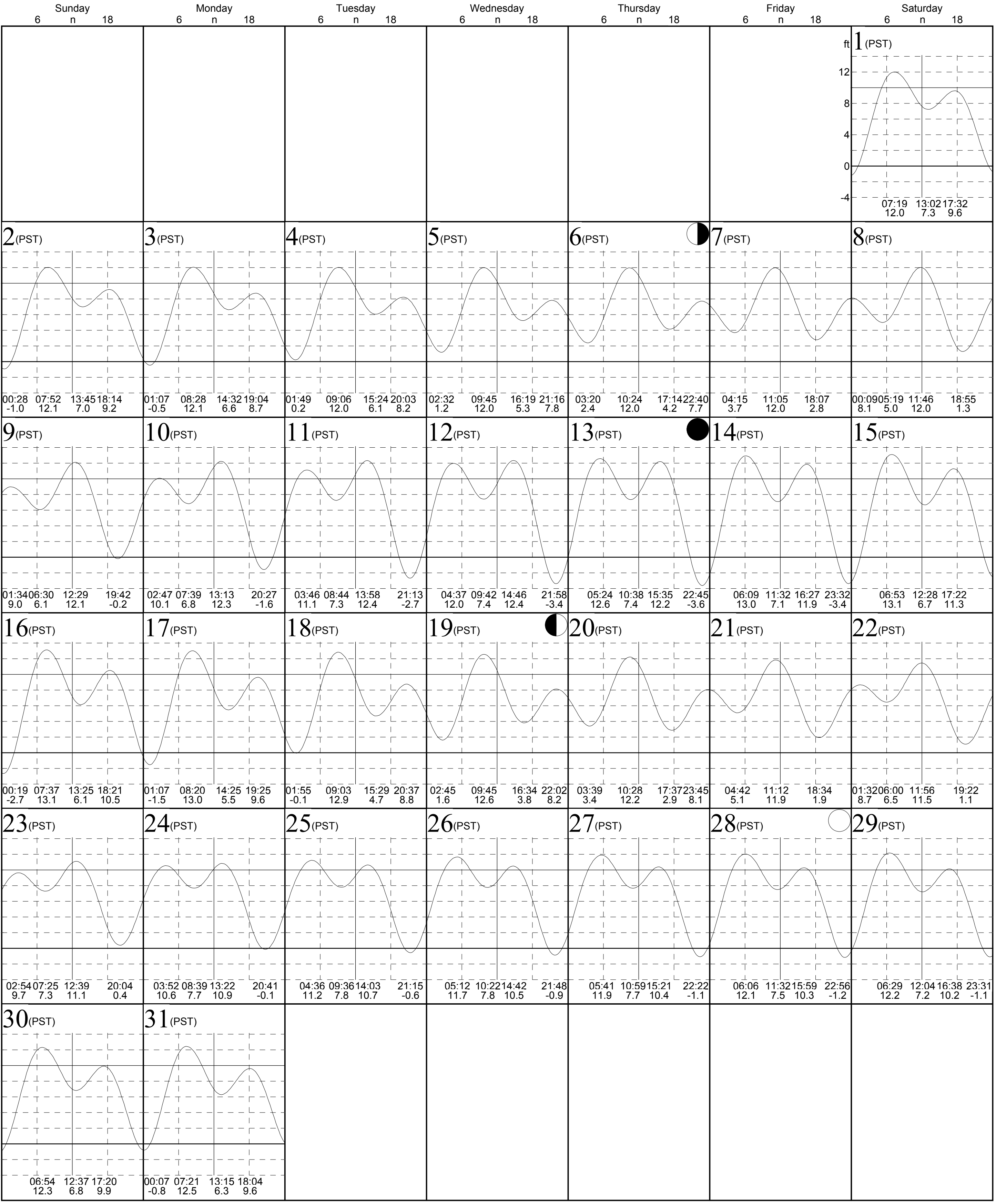
Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides	
Mean Range:	7.8 ft
MHHW:	11.5 ft
Mean Tide:	6.7 ft

December 2012

Monthly High & Low
High December 16, 07:3713.1 ft
Low December 13, 22:45 -3.6 ft



Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1 (PST) 07:19 13:02 17:32 12.0 7.3 9.6
2 (PST) 00:28 07:52 13:45 18:14 -1.0 12.1 7.0 9.2	3 (PST) 01:07 08:28 14:32 19:04 -0.5 12.1 6.6 8.7	4 (PST) 01:49 09:06 15:24 20:03 0.2 12.0 6.1 8.2	5 (PST) 02:32 09:45 16:19 21:16 1.2 12.0 5.3 7.8	6 (PST) ◑ 03:20 10:24 17:14 22:40 2.4 12.0 4.2 7.7	7 (PST) 04:15 11:05 18:07 3.7 12.0 2.8	8 (PST) 00:09 05:19 11:46 18:55 8.1 5.0 12.0 1.3
9 (PST) 01:34 06:30 12:29 19:42 9.0 6.1 12.1 -0.2	10 (PST) 02:47 07:39 13:13 20:27 10.1 6.8 12.3 -1.6	11 (PST) 03:46 08:44 13:58 21:13 11.1 7.3 12.4 -2.7	12 (PST) 04:37 09:42 14:46 21:58 12.0 7.4 12.4 -3.4	13 (PST) ● 05:24 10:38 15:35 22:45 12.6 7.4 12.2 -3.6	14 (PST) 06:09 11:32 16:27 23:32 13.0 7.1 11.9 -3.4	15 (PST) 06:53 12:28 17:22 13.1 6.7 11.3
16 (PST) 00:19 07:37 13:25 18:21 -2.7 13.1 6.1 10.5	17 (PST) 01:07 08:20 14:25 19:25 -1.5 13.0 5.5 9.6	18 (PST) 01:55 09:03 15:29 20:37 -0.1 12.9 4.7 8.8	19 (PST) ◐ 02:45 09:45 16:34 22:02 1.6 12.6 3.8 8.2	20 (PST) 03:39 10:28 17:37 23:45 3.4 12.2 2.9 8.1	21 (PST) 04:42 11:12 18:34 5.1 11.9 1.9	22 (PST) 01:32 06:00 11:56 19:22 8.7 6.5 11.5 1.1
23 (PST) 02:54 07:25 12:39 20:04 9.7 7.3 11.1 0.4	24 (PST) 03:52 08:39 13:22 20:41 10.6 7.7 10.9 -0.1	25 (PST) 04:36 09:36 14:03 21:15 11.2 7.8 10.7 -0.6	26 (PST) 05:12 10:22 14:42 21:48 11.7 7.8 10.5 -0.9	27 (PST) 05:41 10:59 15:21 22:22 11.9 7.7 10.4 -1.1	28 (PST) ○ 06:06 11:32 15:59 22:56 12.1 7.5 10.3 -1.2	29 (PST) 06:29 12:04 16:38 23:31 12.2 7.2 10.2 -1.1
30 (PST) 06:54 12:37 17:20 12.3 6.8 9.9	31 (PST) 00:07 07:21 13:15 18:04 -0.8 12.5 6.3 9.6					

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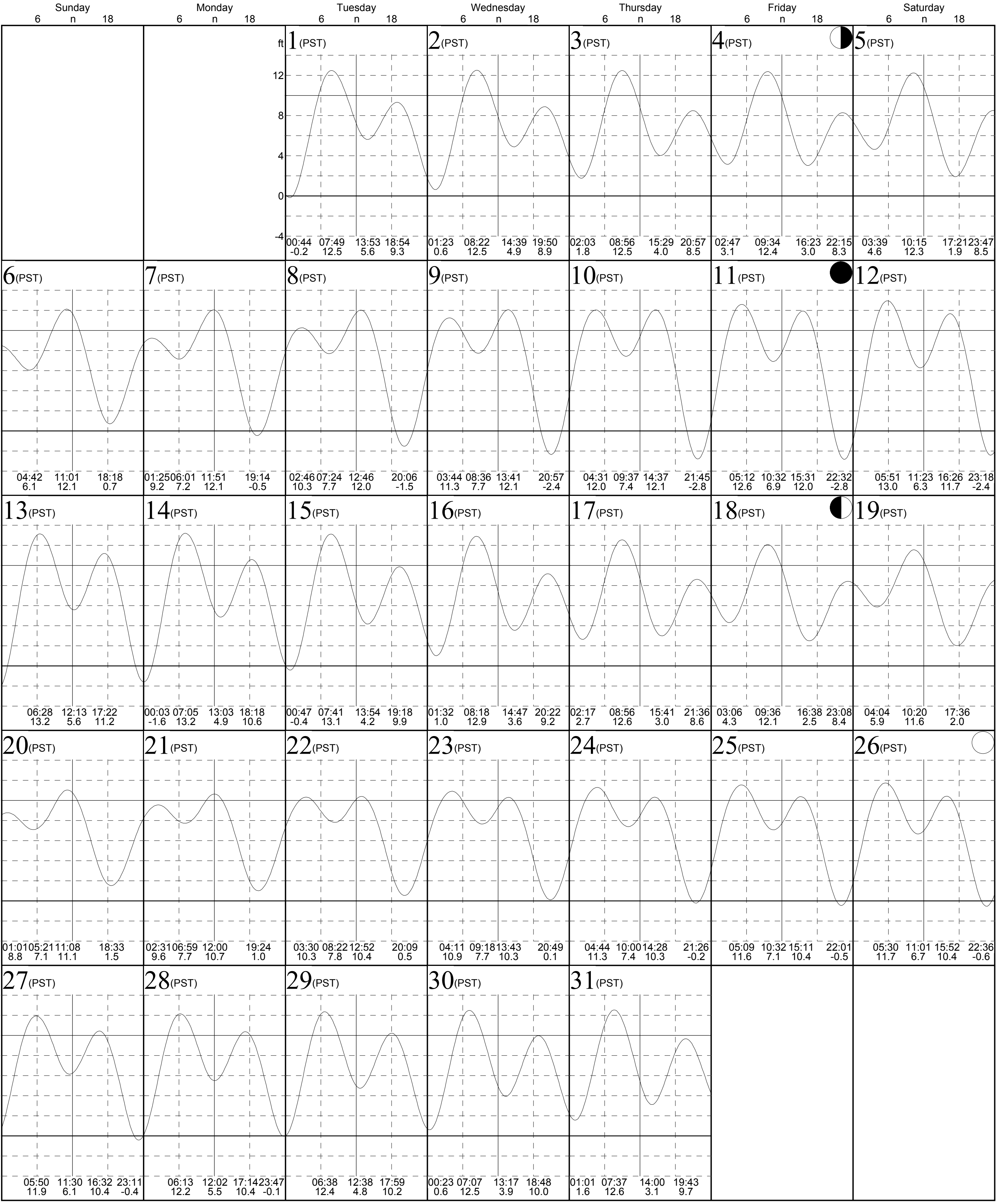
Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides	
Mean Range:	7.8 ft
MHHW:	11.5 ft
Mean Tide:	6.7 ft

January 2013

Monthly High & Low
High January 14, 07:0513.2 ft
Low January 11, 22:32 -2.8 ft



1(PST)	00:44 -0.2	07:49 12.5	13:53 5.6	18:54 9.3
2(PST)	01:23 0.6	08:22 12.5	14:39 4.9	19:50 8.9
3(PST)	02:03 1.8	08:56 12.5	15:29 4.0	20:57 8.5
4(PST)	02:47 3.1	09:34 12.4	16:23 3.0	22:15 8.3
5(PST)	03:39 4.6	10:15 12.3	17:21 1.9	23:47 8.5
6(PST)	04:42 6.1	11:01 12.1	18:18 0.7	
7(PST)	01:25 9.2	06:01 7.2	11:51 12.1	19:14 -0.5
8(PST)	02:46 10.3	07:24 7.7	12:46 12.0	20:06 -1.5
9(PST)	03:44 11.3	08:36 7.7	13:41 12.1	20:57 -2.4
10(PST)	04:31 12.0	09:37 7.4	14:37 12.1	21:45 -2.8
11(PST)	05:12 12.6	10:32 6.9	15:31 12.0	22:32 -2.8
12(PST)	05:51 13.0	11:23 6.3	16:26 11.7	23:18 -2.4
13(PST)	06:28 13.2	12:13 5.6	17:22 11.2	
14(PST)	00:03 -1.6	07:05 13.2	13:03 4.9	18:18 10.6
15(PST)	00:47 -0.4	07:41 13.1	13:54 4.2	19:18 9.9
16(PST)	01:32 1.0	08:18 12.9	14:47 3.6	20:22 9.2
17(PST)	02:17 2.7	08:56 12.6	15:41 3.0	21:36 8.6
18(PST)	03:06 4.3	09:36 12.1	16:38 2.5	23:08 8.4
19(PST)	04:04 5.9	10:20 11.6	17:36 2.0	
20(PST)	01:01 8.8	05:21 7.1	11:08 11.1	18:33 1.5
21(PST)	02:31 9.6	06:59 7.7	12:00 10.7	19:24 1.0
22(PST)	03:30 10.3	08:22 7.8	12:52 10.4	20:09 0.5
23(PST)	04:11 10.9	09:18 7.7	13:43 10.3	20:49 0.1
24(PST)	04:44 11.3	10:00 7.4	14:28 10.3	21:26 -0.2
25(PST)	05:09 11.6	10:32 7.1	15:11 10.4	22:01 -0.5
26(PST)	05:30 11.7	11:01 6.7	15:52 10.4	22:36 -0.6
27(PST)	05:50 11.9	11:30 6.1	16:32 10.4	23:11 -0.4
28(PST)	06:13 12.2	12:02 5.5	17:14 10.4	23:47 -0.1
29(PST)	06:38 12.4	12:38 4.8	17:59 10.2	
30(PST)	00:23 0.6	07:07 12.5	13:17 3.9	18:48 10.0
31(PST)	01:01 1.6	07:37 12.6	14:00 3.1	19:43 9.7

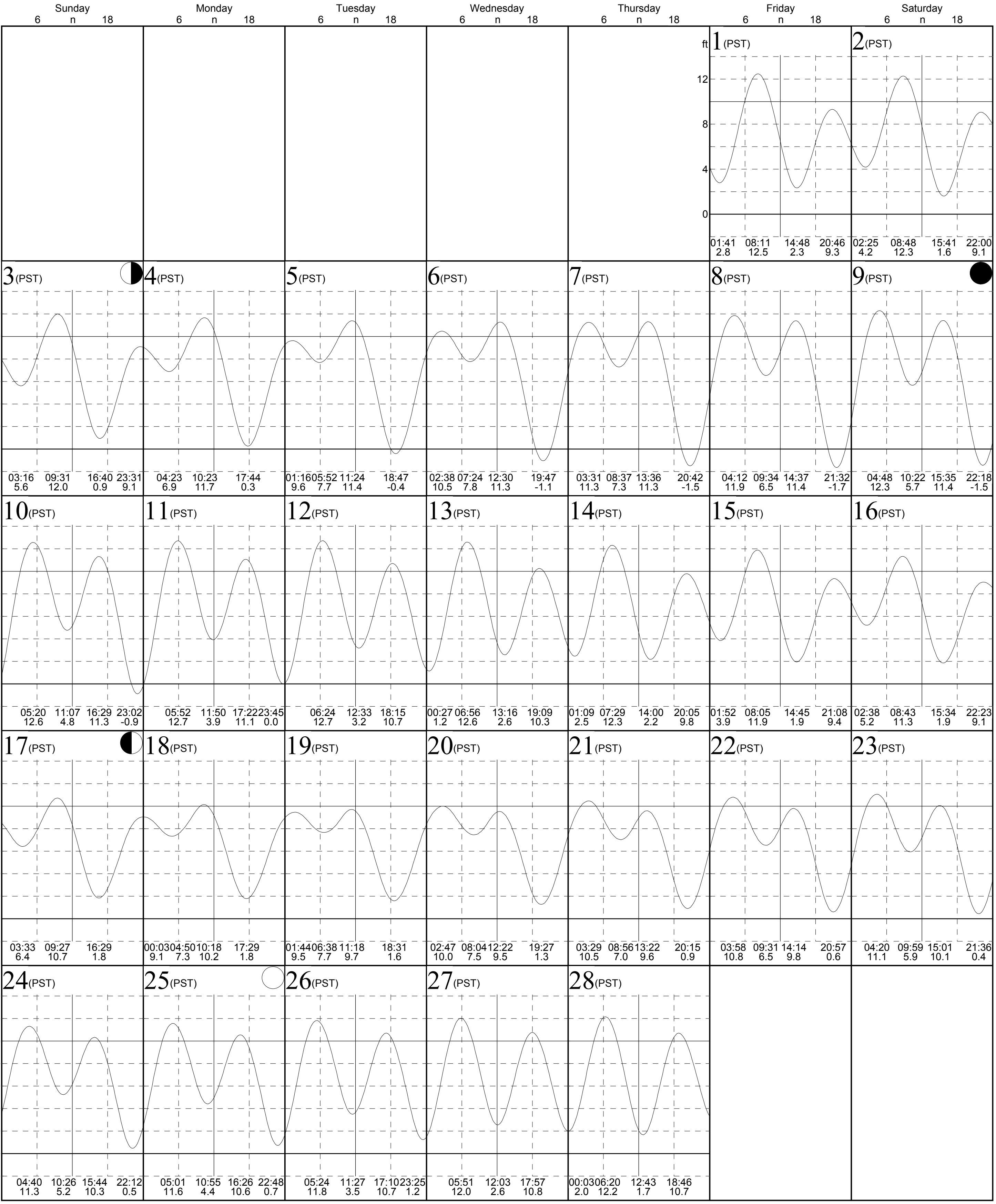
Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

February 2013

Average Tides
Mean Range: 7.8 ft
MHHW: 11.5 ft
Mean Tide: 6.7 ft

Monthly High & Low
High February 12, 06:2412.7 ft
Low February 8, 21:32 -1.7 ft



Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1 (PST) 01:41 2.8 08:11 12.5 14:48 2.3 20:46 9.3	2 (PST) 02:25 4.2 08:48 12.3 15:41 1.6 22:00 9.1
3 (PST) ◑ 03:16 5.6 09:31 12.0 16:40 0.9 23:31 9.1	4 (PST) 04:23 6.9 10:23 11.7 17:44 0.3	5 (PST) 01:16 9.6 05:52 7.7 11:24 11.4 18:47 -0.4	6 (PST) 02:38 10.5 07:24 7.8 12:30 11.3 19:47 -1.1	7 (PST) 03:31 11.3 08:37 7.3 13:36 11.3 20:42 -1.5	8 (PST) 04:12 11.9 09:34 6.5 14:37 11.4 21:32 -1.7	9 (PST) ● 04:48 12.3 10:22 5.7 15:35 11.4 22:18 -1.5
10 (PST) 05:20 12.6 11:07 4.8 16:29 11.3 23:02 -0.9	11 (PST) 05:52 12.7 11:50 3.9 17:22 11.1 23:45 0.0	12 (PST) 06:24 12.7 12:33 3.2 18:15 10.7	13 (PST) 00:27 1.2 06:56 12.6 13:16 2.6 19:09 10.3	14 (PST) 01:09 2.5 07:29 12.3 14:00 2.2 20:05 9.8	15 (PST) 01:52 3.9 08:05 11.9 14:45 1.9 21:08 9.4	16 (PST) 02:38 5.2 08:43 11.3 15:34 1.9 22:23 9.1
17 (PST) ◐ 03:33 6.4 09:27 10.7 16:29 1.8	18 (PST) 00:03 9.1 04:50 7.3 10:18 10.2 17:29 1.8	19 (PST) 01:44 9.5 06:38 7.7 11:18 9.7 18:31 1.6	20 (PST) 02:47 10.0 08:04 7.5 12:22 9.5 19:27 1.3	21 (PST) 03:29 10.5 08:56 7.0 13:22 9.6 20:15 0.9	22 (PST) 03:58 10.8 09:31 6.5 14:14 9.8 20:57 0.6	23 (PST) 04:20 11.1 09:59 5.9 15:01 10.1 21:36 0.4
24 (PST) 04:40 11.3 10:26 5.2 15:44 10.3 22:12 0.5	25 (PST) ○ 05:01 11.6 10:55 4.4 16:26 10.6 22:48 0.7	26 (PST) 05:24 11.8 11:27 3.5 17:10 10.7 23:25 1.2	27 (PST) 05:51 12.0 12:03 2.6 17:57 10.8	28 (PST) 00:03 2.0 06:20 12.2 12:43 1.7 18:46 10.7		

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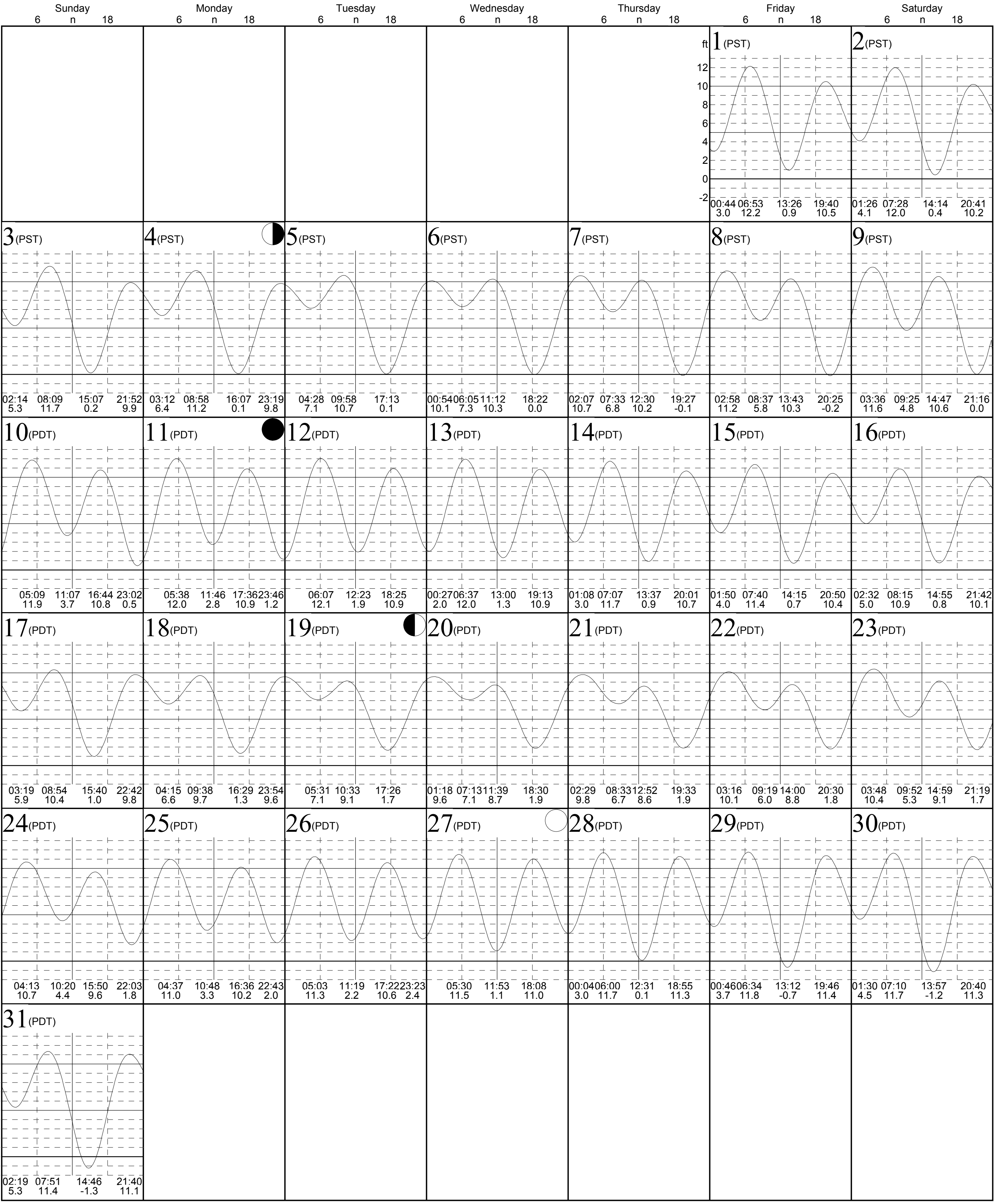
Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides
Mean Range: 7.8 ft
MHHW: 11.5 ft
Mean Tide: 6.7 ft

March 2013

Monthly High & Low
High March 1, 06:5312.2 ft
Low March 31, 14:46 -1.3 ft



Day					
1 (PST)	00:44 3.0	06:53 12.2	13:26 0.9	19:40 10.5	
2 (PST)	01:26 4.1	07:28 12.0	14:14 0.4	20:41 10.2	
3 (PST)	02:14 5.3	08:09 11.7	15:07 0.2	21:52 9.9	
4 (PST) ◑	03:12 6.4	08:58 11.2	16:07 0.1	23:19 9.8	
5 (PST)	04:28 7.1	09:58 10.7	17:13 0.1		
6 (PST)	00:54 10.1	06:05 7.3	11:12 10.3	18:22 0.0	
7 (PST)	02:07 10.7	07:33 6.8	12:30 10.2	19:27 -0.1	
8 (PST)	02:58 11.2	08:37 5.8	13:43 10.3	20:25 -0.2	
9 (PST)	03:36 11.6	09:25 4.8	14:47 10.6	21:16 0.0	
10 (PDT)	05:09 11.9	11:07 3.7	16:44 10.8	23:02 0.5	
11 (PDT) ●	05:38 12.0	11:46 2.8	17:36 10.9	23:46 1.2	
12 (PDT)	06:07 12.1	12:23 1.9	18:25 10.9		
13 (PDT)	00:27 2.0	06:37 12.0	13:00 1.3	19:13 10.9	
14 (PDT)	01:08 3.0	07:07 11.7	13:37 0.9	20:01 10.7	
15 (PDT)	01:50 4.0	07:40 11.4	14:15 0.7	20:50 10.4	
16 (PDT)	02:32 5.0	08:15 10.9	14:55 0.8	21:42 10.1	
17 (PDT)	03:19 5.9	08:54 10.4	15:40 1.0	22:42 9.8	
18 (PDT)	04:15 6.6	09:38 9.7	16:29 1.3	23:54 9.6	
19 (PDT) ◐	05:31 7.1	10:33 9.1	17:26 1.7		
20 (PDT)	01:18 9.6	07:13 7.1	11:39 8.7	18:30 1.9	
21 (PDT)	02:29 9.8	08:33 6.7	12:52 8.6	19:33 1.9	
22 (PDT)	03:16 10.1	09:19 6.0	14:00 8.8	20:30 1.8	
23 (PDT)	03:48 10.4	09:52 5.3	14:59 9.1	21:19 1.7	
24 (PDT)	04:13 10.7	10:20 4.4	15:50 9.6	22:03 1.8	
25 (PDT)	04:37 11.0	10:48 3.3	16:36 10.2	22:43 2.0	
26 (PDT)	05:03 11.3	11:19 2.2	17:22 10.6	23:23 2.4	
27 (PDT) ○	05:30 11.5	11:53 1.1	18:08 11.0		
28 (PDT)	00:04 3.0	06:00 11.7	12:31 0.1	18:55 11.3	
29 (PDT)	00:46 3.7	06:34 11.8	13:12 -0.7	19:46 11.4	
30 (PDT)	01:30 4.5	07:10 11.7	13:57 -1.2	20:40 11.3	
31 (PDT)	02:19 5.3	07:51 11.4	14:46 -1.3	21:40 11.1	

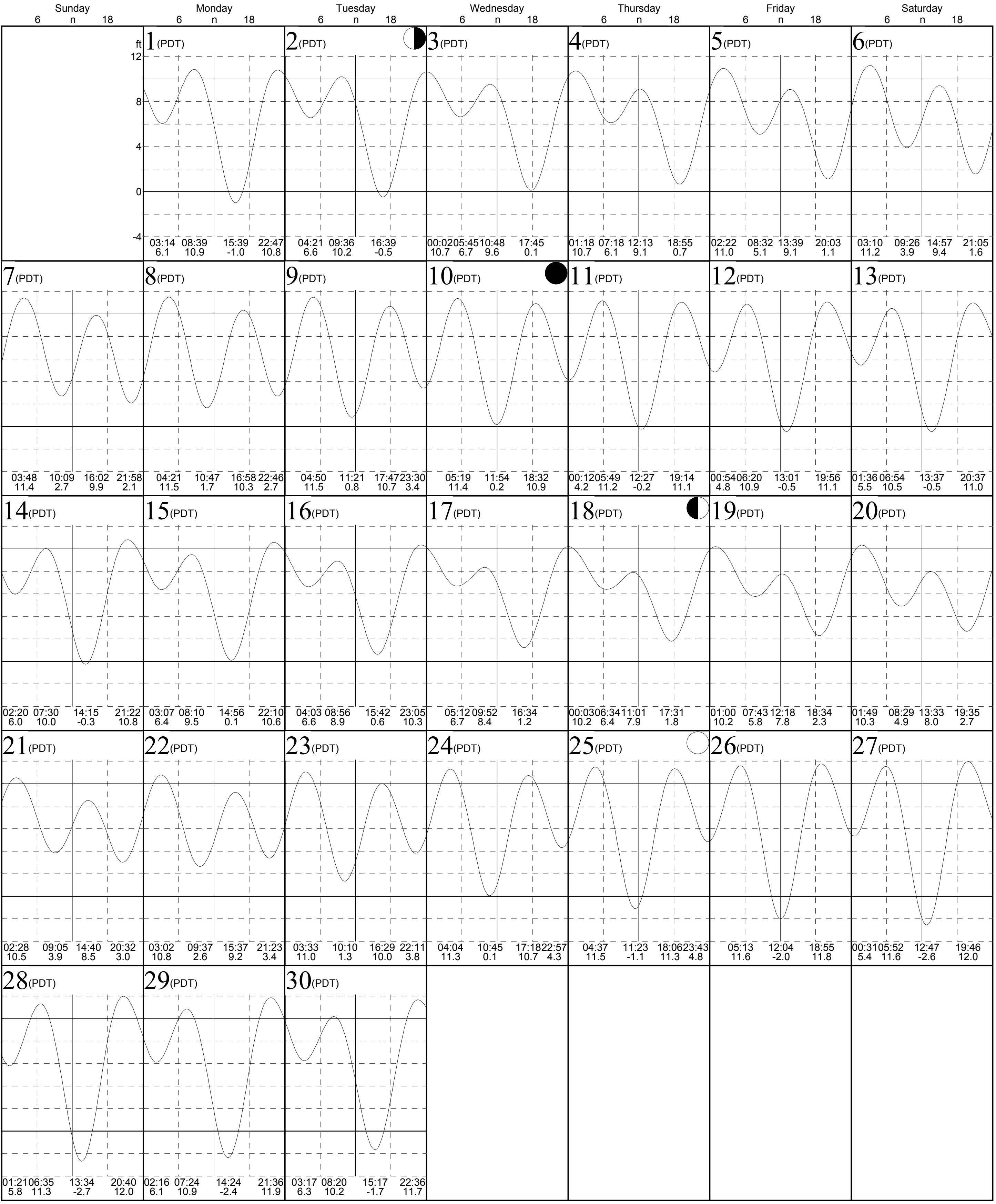
Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides
Mean Range: 7.8 ft
MHHW: 11.5 ft
Mean Tide: 6.7 ft

April 2013

Monthly High & Low
High April 28, 20:4012.0 ft
Low April 28, 13:34 -2.7 ft



Day				
1	03:14 6.1	08:39 10.9	15:39 -1.0	22:47 10.8
2	04:21 6.6	09:36 10.2	16:39 -0.5	
3	00:02 10.7	05:45 6.7	10:48 9.6	17:45 0.1
4	01:18 10.7	07:18 6.1	12:13 9.1	18:55 0.7
5	02:22 11.0	08:32 5.1	13:39 9.1	20:03 1.1
6	03:10 11.2	09:26 3.9	14:57 9.4	21:05 1.6
7	03:48 11.4	10:09 2.7	16:02 9.9	21:58 2.1
8	04:21 11.5	10:47 1.7	16:58 10.3	22:46 2.7
9	04:50 11.5	11:21 0.8	17:47 10.7	23:30 3.4
10	05:19 11.4	11:54 0.2	18:32 10.9	
11	00:12 4.2	05:49 11.2	12:27 -0.2	19:14 11.1
12	00:54 4.8	06:20 10.9	13:01 -0.5	19:56 11.1
13	01:36 5.5	06:54 10.5	13:37 -0.5	20:37 11.0
14	02:20 6.0	07:30 10.0	14:15 -0.3	21:22 10.8
15	03:07 6.4	08:10 9.5	14:56 0.1	22:10 10.6
16	04:03 6.6	08:56 8.9	15:42 0.6	23:05 10.3
17	05:12 6.7	09:52 8.4	16:34 1.2	
18	00:03 10.2	06:34 6.4	11:01 7.9	17:31 1.8
19	01:00 10.2	07:43 5.8	12:18 7.8	18:34 2.3
20	01:49 10.3	08:29 4.9	13:33 8.0	19:35 2.7
21	02:28 10.5	09:05 3.9	14:40 8.5	20:32 3.0
22	03:02 10.8	09:37 2.6	15:37 9.2	21:23 3.4
23	03:33 11.0	10:10 1.3	16:29 10.0	22:11 3.8
24	04:04 11.3	10:45 0.1	17:18 10.7	22:57 4.3
25	04:37 11.5	11:23 -1.1	18:06 11.3	23:43 4.8
26	05:13 11.6	12:04 -2.0	18:55 11.8	
27	00:31 5.4	05:52 11.6	12:47 -2.6	19:46 12.0
28	01:21 5.8	06:35 11.3	13:34 -2.7	20:40 12.0
29	02:16 6.1	07:24 10.9	14:24 -2.4	21:36 11.9
30	03:17 6.3	08:20 10.2	15:17 -1.7	22:36 11.7

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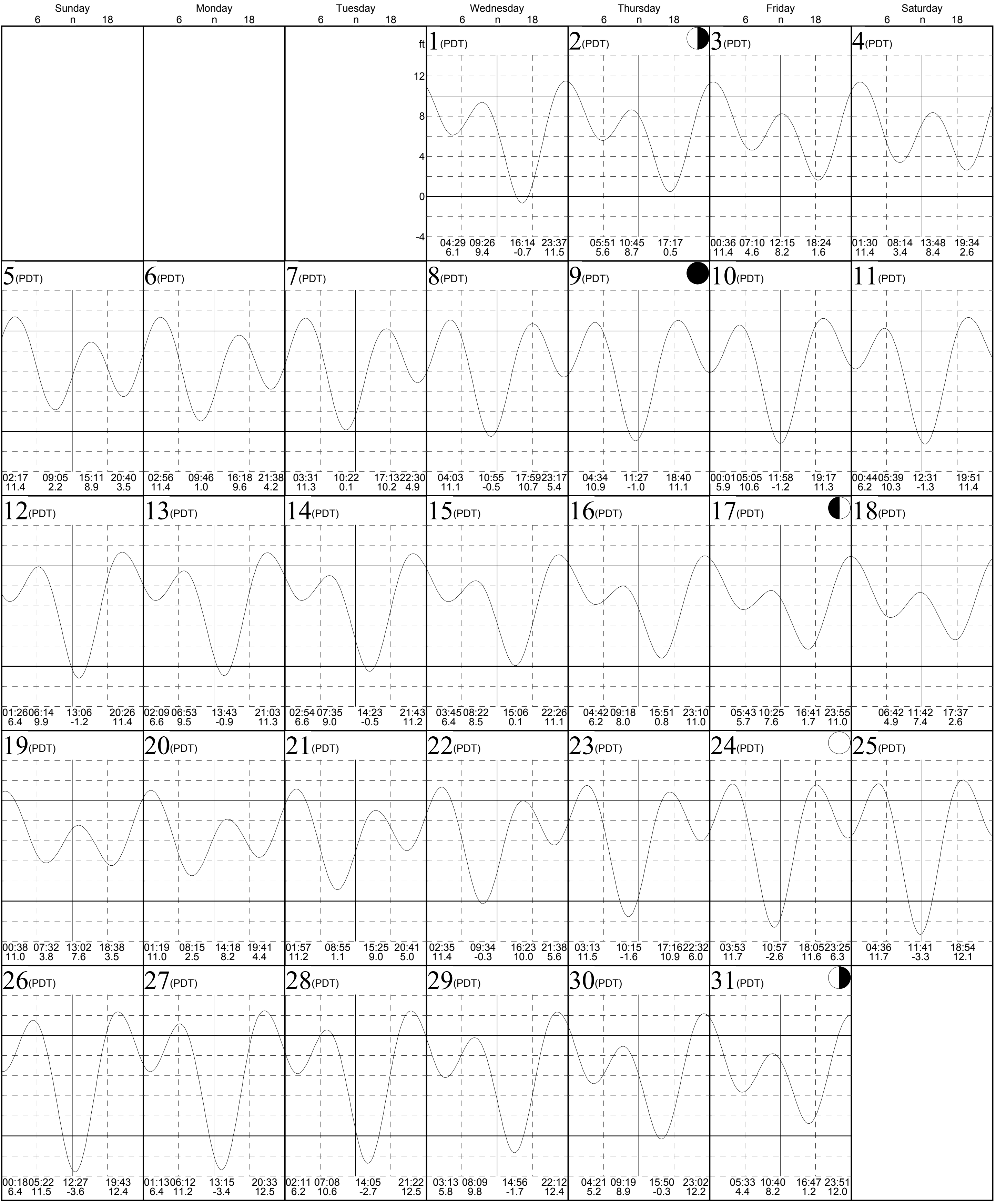
Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides
Mean Range: 7.8 ft
MHHW: 11.5 ft
Mean Tide: 6.7 ft

May 2013

Monthly High & Low
High May 27, 20:3312.5 ft
Low May 26, 12:27 -3.6 ft



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Tides:Clam Bay, Rich Passage

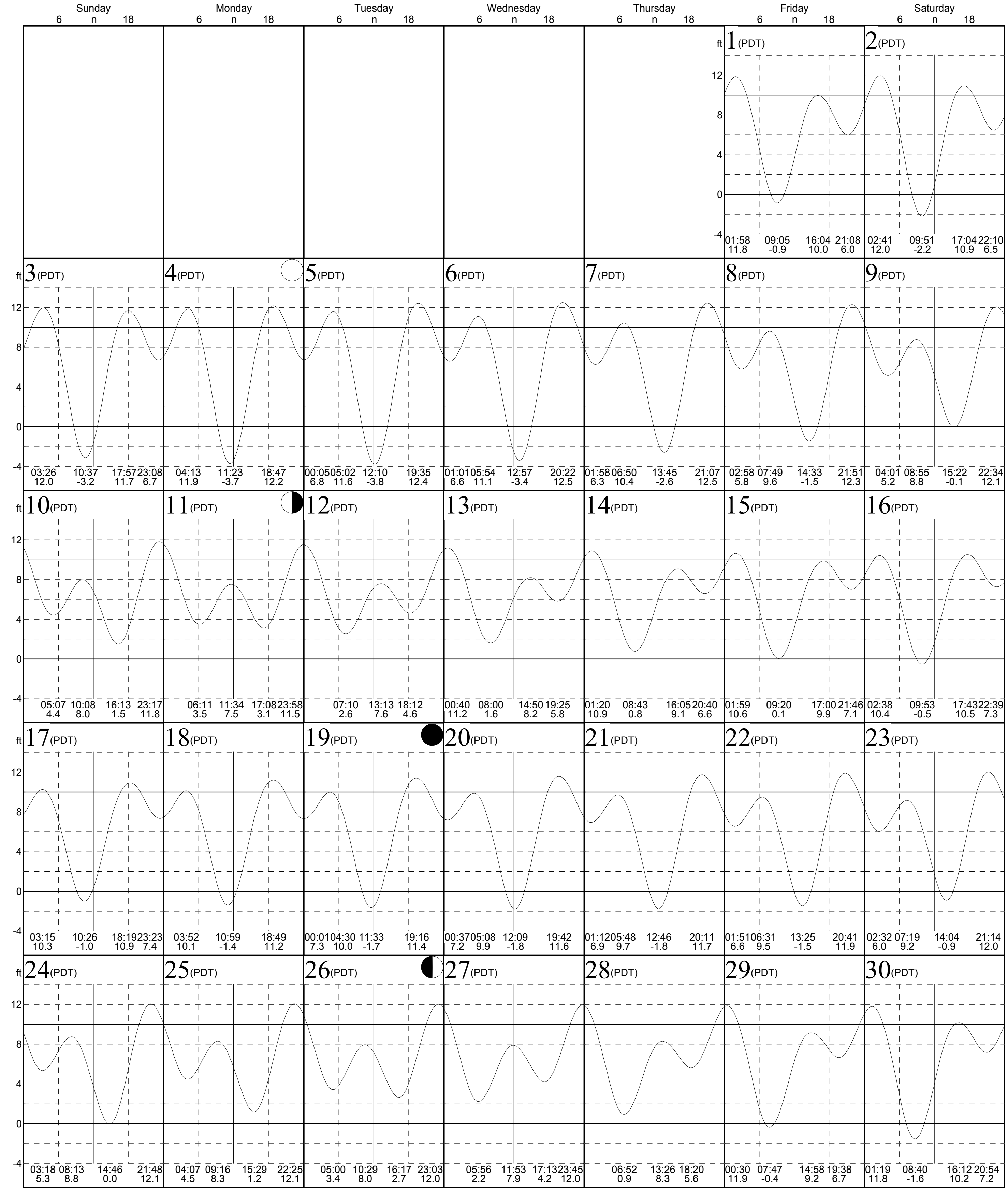
based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides

Mean Range:	7.8 ft
MHHW:	11.5 ft
Mean Tide:	6.7 ft

June 2012

Monthly High & Low
High June 6, 20:2212.5 ft
Low June 5, 12:10 -3.8 ft



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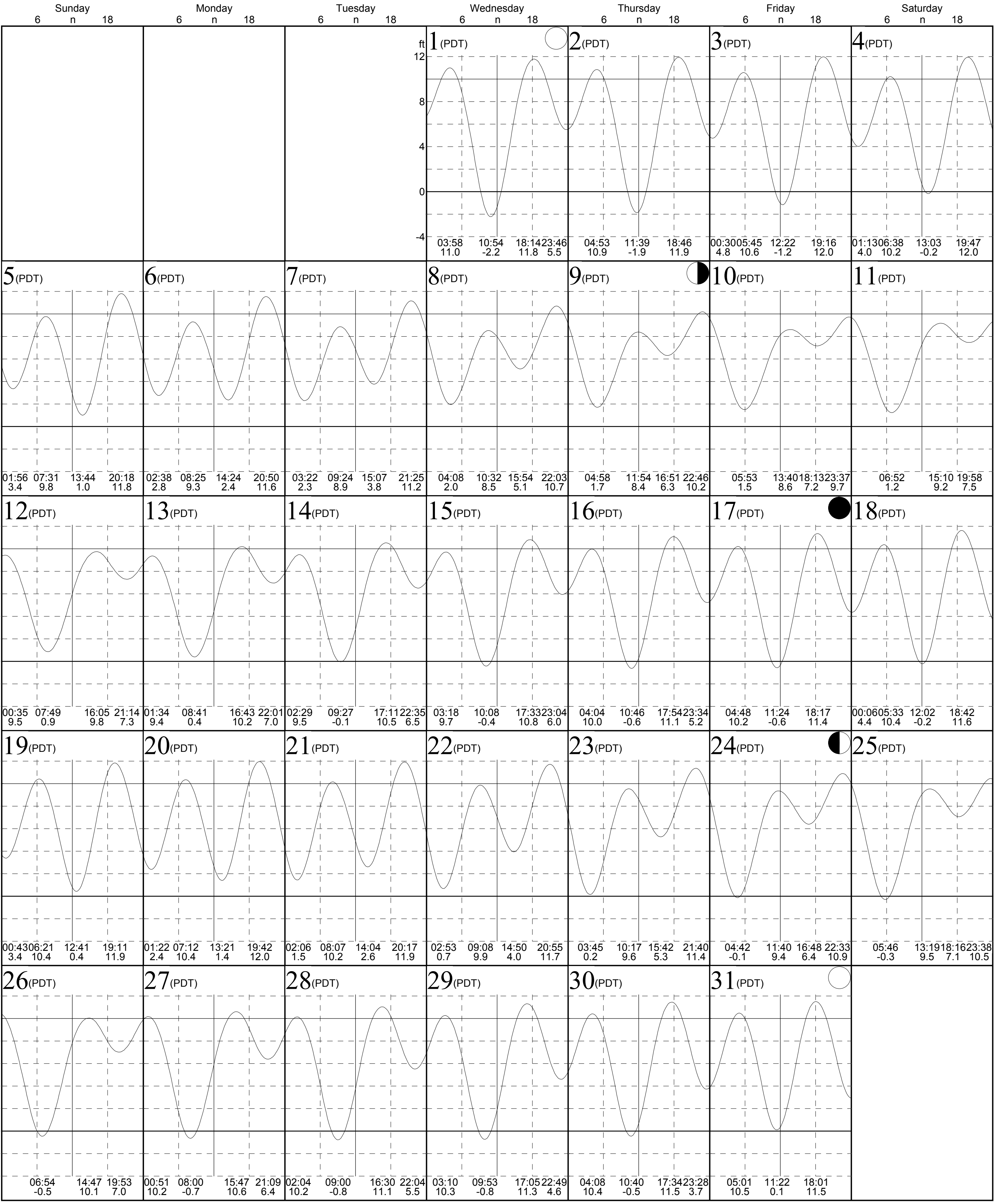
Tides:Clam Bay, Rich Passage

based on Seattle (Madison St), Elliot Bay Washington (NOAA)
47° 34 30 N 122° 32 36 W

Average Tides	
Mean Range:	7.8 ft
MHHW:	11.5 ft
Mean Tide:	6.7 ft

Monthly High & Low
High August 3, 19:1612.0 ft
Low August 1, 10:54 -2.2 ft

August 2012



Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1 (PDT) ○ 03:58 11.0 10:54 -2.2 18:14 11.8 23:46 5.5	2 (PDT) 04:53 10.9 11:39 -1.9 18:46 11.9	3 (PDT) 00:30 4.8 05:45 10.6 12:22 -1.2 19:16 12.0	4 (PDT) 01:13 4.0 06:38 10.2 13:03 -0.2 19:47 12.0
5 (PDT) 01:56 3.4 07:31 9.8 13:44 1.0 20:18 11.8	6 (PDT) 02:38 2.8 08:25 9.3 14:24 2.4 20:50 11.6	7 (PDT) 03:22 2.3 09:24 8.9 15:07 3.8 21:25 11.2	8 (PDT) 04:08 2.0 10:32 8.5 15:54 5.1 22:03 10.7	9 (PDT) ◑ 04:58 1.7 11:54 8.4 16:51 6.3 22:46 10.2	10 (PDT) 05:53 1.5 13:40 8.6 18:13 7.2 23:37 9.7	11 (PDT) 06:52 1.2 15:10 9.2 19:58 7.5
12 (PDT) 00:35 9.5 07:49 0.9 16:05 9.8 21:14 7.3	13 (PDT) 01:34 9.4 08:41 0.4 16:43 10.2 22:01 7.0	14 (PDT) 02:29 9.5 09:27 -0.1 17:11 10.5 22:35 6.5	15 (PDT) 03:18 9.7 10:08 -0.4 17:33 10.8 23:04 6.0	16 (PDT) 04:04 10.0 10:46 -0.6 17:54 11.1 23:34 5.2	17 (PDT) ● 04:48 10.2 11:24 -0.6 18:17 11.4	18 (PDT) 00:06 4.4 05:33 10.4 12:02 -0.2 18:42 11.6
19 (PDT) 00:43 3.4 06:21 10.4 12:41 0.4 19:11 11.9	20 (PDT) 01:22 2.4 07:12 10.4 13:21 1.4 19:42 12.0	21 (PDT) 02:06 1.5 08:07 10.2 14:04 2.6 20:17 11.9	22 (PDT) 02:53 0.7 09:08 9.9 14:50 4.0 20:55 11.7	23 (PDT) 03:45 0.2 10:17 9.6 15:42 5.3 21:40 11.4	24 (PDT) ◐ 04:42 -0.1 11:40 9.4 16:48 6.4 22:33 10.9	25 (PDT) 05:46 -0.3 13:19 9.5 18:16 7.1 23:38 10.5
26 (PDT) 06:54 -0.5 14:47 10.1 19:53 7.0	27 (PDT) 00:51 10.2 08:00 -0.7 15:47 10.6 21:09 6.4	28 (PDT) 02:04 10.2 09:00 -0.8 16:30 11.1 22:04 5.5	29 (PDT) 03:10 10.3 09:53 -0.8 17:05 11.3 22:49 4.6	30 (PDT) 04:08 10.4 10:40 -0.5 17:34 11.5 23:28 3.7	31 (PDT) ○ 05:01 10.5 11:22 0.1 18:01 11.5	

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APPENDIX B

Marine Taxanomic Services - Quality Control Protocol

Quality Control Protocol

MTS quality control procedure recommends that at least 20 percent of each sample be re-sorted for QA/QC purposes. Resorting is the examination of a sample that has been sorted once and is considered free of organisms. The 20 percent aliquot should be taken after the entire sample has been spread out in a pan or tray. It is critical that the aliquot be a representative subsample of the total sample. Care is taken to include any organisms that may be floating in the preservative. Resorting will be conducted using a dissection microscope capable of magnification to 25power. A partial resorting of every sample will ensure that all gross sorting errors are detected. In addition, it will give added incentive to sorters to process every sample accurately. Resorting will be conducted by an individual other than the one who sorted the original sample.

In addition to the efficient sample sorting, consistent identification of organisms among individuals and among sampling programs is critical to the collection of high quality data. Consistent identifications are achieved by implementing the procedures discussed below and by maintaining informal, but constant, interaction among the taxonomists working on each major group. One important procedure at MTS is to verify identifications by comparison with the reference collection specimens. To ensure that identifications are correct and consistent, 5 percent of all samples identified by one taxonomist should be re-identified by another taxonomist who is also qualified to identify organisms in that major taxonomic group. It is the duty of the senior MTS taxonomist to decide upon the proper identification(s). The senior taxonomist may also decide whether the taxonomic level to which a given organism is identified is appropriate. If it is not, the senior taxonomist may decide to drop back to a higher taxonomic level, or to further refine the taxonomy of that group through additional study.

When all identifications and QA/QC procedures are completed, the jars containing the vials of identified species are topped off with 5 percent glycerin/70 percent alcohol. The lids are then sealed tightly with black electrical tape to prevent evaporation. All sample jars are to be placed in containers filled with 70percent alcohol for long term storage. The containers are fitted with a tightly sealed lid, and electrical tape is again used to seal the joints. Each container is labeled clearly with the survey name, date, and number and type of samples within it.

Corrective Actions

Following QA/QC procedures discussed above, each 20 percent sample aliquot is checked for complete or nearly complete removal of organisms. Then each sample elicits a decision concerning a possible resort. When a sample is found that does not meet there commended 95 percent removal criterion (see Data Quality and Reporting Requirements below), it will be resorted.

When a taxonomic error or inconsistency is found, it is MTS policy to trace all of the work of the taxonomist responsible for the error, so as to identify those samples into which the specific error or inconsistency may have been introduced. This process can be time consuming. However, upon completion of all taxonomic work, few (if any) taxonomic errors or inconsistencies remain in the data set. Avoiding errors and inconsistencies through the constant interchange of information and ideas among taxonomists is the best way to minimize lost time due to faulty identification.

Data Quality and Reporting Requirements

At MTS a sample sorting efficiency of 95 percent of total number of individuals is considered acceptable. That is, no more than five percent of the organisms in a given sample are missed by the sorter. Similarly, species identifications by each taxonomist can reasonably be expected to be accurate for at least 95 percent of total number of species. Unless otherwise specified, all organisms will be identified to the lowest possible taxon; to species level whenever possible. In cases where the identity of a species is uncertain, a species number is used (e.g., Macoma sp. 1, Macoma sp. 2) Numerical designations must be consistent throughout each study.

APPENDIX C

Survey Data

Appendix B
Rich Passage Biophysical Surveys
Location: Manette Beach
Site/Transect Number: 1B
Date: May 18, 2012

Project Number: 11393490/200/220

Transect Lat/Long Onshore/Offshore (ddmm.mm):
47 34.429, 122 36.218/47 34.398, 122 36.177

					Substrate Type (% Areal Cover)					Other (% Areal Cover)			Green Algae (Phylum Chlorophyta) (% Areal Cover)				Brown Algae (Phylum Ochrophyta) (% Areal Cover)				Red Algae (Phylum Rhodophyta) (% Areal Cover)												Arthropods					Molluscs										Echinoderms					Cnidarians (% Areal Cover)		Worms			Vertebrates		
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/ Intertidal Slope	Corrected Elevation (m)*	Time	Boulder (> 25cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand / Silt (<0.2 cm)	Shell fragments	Wood debris	Grass	Detrital algae	Sea lettuce (*Ulva/ Ulvaria* spp.)	*Enteromorpha intestinalis / Ulva intestinalis*	*Acrosiphonia* spp.	*Derbesia* spp.	Rockweed (*Fucus* spp.)	Wireweed (*Sargassum muticum*)	Filamentous Brown algae (Unidentified species)	*Laminaria* spp.	*Microcladia borealis*	*Sarcodiotheca* spp.	*Gracilaria* sp.	*Prionitis lanceolata*	*Mazzaella* spp.	Turkish towel (*Chondracanthus exasperatus*)	*Porphyra* spp.	*Ceramium* spp.	Encrusting coralline algae (Unidentified species)	*Palmaria* spp.	Filamentous Red algae (Unidentified species)	Red algae (Unidentified species)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Longhorn decorator crab (*Chorilia longipes*)	Helmet crab (*Telmessus* sp.)	Kelp crab (*Pugettia* sp.)	Amphipod (*Gammarus* sp.)	Mussels (*Mytilus* sp.) (Count & % Areal Cover)	Periwinkle (*Littorina* spp.)	Dogwinkle (*Nucella* spp.)	False jingle shell (*Pododesmus* sp.)	Horse clam (*Tresus* sp.)	Limpets (Family Lottiidae)	Chiton (*Tonicella / Mopalia* sp.)	Nudibranch (*Janolus fuscus*)	Nudibranch (Unidentified species)	Snail (Class Gastropoda)	Sunflower star (*Pycnopodia helianthoides*)	Brittle star (Family Ophiodermatidae)	Mottled star (*Evasterias troschelii*)	Morning sun star (*Solaster dawsoni*)	Spiny pink star (*Pisaster brevispinus*)	Pink-tipped anemone (*Anthopleura elegantissima*) (Count & % Areal Cover)	Stubby rose anemone (*Urticina* sp.)	Slime-tubed feather duster worm (*Myxicola infundibulum*)	Unidentified Worm casings	Jointed tubeworm (*Spiochaetopterus costarum*)	Sculpin (Family Cottidae)	Tubesnout (Family Aulorhynchidae)	Comments
I-Q1	0	19%/11˚	4.87	10:01		5	90		< 1	5	2																																																	Intertidal slope 0 to 16m = 19%(11˚); 16 to 23m = 16%(9˚); 23 to 38m = 5%(3˚).
TS1	0 to 5					5 to 25	75 to 100		< 5			< 5																																																35 cm diameter log observed from 1-2m from OHWM, transect went over logs. Grass at backshore.
I-Q2	5	19%/11˚	3.94	10:20		15	85					< 5																																																
TS2	5 to 10					5 to 25	75 to 100		< 5			5 to 25																																																Scrap metal present. Substate very similar in size.
I-Q3	10	19%/11˚	3	10:25		40	60																																																					
TS3	10 to 15					50 to 75	50 to 75																										< 1																											Well-mixed substrate.
I-Q4	15	19%/11˚	2.07	10:28		80	20																										1					1 (0.05%)[1]																						Well-mixed substrate.
	16	19%/11˚																																																											
TS4	15 to 20					75 to 100	5 to 25						< 5																				< 5																											Well-mixed substrate, slope changes at 16 m.
I-Q5	20	16%/9˚	1.25	10:30		90	10						1																				5					80 (4%)[1]	2				3																	
	23	16%/9˚																																																										Slope changes at 23m.
TS5	20 to 25			10:34		25 to 50	5 to 25	25 to 50 (silt)				< 1	25 to 50		< 5												< 1						25 to 50					5 to 25	F														M							Substrate changes from silt to sand @ 23m. Detrital *Gracilaria sp.*.
I-Q6	25	5%/3˚	0.68	10:39		10		88 (silt)	2				80														10																										3 (0.9%)[2]							Substrate mainly silt with underlying cobbles. Crab moult present.
TS6	25 to 30			10:36		< 5		75 to 100	5 to 25				5 to 25				< 5	< 5								< 5							< 5					< 5 %															M				A			Worm casings in sandy zone only.
I-Q7	30	5%/3˚	0.43	10:50		1		98 (sand)	1			< 5	1															1					1																								14			
TS7	30 to 35			10:58		75 to 100		5 to 25					5 to 25		< 5		< 5		< 5		< 1					< 1	< 5						50 to 75					5 to 25		F			F										< 5 %				M			Worm casings in sandy zone only. Clams squirting but no obvious siphons at 38m. Cobble begins at 31.5m. Moonsnail egg casing present.
I-Q8	35	5%/3˚	0.18	11:05		35	35	25	5				20	2																			10																											*Nucella* eggs present. Substrate well-mixed.
	38	5%/3˚	0.03																																																										End of intertidal transect.
TS8	35 to 40			11:10		25 to 50	25 to 50	25 to 50					5 to 25	5 to 25	< 1		< 5	< 5											< 1			< 5	5 to 25										F										F							*Nucella* eggs present. Substrate well-mixed.
S-Q1	40	0	0.93	12:52		75	5	20	1				15	1		10	40	5															5								1		3	1			1													Poor visibility. Red algae was foliose but unrecognizeable.
TS9	40 to 45			13:02		75 to 100		5 to 25					5 to 25					5 to 25															< 5									S	F										F							Poor visibility.
S-Q2	45	1.1	-0.17	13:05		40		60					15			2	3	3				2							1				4																				2 (2%)[2]							Poor visibility.
TS10	45 to 50			13:11		25 to 50	< 5	25 to 50	< 5				5 to 25					50 to 75				< 5													S	F													S												Poor visibility.
S-Q3	50	1.6	-0.67	13:15		50		50	2				5					40				5		2		5						2	3		1						3			1																Poor visibility.
TS11	50 to 55			13:23		25 to 50	< 5	25 to 50					25 to 50					25 to 50		< 5		< 5										< 5																S						S						Poor visibility.
S-Q4	55	2	-0.72	13:28		10	5	80					25							30		5										15	2																											Unidentified red algae was old, damaged andcould not be properly characterized.
TS12	55 to 60			13:34		25 to 50	25 to 50	25 to 50					5 to 25					25 to 50		25 to 50						5 to 25						5 to 25																		S										
S-Q5	60	2.3	-1.02			40	25	35					5					5		60			5									1			1	1					1		1					1												
TS13	60 to 65			13:46		25 to 50	25 to 50	25 to 50					5 to 25					5 to 25		25 to 50						5 to 25						5 to 25													S						S	S								Nudibranch = *Janolus fuscus*
S-Q6	65	2.7	-1.42			5	40	55					25						1	40		40			5				1		1		2																P											Brittle star legs sticking through substrate.
TS14	65 to 70			13:55		5 to 25	50 to 75	25 to 50					25 to 50							5 to 25												< 5	< 5																											
S-Q7	70	3.1	-1.47	14:00		30	20	50					30					2		60		15	5																							1		1	P									1		Brittle star legs sticking through substrate.
TS15	70 to 75			14:07	< 5	< 5	50 to 75	25 to 50					5 to 25					< 5		25 to 50												5 to 25																											S	
S-Q8	75	3.8	-2.17	14:11			49	49	2				10							30				2		25				5			1		1		1																			5		1		Brittle star legs sticking through well mixed substrate; juvenile sailfin sculpin.
TS16	75 to 80			13:24			50 to 75	25 to 50					5 to 25					< 5		5 to 25		5 to 25	< 5									5 to 25		S	S						F								S		S					S					Well-mixed substrate.

Notes

* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For May 18, 2012 (Tide at 11:00 = 0.03 m, Tide at 14:00 = 1.63 m)

I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)

Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect
Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.

Transect segment observations were recorded every 5m.

Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : <1%, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.

Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)

Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes

[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

[2] Percent cover for Pink-tipped Anemone (*Anthopleura elengatissima*) was determined during survey *in situ* or using the average size per anemone as 15mm x 15mm or 0.3% of the total quadrat area

Data Entered By: Andrew Rippington (on Sept 13, 2012)
Data Checked By: Andrew Rippington (on Nov 20, 2012); Michelle Spani (on Dec 7, 2012)

Appendix B
Rich Passage Biophysical Surveys
Location: Manette Beach
Site/Transect Number: 1B
Date: August 26, 2012

Project Number: 11393490/200/220

Transect Lat/Long Onshore/Offshore (ddmm.mm):
47 34.429, 122 36.218/47 34.398, 122 36.177

Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/ Intertidal Slope	Corrected Elevation (m)*	Time	Substrate Type (% Areal Cover): Boulder (> 25 cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand (0.006 to 0.2 cm)	Silt (<0.006 cm)	Shell fragments	Other (% Areal Cover): Wood debris	Detrital algae	Green Algae (Phylum Chlorophyta) (% Areal Cover): *Derbesia* spp.	Sea lettuce (*Ulva/ Ulvaria* spp.)	Brown Algae (Phylum Ochrophyta) (% Areal Cover): Rockweed (*Fucus* sp.)	Wireweed (*Sargassum muticum*)	*Laminaria* spp.
I-Q1	0	19%/11˚	3.92	9:06			100			<1							
-	2	16%/9˚	3.54	-													
TS1	0 to 5			9:03			100			5	5	5					
I-Q2	5	16%/9˚	3.07	9:00			100					10					
TS2	5 to 10			8:56			100					5					
I-Q3	10	16%/9˚	2.28	8:56			100			<1		<1					
TS3	10 to 15			8:52		5 to 25	75 to 100					<1					
I-Q4	15	16%/9˚	1.49	8:52		5	95					<1					
TS4	15 to 20			8:45		5 to 25	75 to 100					<5					
I-Q5	20	16%/9˚	0.7	8:42		8	92			<1		<5					
-	22	5%/3˚	0.6														
TS5	20 to 25			8:34		25 to 50	25 to 50	50 to 75		5 to 25				5 to 25	<5		
I-Q6	25	5%/3˚	0.45	8:27		8	9	93						17			
TS6	25 to 30			8:20		<5	<5	75 to 100		<5				25 to 50	<1		
I-Q7	30	5%/3˚	0.2	8:14			1	99		2				15			
TS7	30 to 35			7:25		<5	<5	75 to 100		<5				25 to 50	<5		
I-Q8	35	5%/3˚	-0.05	7:15		2	2	96		2				48			
	36.6	5%/3˚	-0.13														
TS8	35 to 40			10:04		25 to 50	5 to 25	50 to 75		<5				25 to 50		<5	
S-Q1	40	1.6	-0.56	9:58		4	1	95						30	15		
TS9	40 to 45			9:54		25 to 50	5 to 25	5 to 25						50 to 75	5 to 25		
S-Q2	45	1.6	-0.56	9:50		80	10	10		5				60	<1		
TS10	45 to 50			9:45		75 to 100	5 to 25	5 to 25						75 to 100	<5	5 to 25	
S-Q3	50	1.6	-0.88	9:30		70	20	5	5					30		1	30
TS11	50 to 55			9:30	<5	50 to 75	25 to 50	5 to 25	5 to 25					75 to 100		5 to 25	
S-Q4	55	1.8	-1.08	9:19		20	10	35	35	<1				20			
TS12	55 to 60			9:12		25 to 50	25 to 50	5 to 25	5 to 25					25 to 50		5 to 25	5 to 25
S-Q5	60	2.1	-1.67	9:07		5	80	10	5					5			
TS13	60 to 65			9:03	<5	25 to 50	25 to 50	5 to 25	5 to 25	<5				50 to 75		5 to 25	<5
S-Q6	65	2.3	-1.87	8:51		5	75	10	10	<1			<1	20			
TS14	65 to 70			8:47		5 to 25	50 to 75	5 to 25	5 to 25	<5				50 to 75			5 to 25
S-Q7	70	2.4	-2.22	8:33		5	50	25	20	<1			4	30			
TS15	70 to 75			8:32		5 to 25	25 to 50	25 to 50	25 to 50					25 to 50		<5	25 to 50
S-Q8	75	2.6	-2.42	8:16		5	65	15	15					15			15
TS16	76 to 80			8:16		5 to 25	25 to 50	25 to 50	25 to 50					25 to 50			25 to 50

Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Red Algae (Phylum Rhodophyta) (% Areal Cover): *Microcladia* spp.	*Sarcodiotheca* spp.	*Gracilaria* sp.	*Prionitis lanceolata*	Turkish washcloth (*Mastocarpus* spp.)	Turkish towel (*Chondracanthus exasperatus*)	*Neoptilota* sp.	*Odonthalia* spp.	*Porphyra* spp.	Red cup (*Constantinea* sp.)	Encrusting coralline algae (Unidentified species)	*Rhodoptilum* spp.	Red algae (Class Florideophyceae)	*Rhodymenia* sp.	Blue branching (*Fauchea* sp.)	*Hymenena* spp.	Filamentous Red algae (Unidentified species)
I-Q1	0																	
-	2																	
TS1	0 to 5																	
I-Q2	5																	
TS2	5 to 10																	
I-Q3	10																	
TS3	10 to 15																	
I-Q4	15																	
TS4	15 to 20																	
I-Q5	20																	
-	22																	
TS5	20 to 25		<1			<1				<5								
I-Q6	25		<1							<1								
TS6	25 to 30	<1	<1		<1	<1	<1			<1				<1				
I-Q7	30			<1		2												
TS7	30 to 35		<1	<1		<1				<5								
I-Q8	35																	
	36.6																	
TS8	35 to 40						<5											
S-Q1	40						<1					<1						
TS9	40 to 45																	
S-Q2	45		2				20					<1						<1
TS10	45 to 50																	
S-Q3	50		2		5							<1			1		1	1
TS11	50 to 55						<5											
S-Q4	55		15	4	5		5	4				<1						
TS12	55 to 60		<5				<5											
S-Q5	60	<1	5		3		20		2			<1						
TS13	60 to 65						<5											
S-Q6	65	<1	35		<1		2						<1			<1		
TS14	65 to 70		5 to 25				<5											
S-Q7	70		40		<1						<1						<1	<1
TS15	70 to 75		5 to 25				<5											
S-Q8	75		10						<1						<1			
TS16	76 to 80		25 to 50				<5											

Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Arthropods: Barnacles (Suborder Balanomorpha) (% Areal Cover)	Graceful crab (*Cancer gracilis*)	Red Rock crab (*Cancer productus*)	Helmet crab (Telmessus sp.)	Kelp crab (*Pugettia* sp.)	Hermit crab (*Pagurus* spp.)	Shrimp (*Crangon* spp.)	Coonstripe shrimp (*Pandalus danae*)	Molluscs: Mussels (*Mytilus sp.*) (Count & % Areal Cover)	Periwinkle (*Littorina* spp.)	False jingle shell (*Pododesmus macrochisma*)	Limpets (Family Lottiidae)	Whelk (Unidentified species)	Frosted nudibranch (*Dirona albolineata*)	Snail (Class Gastropoda)	Echinoderms: Sunflower star (*Pycnopodia helianthoides*)	Ochre star (*Pisaster ochraceus*)	Spiny pink star (*Pisaster brevispinus*)	Cnidarians (% Areal Cover): Pink-tipped anemone (*Anthopleura elegantissima*) (Count & % Areal Cover)	Stubby rose anemone (*Urticina* sp.)	Worms: Slime-tubed feather duster worm (*Myxicola infundibulum*)	Jointed tubeworm (*Spiochaetopterus costarum*)	Bryozoan (% Areal Cover): Bryozoan (Phylum Bryozoa)	Vertebrates: Sculpin (Family Cottidae)	Gunnel (Family Pholidae)	Comments
I-Q1	0																										
-	2																										
TS1	0 to 5																										45cm diameter protection log observed at 1.3m
I-Q2	5																										
TS2	5 to 10																										
I-Q3	10																										
TS3	10 to 15																										
I-Q4	15	10									6																
TS4	15 to 20	5 to 25								M			F														
I-Q5	20	4								6 (<1%)[1]	6		35														Species presence obeserved above 21m and substrate consists mostly of large sediment
-	22																										
TS5	20 to 25	5 to 25								A			A							M							Slope changes at 22m; transition of substrate from sand to cobble
I-Q6	25	8								136 (7%)[1]			26							8 (2%)[2]							Fine sand
TS6	25 to 30	< 1								M			M							M			A				Clam squirts
I-Q7	30						1													3 (<1%)[2]			75				Intertidal slope 2 to 22m = 16%(9˚); 22 to 37m = 5%(3˚). Worm casings.
TS7	30 to 35	< 1	S							M			M	F						M			M				Substrate is fine sand almost silt; mussels only observed on rocks; many worm casings in sandy zone only; clam squirts
I-Q8	35																			1 (<1%)[2]			75				36.6m to waterline at 7:15am. Fine sand with worm casings present.
	36.6																										End of intertidal transect
TS8	35 to 40																			M			A				Substrate distal along transect line is predominantly sand/silt (75-100%) and the substrate shoreward along the transect line is mainly cobble (50-75%) with sand/silt (5-25%). *Ulva* spp. density increased with depth.
S-Q1	40		1					1					5							5 (<2%)[2]			55				
TS9	40 to 45		1																	F							Difficult to see the substrate as it is obscured by *Ulva* spp.
S-Q2	45	<1	1				1						25	8		2								3		1	
TS10	45 to 50																S				S						Difficult to see the substrate as it is obscured by *Ulva* spp.
S-Q3	50								6			2	1										1		1		
TS11	50 to 55				S												F										
S-Q4	55		1		1							1													1		
TS12	55 to 60			S															S								
S-Q5	60	<1							3				1														
TS13	60 to 65		S									F						S				S					
S-Q6	65	<1							1															1	1		
TS14	65 to 70				S																						
S-Q7	70	<1							2															<1			Brittle star legs poking out of substrate.
TS15	70 to 75				S																						
S-Q8	75	<1							2			2			1				1								Brittle star legs poking out of substrate.
TS16	76 to 80					S			F								S		F								

Notes

* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For August 26, 2012 (Tide at 7:00 = -0.15 m, Tide at 9:00 = 0.43 m)

I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)

Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect

Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.

Transect segment observations were recorded every 5m.

Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : < 1 %, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.

Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)

[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

[2] Percent cover for Pink-tipped Anemone (*Anthopleura elengatissima*) was determined during survey *in situ* or using the average size per anemone as 15mm x 15mm or 0.3% of the total quadrat area

Data Entered By: Trish Tomliens (on November 21, 2012)
Data Checked By: Andrew Rippington (on December 18, 2012)

Appendix B
Rich Passage Biophysical Surveys
Location: Point White West
Site/Transect Number: 3B
Date: May 19, 2012

Project Number: 11393490/200/220

Transect Lat/Long Onshore/Offshore (ddmm.mmm):
47 35.490, 122 33.938/47 35.474, 122 33.918

					Substrate Type (% Areal Cover)							Green Algae (Phylum Chlorophyta) (% Areal Cover)	Brown Algae (Phylum Ochrophyta) (% Areal Cover)		Red Algae (Phylum Rhodophyta) (% Areal Cover)										Arthropods				Molluscs									Echinoderms				Cnidarians (% Areal Cover)		Worms	
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/ Intertidal Slope	Corrected Elevation (m)*	Time	Boulder (> 25cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand (0.006 to 0.2 cm)	Silt (<0.006 cm)	Shell fragments	Hard clay	Sea lettuce (*Ulva*/ *Ulvaria* spp.)	Acid-weed (*Desmarestia viridis*)	Wireweed (*Sargassum muticum*)	Encrusting coralline algae (Unidentified species)	*Microcladia borealis*	*Plocamium* sp.	Turkish towel (*Chondracanthus exasperatus*)	*Sarcodiotheca gaudochaudii*	*Mazzaella* spp.	*Palmaria* spp.	*Rhodymenia* spp.	Filamentous Red algae (Unidentified species)	Red algae (Unidentified species)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Kelp crab (*Pugettia* sp.)	Helmet crab (*Telmessus cheiragonus*)	Shrimp (*Pandalus* sp.)	False jingle shell (*Pododesmus macrochisma*)	Horse clam (*Tresus capax*)	Piddock clam (*Zirphaea pilsbryi*)	Mussels (*Mytilus* sp.) (Count & % Areal Cover)	Chiton (*Tonicella* / *Mopalia* sp.)	Limpets (Family Lottiidae)	Whelk (Unidentified species)	Periwinkle (*Littorina* spp.)	Nudibranch (*Onchidoris bilamellata*)	Ochre star (*Pisaster ochraceus*)	Leather star (*Dermasterias imbricata*)	Sea cucumber (*Cucumaria miniata*)	Six leg sea star (*Leptasterias hexactis*)	Pink-tipped anemone (*Anthopleura elegantissima*) (Count & % Areal Cover)	Hydroid (Class Hydrozoa)	Calcareous tubeworm (Family Serpulidae) (% Areal Cover)	Comments
I-Q1	0	15%/8.5˚	3	9:30		4	95			1															4																				Beach mainly gravel with few scattered boulders; no algae observed. Slopw consistent throughout intertidal reach.
TS1	0-5				<5	5 to 25	75 to 100			<5																																			Mainly gravel .
I-Q2	5	15%/8.5˚	2.26	9:38		5	95																		1																				
TS2	5 to 10				< 5	5 to 25	75 to 100																		< 5																				Barnacles restricted to boulders.
I-Q3	10	15%/8.5˚	1.51	9:40		10	90																		1																				
TS3	10 to 15				< 5	50 to 75	5 to 25	< 5		<5															5 to 25																				Barnacle density increased towards the waterline after 12m along the transect.
I-Q4	15	15%/8.5˚	0.77	9:43		90	8	2		<1															80									1		18						1 (0.3%)[2]			
TS4	15 to 20				<5	75 to 100	5 to 25	<5				<5													25 to 50																				Small sized boulderes were observed. An Ochre star was observed approx 5m from the transect line.
I-Q5	20	15%/8.5˚	0.03	9:53		85	10	5		<1															95							1 (<1%)[1]		6		7	3					3 (0.9%)[2]			
TS5	20 to 25					75 to 100	5 to25			5 to 25				5 to 25		< 1		< 1		<1	<5			5 to 25								F			S										Very poor visibility. Wireweed began at 24.5 m along transect. Clam siphon holes observed near 25 m. Clam squirts and *P. ochraceus* nearby.
S-Q1	25	0	-0.14	11:03		P								P											P																				Poor visibility (<5cm), unable to determine % cover of quadrat components. Very shallow.
TS6	25 to 30				5 to 25	50 to 75	< 5	5 to 25	5 to 25			<1		25 to 50										5 to 25						S	F														Wireweed ends at 29m. Very poor visibility, other algae unable to be seen.
S-Q2	30	0.6	-0.74	11:30		40	10	45		5		5						30	10	35	5	5	5			1	1	1		1											1				
TS7	30 to 35				5 to 25	5 to 25	5 to 25	5 to 25			5 to 25		< 5											50 to 75														S	F	S					
S-Q3	35	2	-2.14	11:35	15	30	10	45	<1				< 5		<1		30			5					1	1			3				1	1									1	<1	Small sized boulders.
TS8	35 to 38				5 to 25	5 to 25	5 to 25	5 to 25			5 to 25				<5									50 to 75							F														Dense algae cover over hard clay / mudstone (hard pan) resulted in difficulties idtenifying organisms and substrate types present along this transect segment.

Notes

* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For May 19, 2012 (Tide at 9:30 = 0.25 m, Tide at 11:30 = -0.12 m)

I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)

Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect
Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.
Transect segment observations were recorded every 5m.
Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : <1%, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.
Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)
Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes

[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

[2] Percent cover for Pink-tipped Anemone (*Anthopleura elengatissima*) was determined during survey *in situ* or using the average size per anemone as 15mm x 15mm or 0.3% of the total quadrat area

Data Entered By: Michelle Spani (on June 11 2012)
Data Checked By: Andrew Rippington (on Nov 20, 2012); Michelle Spani (on Dec 7, 2012)

Appendix B
Rich Passage Biophysical Surveys
Location: Manette Beach
Site/Transect Number: 3B
Date: August 27, 2012

Project Number: 11393490/200/220

Transect Lat/Long Onshore/Offshore (ddmm.mm):
47 35.490, 122 33.938/47 35.474, 122 33.918

Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/ Intertidal Slope	Corrected Elevation (m)*	Time	Substrate Type (% Areal Cover)						Other (% Areal Cover)	Green Algae (Phylum Chlorophyta) (% Areal Cover)	Brown Algae (Phylum Ochrophyta) (% Areal Cover)	
					Boulder (> 25 cm)	Hardpan	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand (0.006 to 0.2 cm)	Shell fragments	Detrital algae	Sea lettuce (*Ulva/ Ulvaria* spp.)	Wireweed (*Sargassum muticum*)	Acid-weed (*Desmerestia* sp.)
I-Q1	0	15%/8°	3.02	9:19				15	35	50				
TS1	0-5			9:18			< 1	25 to 50	25 to 50	5 to 25	< 1			
I-Q2	5	15%/8°	2.28	9:16				99	1	<1	<1			
TS2	5 to 10			9:15	<5		5 to 25	50 to 75		< 1	< 1			
I-Q3	10	16%/9°	1.49	9:13			2	96	1	1				
TS3	10 to 15			9:10	<5		25 to 50	25 to 50	< 1	<5		< 1		
I-Q4	15	13%/7.5°	0.84	9:04			55	43		2				
TS4	15 to 20			8:59			50 to 75	25 to 50		<5		<5		
I-Q5	20	14%/8°	0.15	8:49			16	81		3		5		
TS5	20 to 25			8:42			50 to 75	25 to 50		<5		5 to 25	<5	
	21.9	14%/8°	-0.12	8:43										
S-Q1	25	0.5	-0.56	9:15			75	15	10			15		
TS6	25 to 30				<5		50 to 75	5 to 25	5 to 25			25 to 50	25 to 50	
S-Q2	30	0.8	-0.86	8:52	30		35	10	25	<1		15		
TS7	30 to 35					50 to 75	25 to 50	5 to 25	5 to 25			25 to 50		
S-Q3	35	2.2	-2.37	8:41	10		40	10	10	<1				
TS8	35 to 38			8:35	5 to 25		25 to 50	25 to 50	5 to 25	<5		5 to 25		<5

Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Red Algae (Phylum Rhodophyta) (% Areal Cover)														
		Microcladia spp.	*Sarcodiotheca* spp.	*Prionitis lanceolata*	*Mazzaella* spp.	Turkish washcloth (*Mastocarpus* spp.)	Turkish towel (*Chondracanthus exasperatus*)	*Porphyra* spp.	Red cup (*Constantinea* sp.)	Encrusting coralline algae (Unidentified species)	*Plocamium* sp.	*Cryptosiphonia* sp.	*Polyneura* spp.	*Hymenena* sp.	Filamentous Red algae (Unidentified species)	Red algae (Unidentified species)
I-Q1	0															
TS1	0-5															
I-Q2	5															
TS2	5 to 10															
I-Q3	10															
TS3	10 to 15							< 1								
I-Q4	15							2								
TS4	15 to 20					< 1		< 1								
I-Q5	20							2								
TS5	20 to 25				< 1	< 1		<5								
	21.9															
S-Q1	25	2		5			5		2			<1				
TS6	25 to 30						25 to 50									
S-Q2	30		15		20		20			5	15		10	4		
TS7	30 to 35						50 to 75									5 to 25
S-Q3	35						60		1		2				2	
TS8	35 to 38						75 to 100			<5						<5

Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Arthropods								Molluscs							
		Barnacles (Suborder Balanomorpha) (% Areal Cover)	Red Rock crab (*Cancer productus*)	Shore crab (*Hemigrapsus* spp.)	Longhorn decorator crab (*Chorilia longipes*)	Helmet crab (Telmessus sp.)	Kelp crab (*Pugettia* sp.)	Hermit crab (*Pagurus* spp.)	Shrimp (*Crangon* spp.)	Mussels (*Mytilus* sp.) (Count & % Areal Cover)	Periwinkle (*Littorina* spp.)	Piddock clam (*Zirphaea pilsbryi*)	False jingle shell (*Pododesmus macrochisma*)	Horse clam (*Tresus* sp.)	Limpets (Family Lottiidae)	Whelk (Unidentified species)	Chiton (*Tonicella* / *Mopalia* sp.)
I-Q1	0																
TS1	0-5																
I-Q2	5																
TS2	5 to 10	< 5								F	M						
I-Q3	10	<1								5 (<1%)[1]	1				4		
TS3	10 to 15	5 to 25						S		F	M				M		
I-Q4	15	32									48				7		
TS4	15 to 20	50 to 75		F				S		M	A				A		
I-Q5	20	10													21	2	
TS5	20 to 25	25 to 50		S											A	F	
	21.9																
S-Q1	25	<1													5		2
TS6	25 to 30		S			S								S			
S-Q2	30				1	1							1		15		2
TS7	30 to 35					S	S	S	F			F		S			
S-Q3	35								1				3				1
TS8	35 to 38					S						F					

Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Echinoderms			Sponge (% Areal Cover)	Bryozoan (% Areal Cover)	
		Sunflower star (*Pycnopodia helianthoides*)	Leather star (*Dermasterias imbricata*)	Ochre star (*Pisaster ochraceus*)	Sponge (Phylum Porifera)	Bryozoan (Phylum Bryozoa)	Comments
I-Q1	0						Shell fragments approximately 5-10mm in diameter (similar in size to gravel).
TS1	0-5						Sandy bands (small gravel) was observed in the upper intertidal zone.
I-Q2	5						
TS2	5 to 10						
I-Q3	10						Waterline at 20m at 9:25am
TS3	10 to 15						Cobble becomes gravel at 13m
I-Q4	15						
TS4	15 to 20			S			A band of barnacles was observed from 12m to 20m
I-Q5	20						
TS5	20 to 25			F			Waterline is 21.9m at 8:43am; *Sargassum* begins at 24m and *Evasterias* was observed at the waterline. Clam squirts.
	21.9						
S-Q1	25					<1	Very poor visibility; Too shallow for gauge depth; small limpets
TS6	25 to 30						Poor visibility; bottom obscured by 75 to 100% algae
S-Q2	30				2	<1	Bottom obscured by algae. Limpets very small.
TS7	30 to 35						Bottom obscured by 75 to 100% algae; smaller substrates overlying shale
S-Q3	35				1	2	Quadrat covered by Turkish towel blades, worm casings observed
TS8	35 to 38	S	S				Bottom obscured by 75 to 100% algae

Notes

* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For August 27, 2012 (Tide at 8:45 = -0.12 m, Tide at 9:00 = -0.06 m)

I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)

Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect

Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.

Transect segment observations were recorded every 5m.

Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : < 1%, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.

Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)

Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes

[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

Data Entered By: Trish Tomliens (on November 23, 2012)
Data Checked By: Andrew Rippington (on December 18, 2012)

Appendix B
Rich Passage Biophysical Surveys
Location: Point White
Site/Transect: 5D
Date: May 21, 2012

Project Number: 11393490/200/220

Transect Lat/Long Onshore/Offshore (ddmm.mmm):
47 35.722, 122 33.624/47 35.715, 122 33.604

					Substrate Type (% Areal Cover)						Other (% Areal Cover)		Green Algae (Phylum Chlorophyta) (% Areal Cover)	Brown Algae (Phylum Ochrophyta) (% Areal Cover)					Red Algae (Phylum Rhodophyta) (% Areal Cover)											Arthropods				Molluscs							Echinoderms			Cnidarians (% Areal Cover)		Worms	Sponge (% Areal Cover)	Bryozoan (% Areal Cover)	
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/ Intertidal Slope	Corrected Elevation (m)*	Time	Boulder (> 25 cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand (0.006 to 0.2 cm)	Silt (<0.006 cm)	Shell fragments	Wood debris	Detrital algae	Sea lettuce (*Ulva/ Ulvaria* spp.)	Rockweed (*Fucus* sp.)	Wireweed (*Sargassum muticum*)	Sea cauliflower (*Leathesia difformis*)	*Scytosiphon lomentaria*	Filamentous Brown algae (Unidentified species)	Encrusting coralline algae (Unidentified species)	*Microcladia borealis*	Turkish towel (*Chondracanthus exasperatus*)	*Sarcodiotheca gaudochaudii*	*Erythonia* sp.	*Hymenena* spp.	*Mazzaella* spp.	*Delesseria decipiens*	*Palmaria* spp.	*Prionitis lanceolata*	Red algae (Unidentified species)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Hermit crab (Unidentified species)	Shore crab (*Hemigrapsus* spp.)	Helmet crab (*Telmessus cheiragonus*)	False jingle shell (Pododesmus macrochisma)	Mussels (*Mytilus* sp.) (Count & % Areal Cover)	Chiton (*Tonicella / Mopalia* sp.)	Limpets (Family Lottiidae)	Periwinkle (*Littorina* spp.)	Nudibranch (Unidentified species)	Whelk (Unidentified species)	Sunflower star (*Pycnopodia helianthoides*)	Mottled star (*Evasterias troscheli*)	Sea cucumber (*Cucumaria miniata*)	Anemone (Unidentified species)	Hydroid (Class Hydrozoa)	Calcareous tubeworm (Family Serpulidae) (% Areal Cover)	Sponge (Phylum Porifera)	Bryozoan (Phylum Bryozoa)	Comments
I-Q1	0	16%/9˚	3.42	10:34		2	95			3	< 1	8																		1																			Detrital algae and woody debris present near high water mark. Transect begins at base of rip rap.
TS1	0 to 5					<1	75 to 100			<1		< 1																																					Detrital algae present. Larger diameter gravel oberved 0m and 5m.
I-Q2	5	16%/9˚	2.63	11:14		4	96					< 1																		2																			Detrital algae present. Larger diameter gravel oberved 0m and 5m.
TS2	5 to 10					<5	75 to 100																							1																			Larger diameter substrate observed towards 10 m.
I-Q3	10	16%/9˚	1.84	11:18		4	96																							<1								7											Large diameter gravel present .
TS3	10 to 15				<1	25 to 50	50 to 75					< 1																		5 to 25					M		M	M											Well mixed cobble and gravel. Detrital algae present.
I-Q4	15	16%/9˚	1.05	11:25	20	20	60																							40					~80 (<5%)[1]		3	60		1									Well mixed cobble and gravel present. Mussels growing just beneath cobble/gravel surface layer. Shell, small gravel and sand immediately beneath surface substrate.
TS4	15 to 20				<5	50 to 75	25 to 50			5 to 25																				50 to 75		M			A		M	M											Detrital algae present . Substrate coarsening offshore. Small diameter gravel and shell observed below boulder and cobble. Many small *Hemigrapsus* spp. present within gravel/shell layer.
I-Q5	20	16%/9˚	0.26	11:41		70	30			< 1		< 1																		50					6 (0.3%)[1]		6												Detrital algae and well mixed cobble and gravel present.
TS5	20 to 25				<5	50 to 75	50 to 75			< 1			<1	<1		< 1		<5		<1	<1									25 to 50	F	F		F	M		A		S	M								<1	Detrital algae and nudibranch eggs observed. Clam squirts present.
S-Q1	25	0	-0.14	10:58	20	75	<1			5			10				<1	30												5							2							1				1	Abundant empty barnacle casings.
TS6	25 to 30				5 to 25	50 to 75	<5	5 to 25					<5		25 to 50														5 to 25					F							S								
S-Q2	30	0.9	-1.04	11:15	40	45		15					<1		25				<1		30	<1			5	3			< 1					3			3							6			1	2	Calcareous tubeworm casings observed on hard substrate.
TS7	30 to 35				<5	75 to 100	5 to 25	<5		<5			<5		5 to 25													< 5	5 to 25				S	F								S	S						Red algae - mainly Turkish towel.
S-Q3	35	1.8	-2.11	11:33	28	58	10	<4											10	2			2	3	10		12		34					11		2									<1	2	3		Boulder close to cobble size. Two species of *Palmaria* spp. algae present.
TS8	35 to 37			11:51		75 to 100	5 to 25	5 to 25					<5		<5						< 5								25 to 50							F					S			1					Poor visibility.

Notes

* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For May 21, 2012 (Tide at 10:30 = 0.1 m, Tide at 11:30 = -0.31 m)

I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)

Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect

Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.

Transect segment observations were recorded every 5m.

Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : <1%, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.

Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)

Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes

[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

Data Entered By: Michelle Spani June 5

Data Checked By: Andrew Rippington (on Nov 20, 2012); Michelle Spani (on Dec 7, 2012)

Appendix B
Rich Passage Biophysical Surveys
Location: Manette Beach
Site/Transect Number: 5D
Date: August 27, 2012

Project Number: 11393490/200/220

Transect Lat/Long Onshore/Offshore (ddmm.mm):
47 35.722, 122 33.624/47 35.715, 122 33.604

					Substrate Type (% Areal Cover)					Other (% Areal Cover)	Green Algae (Phylum Chlorophyta) (% Areal Cover)	Brown Algae (Phylum Ochrophyta) (% Areal Cover)			Red Algae (Phylum Rhodophyta) (% Areal Cover)											Arthropods					Molluscs					Echinoderms			Cnidarians (% Areal Cover)	Worms	Sponge	Bryozoan (% Areal Cover)	Vertebrates	
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/ Intertidal Slope	Corrected Elevation (m)*	Time	Boulder (> 25 cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand / Silt (<0.2 cm)	Shell fragments	Detrital algae	Sea lettuce (*Ulva/ Ulvaria* spp.)	Rockweed (*Fucus* sp.)	Wireweed (*Sargassum muticum*)	*Agarum* sp.	*Microcladia* spp.	*Sarcodiotheca* spp.	*Prionitis lanceolata*	*Mazzaella* spp.	Turkish washcloth (*Mastocarpus* spp.)	Turkish towel (*Chondracanthus exasperatus*)	*Porphyra* spp.	Encrusting coralline algae (Unidentified species)	*Rhodymenia* spp.	Filamentous Red algae (Unidentified species)	Red algae (Unidentified species)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Red Rock crab (*Cancer productus*)	Helmet crab (Telmessus sp.)	Kelp crab (*Pugettia* sp.)	Coonstripe shrimp (*Pandalus danae*)	Mussels (*Mytilus* sp.) (Count & % Areal Cover)	Periwinkle (*Littorina* spp.)	False jingle shell (*Pododesmus macrochisma*)	Limpets (Family Lottidae)	Whelk (Unidentified species)	Sunflower star (*Pycnopodia helianthoides*)	Mottled star (*Evasterias troschelii*)	Ochre star (*Pisaster ochraceus*)	Plumose anemone (*Metridium* spp.)	Calcareous tubeworm (Family Serpulidae)	Sponge (Phylum Porifera)	Bryozoan (Phylum Bryozoa)	Sculpin (Family Cottidae)	Comments
I-Q1	0	19%/9˚	3.77	10:48			100		<1																																			Waterline at 10:47am is 7.5m. Sampled Aug 25th
TS1	0-5					<1	75 to 100	<1	<1	<1																<1																		Substrate is approximately 100% gravel. Sampled Aug 25th
I-Q2	5	19%/9˚	2.84	10:54		2	98			<1											2					2					1													Mussel dimension is 2cm x 1cm. Sampled Aug 25th
TS2	5 to 10					<1	75 to 100		<1	<1											<1					<1																		Substrate is approximately 100% gravel. Sampled Aug 25th
I-Q3	10	16%/9˚	1.91	7:34		2	98														<1					2																		
TS3	10 to 15					5 to 25	75 to 100														<1					5 to 25						M		M										Increased presence of barnacles observed downslope; large limpets (~1.2cm diameter); large boulders observed below 15m mark.
I-Q4	15	16%/9˚	1.12	7:40	<1	50	50		<1												7					15						11		22										Shell fragments observed beneath surface substrate; most of the gravel is near cobble in size
TS4	15 to 20				<5	50 to 75	25 to 50		<5		<1										5 to 25					25 to 50					<1	A		A										Cobble increasing in size distally; small limpets; mussels observed at 18m
I-Q5	20	17%/9.5˚	0.28	7:50		50	50		<1		3										7					60					39 (2%)[1]	6		32										Large gravel; abundant empty barnacle tests
-	22.8	17%/9.5˚	-0.19	7:55																																								
TS5	20 to 25				<5	25 to 50	50 to 75		<1		5 to 25	<5						<1	<1	<1	<5										<5	M		A										Waterline at 7:55am is 22.8m; *Fucus* sp. observed at 23m along with an increase in *Ulva* spp.; nudibranch egg mass and whelks also observed
S-Q1	25	3.3	-0.1	16:33		95	5				40									<1		<1		<1	< 1	<1		1		2				25								<1		
TS6	25 to 30					75 to 100	5 to 25	<5			75 to 100		5 to 25							5 to 25					< 5			1	1							1							1	Bottom is obscured by 75 to 100% algae; buffalo sculpin
S-Q2	30	4	-0.8	16:41	60	30		10	<1		10						2			70		5					1		4											5	1			Bottom is obscured by Turkish towel, calcareous tubeworm casings observed.
TS7	30 to 35					50 to 75	25 to 50	5 to 25			25 to 50											<5			25 to 50		S			F			F		F	S			S					Bottom is largely obscured by 75 to 100% algae
S-Q3	35	4.7	-1.63	16:54	20	40	20	15	5		<1				1	2			4	15		5	40										3				1				<5			
TS8	35+				<5	50 to 75	50 to 75				5 to 25			<5						50 to 75					50 to 75			S		F			F			F	S	S	F					Substrate mainly large gravel and cobble

Notes
* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For August 27, 2012 (Tide at 8:00 = 3.17-0.19 m, Tide at 17:00 = 3.07 m)
I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)
Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect
Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.
Transect segment observations were recorded every 5m.
Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : < 1%, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.
Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)
Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes
[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

Data Entered By: Trish Tomliens (on November 23, 2012)
Data Checked By: Andrew Rippington (on December 18, 2012)

Appendix B
Rich Passage Biophysical Surveys
Location: Point Glover East
Site/Transect Number: 9B
Date: May 21, 2012

Project Number: 11393490/200/220

Transect Lat,Long Onshore/Offshore (ddmm.mmm):
47 35.366,122 33.109/47 35.401, 122 33.086

					Substrate Type (% Areal Cover)						Flowering Plants (Division Anthophyta) (% Areal Cover)	Green Algae (Phylum Chlorophyta) (% Areal Cover)				Brown Algae (Phylum Ochrophyta) (% Areal Cover)							Red Algae (Phylum Rhodophyta) (% Areal Cover)										Arthropods							Molluscs				Echinoderms		Cnidarians (%Areal Cover)	Vertebrates	
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/ Intertidal Slope	Corrected Elevation (m)*	Time	Boulder (>25 cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand (0.006 to 0.2 cm)	Sand / Silt (<0.2 cm)	Shell fragments	Eelgrass (*Zostera marina*)	Sea lettuce (*Ulva/ Ulvaria* spp.)	*Entromorpha* sp.	*Acrosiphonia* sp.	Encrusting Green algae (Unidentified species)	Rockweed (*Fucus* sp.)	Sea cauliflower (*Leathesia difformis*)	Wireweed (*Sargassum muticum*)	*Laminaria* spp.	*Scytosiphon lomentaria*	Acid-weed (*Desmarestia ligulata*)	Filamentous Brown algae (Unidentified species)	*Microcladia borealis*	*Sarcodiotheca gaudochaudii*	*Gracilaria* sp.	Turkish towel (*Chondracanthus exasperatus*)	*Smithora naiadum*	*Plocamium* sp.	*Mazzaella* spp.	*Porphyra* spp.	Red hair algae (Unidentified species)	Red algae (Unidentified species)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Kelp crab (*Pugettia* sp.)	Graceful crab (*Cancer gracilis*)	Hermit crab (Unidentified species)	Red Rock crab (*Cancer productus*)	Cancer crab (*Cancer* sp.)	Sand flea (Order Amphlipoda)	Mussels (Mytilus sp.) (Count & % Areal Cover)	Limpets (Family Lottiidae)	Periwinkle (*Littorina* spp.)	Moon snail (*Euspira* sp.)	Sunflower star (*Pycnopodia helianthoides*)	Brittle star (Family Ophiodermatidae)	Pink-tipped anemone (*Anthopleura elegantissima*) (Count & % Areal Cover)	Gunnel (Family Pholidae)	Comments
I-Q1	0	16%/9˚	4.26	13:05			90	5		5																							2						3									Transect begins at base of steep grassy bank. Detrital algae and wood drebris present.
TS1	0 to 5					<1	75 to 100	<5		<5																							<1						F									Detrital algae and wood drebris present. Sand and small diameter gravel begins at 2 m.
I-Q2	5	16%/9˚	3.47	13:13			100																										<1															Detrital algae present.
TS2	5 to 10					<1	75 to 100	<5		<1		<1	<1	<1		<1																	<1															Detrital algae present.
I-Q3	10	16%/9˚	2.68	13:21		5	92	3				<1	4			2																	2															Detrital algae present.
TS3	10 to 15					<5	75 to 100	5 to 25		<1		<1	<1	<1	<1	<1														<1			<1									M						Detrital algae present.
I-Q4	15	16%/9˚	1.89	13:26		6	90	3		1		<1	<1	1		<1													<1	1			3															Detrital algae present.
TS4	15 to 20					5 to 25	75 to 100	5 to 25		<5		<5	<1	<1		<1	<1		<1			<1	1	<1	<1	<1				<1			5 to 25						F	F	M	M						
I-Q5	20	16%/9˚	1.1	13:56		12	13	75		<1		40				8									1						2		15							5 (0.25%)[1]	1	2						Detrital algae present. Definite transition to sand beginning at ~20m. Slope change at 20m and remained consistent through to 33m (low tide).
TS5	20 to 25					5 to 25	5 to 25	75 to 100		<1		25 to 50	5 to 25	<1		<5	<1		<1	<1					<5	<5				<1		<5	<5							M	M	M				F		Detrital algae present. *Osmundea* spp. present at site. Unidentified red algae very damaged. Clam siphon holes near waterline. Mussels are very small.
I-Q6	25	10%/5.5˚	0.61	14:04		2	2		96	<1		12	1									5	< 1		2								<1								1							
TS6	25 to 30					5 to 25	5 to 25		75 to 100	<5		5 to 25	5 to 25			5 to 25						5 to 25											<5											S		F		
I-Q7	30	10%/5.5˚	0.11	13:35		2	13		85	<1		25	2									10																								3 (0.9%)[2]		
TS7	30 to 35					<5	5 to 25		75 to 100	<5		5 to 25	<5																			<5								S			S			S		Tide line (low) at 33m.
S-Q1	35	0.5	-0.2	13:42		4	6		90	<1		20	5							<1		15						10								1												Gelatinous tubeworm casings present.
TS8	35 to 40				<5	<5	5 to 25		75 to 100	<5	5 to 25	5 to 25	5 to 25			<5		<5				5 to 25										<5												S				Dense patches of eelgrass present 1m west of transect (approximately 30-36 m along transect).
S-Q2	40	0.7	-0.4	13:56			1		98	1		2	1																																			
TS9	40 to 45				<5		<5		75 to 100	<5	50 to 75	<5	<5																			<5					S											Tire observed, eelgrass starts at 42m along transect.
S-Q3	45	1	-0.7	14:03		4	10		86		70		<1							1																												Eelgrass density 39 shoots/ 0.25 m^2.
TS10	45 to 50				<5		5 to 25		75 to 100	<5	75 to 100							<5				<5										<5			F		F										S	
S-Q4	50	1.3	-1	14:11			10		90	<1	65	2	4									<5		< 1	< 1																				P			Eelgrass density 24 shoots/ 0.25 m^2 , brittle stars burried under substrate, juvenile wolf eel observed in eelgrass bed along transect line.
TS11	50 to 55						5 to 25		50 to 75	<5	50 to 75								<5			5 to 25										<5																Moon snail egg casing.
S-Q5	55	1.7	-1.05	14:22		1	15		84		5		1						2					2													1								P			Eelgrass density 11 shoots/ 0.25 m^2, brittle stars buried in substrate. Two species of Laminariales present.
TS12	55 to 60				<5		<5		75 to 100		75 to 100	<5	<5						<5			5 to 25										<5		S														Filamentous brown algae on eelgrass in addition to % on substrate.
S-Q6	60	1.8	-1.15	14:31			2		98		35		5									4		2			<1																		P			Eelgrass density 19 shoots/ 0.25 m^2, brittle stars buried in substrate.
TS13	60 to 65				<5		5 to 25		75 to 100		75 to 100								<5													<5																Epiphytic filamentous brown algae on eelgrass.
S-Q7	65	2.4	-1.75	14:34			<1		99		90																								2													Eelgrass density 28 shoots/ 0.25 m^2.
TS14	65 to 70						5 to 25		75 to 100	<5	75 to 100								<5													<5																
S-Q8	70	2.5	-1.85	14:43			5		95		30								2		4	<2		1														1										Eelgrass density 14 shoots/ 0.25 m^2.

Notes

Drifting *Nereocsytis luetkeana* with holdfast attached observed floating by beyond end of transect

* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For May 21, 2012 (Tide at 13:00 = - 0.21 m, Tide at 14:30 = 0.65 m)

I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)

Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect
Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.
Transect segment observations were recorded every 5m.
Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : <1%, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.

Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)
Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes

[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

[2] Percent cover for Pink-tipped Anemone (*Anthopleura elengatissima*) was determined during survey *in situ* or using the average size per anemone as 15mm x 15mm or 0.3% of the total quadrat area

Data Entered By: Michelle Spani on June 13 2012
Data Checked By: Andrew Rippington (on Nov 2, 2012); Michelle Spani (on Dec 7, 2012)

Appendix B
Rich Passage Biophysical Surveys
Location: Point Glover East
Site/Transect Number: 9B
Date: August 30, 2012

Project Number: 11393490/200/220

Transect Lat,Long Onshore/Offshore (ddmm.mmm):
47 35.366,122 33.109/47 35.401, 11 33.086

					Substrate Type (% Areal Cover)						Other (% Areal Cover)	Flowering Plants (Division Anthophyta) (% Areal Cover)	Green Algae (Phylum Chlorophyta) (% Areal Cover)		Brown Algae (Phylum Ochrophyta) (% Areal Cover)						Red Algae (Phylum Rhodophyta) (% Areal Cover)											Arthropods					Molluscs							Echinoderms		Cnidarians (% Areal Cover)	Worms	Bryozoan (% Areal Cover)	Vertebrates		
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/ Intertidal Slope	Corrected Elevation (m)*	Time	Boulder (> 25 cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand (0.006 to 0.2 cm)	Silt (<0.006 cm)	Shell fragments	Detrital algae	Eelgrass (*Zostera marina*)	Sea lettuce (*Ulva/ Ulvaria* spp.)	Filamentous Green algae (Unidentified species)	Rockweed (*Fucus* sp.)	Sea cauliflower (*Leathesia difformis*)	Wireweed (*Sargassum muticum*)	*Laminaria* spp.	*Agarum* sp.	Filamentous Brown algae (Unidentified species)	Red algae (Class Florideophyceae)	*Sarcodiotheca gaudichaudii*	*Gracilaria* sp.	Turkish towel (*Chondracanthus exasperatus*)	Turkish washcloth (*Mastocarpus papillatus*)	*Ceramium* spp.	*Smithora naiadum*	*Mazzaella* spp.	*Palmaria* spp.	*Porphyra* spp.	Red algae (Unidentified species)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Kelp crab (*Pugettia* sp.)	Graceful crab (*Cancer gracilis*)	Hermit crab (Unidentified species)	Shrimp (*Pandalus* sp.)	Mussels (*Mytilus* sp.) (Count & % Areal Cover)	Limpets (Family Lottiidae)	False jingle shell (Pododesmus macrochisma)	Periwinkle (*Littorina* spp.)	Snail (Class Gastropoda)	Chiton (Order Neoloricata)	Frosted nudibranch (*Dirona albolineata*)	Sunflower star (*Pycnopodia helianthoides*)	Brittle star (Family Ophiodermatidae)	Pink-tipped anemone (*Anthopleura elegantissima*) (Count & % Areal Cover)	Jointed tubeworm (*Spiochaetopterus costarum*)	Bryozoan (Phylum Bryozoa)	Gunnel (Family Pholidae)	Shiner perch (*Cymatogaster aggregata*)	Comments
I-Q1	0	15%/8.5°	3.81	11:50		2	95			3	20																																								
TS1	0 to 5					< 1	25 to 50	50 to 75		5 to 25	< 5																																								At 1.0m along transect gravel turns to sand then back to gravel at 4.0m
I-Q2	5	14%/8°	3.07	11:48			50			50																																									
TS2	5 to 10					< 5	75 to 100	< 1		5 to 25	< 1																					< 1																			At 8.5m along transect, gravel size decreases (average ~1 cm)
I-Q3	10	14%/8°	2.37	11:40		2	98			< 1																						< 1																			
TS3	10 to 15					5 to 25	75 to 100	< 1		< 1					< 1																	< 1																			
I-Q4	15	15%/8.5°	1.68	11:31		5	95							1																		5																			Large gravel. New barnacle growth.
TS4	15 to 20				< 5	25 to 50	50 to 75	5 to 25	< 5	< 1			< 5		< 1										< 1					< 1		5 to 25					F	F		A						F					
I-Q5	20	9%/5°	0.94	11:16		4	8	45	42	1					< 1					1										2		7						4		2						1 (<1%)^2					
TS5	20 to 25				< 5	< 5	5 to 25	25 to 50	25 to 50	< 1			25 to 50	< 1	< 1	< 1				< 1					< 1					< 5		< 5					M	M								M					
I-Q6	25	5%/3°	0.49	11:04		3	6	45	45	< 1			40	< 1	2					< 1	< 1									1		1					1 (<1%)^1														
TS6	25 to 30					< 1	< 5	50 to 75	50 to 75	< 1			5 to 25		< 1						< 1	< 1	< 1									< 5					S									M					Anemones seen in lower part of section. Horse clam shell observed. Barnacles observed on cobble and gravel only.
I-Q7	30	6%/3°	0.24	10:46		6	12	40	40	2			26																			2														3 (<1%)^2					Clay brick in quadrat
TS7	30 to 35					< 1	< 5	25 to 50	50 to 75	< 1			50 to 75		< 1							< 1	< 1	< 1		< 1		< 1				< 1														M					*Ceramium* spp. was growing epiphytically on *Sarcodiotheca* spp. Silt and sand were similar size and well mixed; eelgrass visible above tide line to west of transect; Clam squirts present; Pink-tipped anemones living in sand.
I-Q8	35	0.3	-0.06	10:46			6	42	50	2			18										< 1																												
TS8	35 to 40				< 5		< 5	25 to 50	25 to 50	< 5		< 5	5 to 25									< 5									< 5																				Poor visibility. Sand and silt well mixed (75 to 100%).
S-Q1	40	0.6	-0.82	12:07			2	40	58	< 1			30				3					2											S																		Sand and silt well mixed. Poor visibility. Brittle star legs sticking through substrate.
TS9	40 to 45						< 5	25 to 50	25 to 50	< 5		75 to 100	5 to 25																		< 5				S																Eelgrass ends at 41.8m. Sand and silt well mixed. 75% to 100% mixed silt/sand.
S-Q2	45	0.6	-0.82	11:54			2	49	49			95															20																								Sand and silt well mixed. Dense eelgrass. Eelgrass density 64 shoots/ 0.25 m^2
TS10	45 to 50						5 to 25	25 to 50	25 to 50			75 to 100	< 5																																						Shallow, poor visibility. Sand and silt well mixed.
S-Q3	50	0.9	-0.93	11:45			6	47	47	< 1		60	< 1									4					30																								Brittle star legs sticking through substrate. Sand and silt well mixed. 75% to 100% mixed silt/sand. Eelgrass density 38 shoots/ 0.25 m^2
TS11	50 to 55				< 5	< 5	5 to 25	25 to 50	25 to 50	< 5		75 to 100	< 5					< 5	< 5																							S									Sand and silt well mixed (75 to 100%).
S-Q4	55	0.9	-0.93	11:32			2	49	49	< 1		45	4														20		< 1		< 5		S										S								Some byrozoans on eelgrass blades; Brittle star legs sticking through substrate. Sand and silt well mixed. Eelgrass density 34 shoots/ 0.25 m^2
TS12	55 to 60			11:36			< 5	25 to 50	25 to 50	< 5		75 to 100	< 5														25 to 50																						S		Brittle star legs sticking through substrate. Sand and silt well mixed.
S-Q5	60	1.1	-1.07	11:27			1	49	49	1		30	1									4					15																S								Brittle star legs sticking through substrate. Sand and silt well mixed. Eelgrass density 32 shoots/ 0.25 m^2
TS13	60 to 65					< 5	5 to 25	25 to 50	25 to 50	< 5		75 to 100	5 to 25														25 to 50				< 5	< 1		S					S												Brittle star legs sticking through substrate. Sand and silt well mixed. 75% to 100% mixed silt/sand.
S-Q6	65	1.3	-1.27	11:17			8	46	46			40	1									4					20							1		S					1				P						Sand and silt well mixed. Eelgrass density 27 shoots/ 0.25 m^2
TS14	65 to 70						5 to 25	25 to 50	25 to 50			75 to 100	< 5														25 to 50				< 5			S													P				Sand and silt well mixed.
S-Q7	70	1.6	-1.66	11:07			8	45	45	2		45	1														25																1		P			P			Sand and silt well mixed. Eelgrass density 26 shoots/ 0.25 m^2
TS15	75 to 76						< 5	25 to 50	25 to 50	< 5		75 to 100	<5									<5		<5			25 to 50				5 to 25												S	S	P					S	Sand and silt well mixed.

Notes
* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For August 30, 2012 (Tide at 10:30 = -0.06 m, Tide at 12:00 = 0.22 m)
I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)
Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect
Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.
Transect segment observations were recorded every 5m.
Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : < 1 %, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.
Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)
Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes
[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area
[2] Percent cover for Pink-tipped Anemone (*Anthopleura elengatissima*) was determined during survey *in situ* or using the average size per anemone as 15mm x 15mm or 0.3% of the total quadrat area

Data Entered By: Andrew Rippington on November 29, 2012
Data Checked By: Michelle Spani on December 21 2012

Appendix B
Rich Passage Biophysical Surveys
Location: Point Glover Mid
Site/Transect Number: 9D
Date: May 22, 2012

Project Number: 11393490/200/220

Transect Lat/Long Onshore/Offshore (ddmm.mmm):
47 35.357,122 33.411/47 35.377, 122 33.439

					Substrate Type (% Areal Cover)							Other (% Areal Cover)	Green Algae (Phylum Chlorophyta) (% Areal Cover)		Brown Algae (Phylum Ochrophyta) (% Areal Cover)								Red Algae (Phylum Rhodophyta) (% Areal Cover)															Arthropods							Molluscs						Echinoderms					Cnidarians (% Areal Cover)		Worms		Sponge (% Areal Cover)	Bryozoan (% Areal Cover)	Vertebrates	
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/ Intertidal Slope	Corrected Elevation (m)*	Time	Bedrock (Shale-like hard clay / mud stone)	Boulder (> 25cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand (0.006 to 0.2 cm)	Silt (< 0.006 cm)	Shell fragments	Detrital algae	Sea lettuce (*Ulva/ Ulvaria* spp.)	*Enteromorpha linza*	Rockweed (*Fucus* sp.)	Wireweed (*Sargassum muticum*)	*Laminaria* spp.	*Agarum* sp.	Acid-weed (*Desmarestia viridis*)	Acid-weed (*Desmarestia ligulata*)	Sea cauliflower (*Leathesia difformis*)	Filamentous Brown algae (Unidentified species)	*Sarcodiotheca gaudochaudii*	Encrusting coralline algae (Unidentified species)	*Prionitis lanceolata*	*Palmaria* spp.	*Hymenena* sp.	*Delesseria decipiens*	*Microcladia borealis*	Red cup (*Constantinea subulifera*)	Turkish towel (*Chondracanthus exasperatus*)	*Gracilaria* sp.	*Plocamium* sp.	*Mazzaella* spp.	*Rhodymenia pacifica*	Red hair algae (Unidentified species)	Red algae (Unidentified species)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Red mite (*Neomolgus littoralis*)	Hermit crab (Unidentified species)	Rockweed isopod (*Idotea* spp.)	Decorator crab (*Hyastenus longipes*)	Helmet crab (*Telmessus cheiragonus*)	Red Rock crab (*Cancer productus*)	Mussels (Mytilus sp.) (Count & % Areal Cover)	Limpets (Family Lottiidae)	Periwinkle (*Littorina* spp.)	Piddock clam (*Zirphaea pilsbryi*)	False jingle shell (*Pododesmus macrochisma*) (% Areal Cover)	Whelk (Unidentified species)	Ochre star (*Pisaster ochraceus*)	Leather star (*Dermasterias imbricata*)	Sunflower star (*Pycnopodia helianthoides*)	Brittle star (Family Ophiodermatidae)	Mottled star (*Evasterias troschelii*)	Pink-tipped anemone (*Anthopleura elegantissima*) (Count & % Areal Cover)	Cup coral (*Caryophyllia alaskensis*)	Spaghetti worm (Family Terebellidae)	Slime-tubed feather duster (*Myxicola infundibulum*)	Sponge (Phylum Porifera)	Bryozoan (Phylum Bryozoa)	Gunnel (Family Pholidae)	Comments
I- Q1	0	14%/8˚	3.31	14:27				15			85	30																											25																								
TS1	0 to 5					< 5	< 5	50 to 75			25 to 50																																																				Shell fragment size equal to gravel ~1cm.
I-Q2	5	14%/8˚	2.62	14:23			5	75			20																																																				
TS2	5 to 10					< 5	5 to 25	75 to 100			5 to 25																											< 1																									
I-Q3	10	14%/8˚	1.92	14:20				98			2	1																																																				
TS3	10 to 15						< 5	75 to 100			< 1		< 5	< 1	< 5							< 1									< 1			< 1				< 1							M		F																Substrate increases in size going downslope.
I-Q4	15	14%/8˚	1.12	14:08	20		10	55		10	5																											15							2 (0.1%)^1		15									2 (0.6%)^2							
	15.8	14%/8˚																																																													
TS4	15 to 20				5 to 25		5 to 25	75 to 100		< 5	5 to 25		< 5	< 5	< 5		< 5				< 1	< 1									< 1	< 5						25 to 50							M	F	M									M							
I-Q5	20	11%/6˚	0.66	13:56			4	89	7			10					5					25									5	3		3				20								1																	Detrital algae = *Sargassum* sp., *Mazzaella* spp. in tar spot form.
TS5	20 to 25				5 to 25	< 5	5 to25	50 to75		5 to25			< 1	< 1			< 1					5 to25	< 1								< 1	5 to 25		< 1				5 to25			F				M	F																	*Mazzaella* spp. in gametophyte and sporophyte stage.
I-Q6	25	11%/6˚	0.11	13:42		8	25	20		47			4	2	2						1	80										4		3				< 1								1																	
	29.7	11%/6˚		13:09																																																											
TS6	25 to 30				50 to 75		< 5	< 5		25 to 50			5 to 25	< 1	< 1	< 1	< 5		< 1			5 to 25	< 1								< 1	< 1		< 1		< 1		> 1		S						F			F							M							
I-Q7	30	0.1	-0.4	13:03			25	75					5	2		5						2												< 1														4								3 (0.9%)^2							
TS7	30 to 35				25 to 50		< 1	< 5		50 to 75			5 to 25	< 5			< 5						< 1																									M								F						S	Abundant salmonid fry above quadrat; very poor visibility; Anemone species difficult to determine.
S-Q1	35	0.5	-0.89	13:10	95			5					2			20						75	2																									7															
TS8	35 to 40				75 to 100		5 to 25	5 to 25	5 to 25				< 5			25 to 50	5 to 25					25 to 50															5 to 25			M		S	F					M			S				F								
S-Q2	40	1	-1.05	14:05	5		40	40	15				30						< 1	< 1		20	2	< 1	< 1	< 1	< 1	< 1	< 1	< 1	15	< 1		< 1		< 1	1					1		S					2	1				P			1				< 1		Brittle star legs poking out of substrate. Gravel and cobble made up of bedrock fragments and overlying hardpan bedrock. Quadrat covered by algal blades led to reduced visibility of benthic community.
TS9	40 to 45				25 to 50		25 to 50	25 to 50	5 to 25							5 to 25	25 to 50	25 to 50																			5 to 25												F									F		P			Gravel and cobble made up of bedrock fragments and overlying hard pan bedrock. Understory kelps occupied 50 to 75% of the segment.
S-Q3	45	1.5	-1.55	14:15		20	70	5	5															5			1			< 1		< 1	< 1	< 1	1	20						1						1													1		Gravel and cobble made up of bedrock fragments and overlying hard pan bedrock. Quadrat covered by algal blades led to reduced visibility of benthic community.
TS10	45 to 50				25 to 50		25 to 50	25 to 50			< 5		< 5				25 to 50	50 to 75		< 5				< 5													5 to 25					S						F				S	S						S				Gravel and cobble made up of bedrock fragments and overlying hard pan bedrock. Understory kelps occupied 75 to 100 % of the segment.
S-Q4	50	2.7	-2.46	14:24	10		10	75	5								10						1	< 1		2			< 1				< 1	2	< 1	2											1																Brittle star legs poking out of substrate. Gravel and cobble made up of bedrock fragments and overlying hard pan bedrock. Quadrat covered by algal blades led to reduced visibility of benthic community.

Notes
Waterline at 29.3m @ 13:10
* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For May 22, 2012 (Tide at 13:00 = - 0.39 m, Tide at 14:30 = 0.24 m)
I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)
Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect
Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.
Transect segment observations were recorded every 5m.
Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : <1%, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.
Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)
Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes
Red hair algae refers to species that exhibit visual traits similar to *Polysiphonia paniculata*

[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

[2] Percent cover for Pink-tipped Anemone (*Anthopleura elengatissima*) was determined during survey *in situ* or using the average size per anemone as 15mm x 15mm or 0.3% of the total quadrat area

Data Entered By: Andrew Rippington on Nov 5, 2012
Data Checked By: Andrew Rippington (on Nov 6, 2012); Michelle Spani (on Dec 7, 2012)

Appendix B
Rich Passage Biophysical Surveys
Location: Point Glover Mid
Site/Transect Number: 9D
Date: August 28, 2012

Project Number: 11393490/200/220

Transect Lat/Long Onshore/Offshore (ddmm.mmm):
47 35.357,122 33.411/47 35.377, 122 33.439

					Substrate Type (% Areal Cover)							Other (% Areal Cover)	Green Algae (Phylum Chlorophyta) (% Areal Cover)		Brown Algae (Phylum Ochrophyta) (% Areal Cover)			
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/ Intertidal Slope	Corrected Elevation (m)*	Time	Bedrock (Shale-like hard clay / mud stone)	Boulder (> 25 cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand (0.006 to 0.2 cm)	Silt (< 0.006 cm)	Shell fragments	Detrital algae	Sea lettuce (*Ulva/ Ulvaria* spp.)	*Enteromorpha linza*	Rockweed (*Fucus* sp.)	Wireweed (*Sargassum muticum*)	*Laminaria* spp.	*Agarum* sp.
I- Q1	0	15%/8.5°	3.92	9:15				5	95		10	1						
TS1	0 to 5						< 1	50 to 75	50 to 75		25 to 50	< 5						
I-Q2	5	15%/8.5°	3.18	9:12				50			50	< 1						
TS2	5 to 10						< 1	50 to 75			50 to 75				< 1			
I-Q3	10	16%/9°	2.39	9:10				75			25							
TS3	10 to 15				5 to 25		5 to 25	50 to 75	< 5	< 5	< 1		< 5		< 1		< 1	
I-Q4	15	16%/9°	1.60	9:02	2		25	50	5	20	< 1	4			< 1			
TS4	15 to 20				25 to 50		25 to 50	25 to 50	< 5		< 5		25 to 50		< 1		< 5	
I-Q5	20	9%/5°	1.06	8:55			12	80	8		2		2		< 1			
TS5	20 to 25				5 to 25		25 to 50	25 to 50	5 to 25	5 to 25	< 5		5 to 25		< 1		< 5	
I-Q6	25	13%/7.5°	0.41	8:44			40	30	14	14	2		1		< 1			
	29.5	13%/7.5°	-0.2	9:16														
TS6	25 to 30				25 to 50		5 to 25	5 to 25	25 to 50	25 to 50	< 5		5 to 25		< 1			
S-Q1	30	1.5	-0.4	12:09			15	5	40	40	< 1		30	5			2	
TS7	30 to 35				25 to 50		5 to 25			25 to 50	< 5		25 to 50		< 5	5 to 25	< 5	
S-Q2	35	1.7	-0.6	11:51	85		10			5			20			30	5	
TS8	35 to 40				5 to 25	< 5	5 to 25	5 to 25		5 to 25			25 to 50			25 to 50	5 to 25	
S-Q3	40	1.7	-0.98	11:40			30	40		30	< 1		40					
TS9	40 to 45				25 to 50		5 to 25	5 to 25		< 5			5 to 25			5 to 25	25 to 50	25 to 50
S-Q4	45	2.1	-1.38	11:25			40	60		< 1							30	45
TS10	45 to 50				50 to 75		5 to 25	5 to 25		< 5	< 1		< 5			< 5	50 to 75	50 to 75
S-Q5	50	2.7	-2.31	11:06	30		50	10	5	5	4							5
TS11	50 to 52			11:00	< 5	< 5	25 to 50	50 to 75		< 5	< 5						50 to 75	50 to 75

		Red Algae (Phylum Rhodophyta) (% Areal Cover)																				
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	*Sarcodiotheca gaudochaudii*	Encrusting coralline algae (Unidentified species)	*Plocamium* sp.	*Gracilaria* sp.	*Prionitis lanceolata*	*Callophyllis* spp.	*Palmaria* spp.	Red cup (*Constantinea* sp.)	*Crytosiphonia woodii*	*Microcladia coulteri*	Turkish towel (*Chondracanthus exasperatus*)	Turkish washcloth (*Mastocarpus* spp.)	*Mazzaella* spp.	*Odonthalia flocossa*	*Osmundea* spp.	*Rhodymenia pacifica*	Sea sacs (*Halosaccion glandiformes*)	Red algae (Class Florideophyceae)	Red algae (Unidentified species)	Filamentous Red algae (Unidentified species)	Branched Red algae (Family Rhodomelacae)
I- Q1	0																					
TS1	0 to 5																					
I-Q2	5																					
TS2	5 to 10																					
I-Q3	10																					
TS3	10 to 15				< 1								< 1						< 1			
I-Q4	15												2									
TS4	15 to 20	< 1			< 1							< 5	< 1						< 1			
I-Q5	20												2									
TS5	20 to 25				< 5	< 1							< 1						< 1			
I-Q6	25				1								2									
	29.5																					
TS6	25 to 30	< 1			< 1							< 1	< 5					< 1			5 to 25	
S-Q1	30									2		1										
TS7	30 to 35																			5 to 25		
S-Q2	35	15	< 1									15										
TS8	35 to 40																			< 5		
S-Q3	40	15			< 1	1						30									1	
TS9	40 to 45		< 5																	< 5		
S-Q4	45		2	1							2	2			1		2					1
TS10	45 to 50		< 5																	< 5		
S-Q5	50		< 1				< 1	< 1	1		1			< 1		< 1					1	
TS11	50 to 52																			< 5		

		Arthropods					Molluscs								Echinoderms		Cnidarians (% Areal Cover)	Worms	Bryozoan (% Areal Cover)	Vertebrates	
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Shrimp (Unidentified species)	Hermit crab (Unidentified species)	Helmet crab (*Telmessus cheiragonus*)	Kelp crab (*Pugettia* sp.)	Mussels (Mytilus sp.) (Count & % Areal Cover)	Limpets (Family Lottiidae)	Periwinkle (*Littorina* spp.)	Piddock clam (*Zirphaea pilsbryi*)	False jingle shell (*Pododesmus macrochisma*) (% Areal Cover)	Pacific oyster (*Crassostrea gigas*)	Frosted nudibranch (*Dirona albolineata*)	Nudibranch(*Janolus* spp.)	Sunflower star (*Pycnopodia helianthoides*)	Brittle star (Family Ophiodermatidae)	Pink-tipped anemone (*Anthopleura elegantissima*) (Count & % Areal Cover)	Spaghetti worm (Family Terebellidae)	Bryozoan (Phylum Bryozoa)	Pile perch (*Rhacochilus vacca*)	Comments
I- Q1	0																				Shell fragments similar in size to gravel and cobble.
TS1	0 to 5																				Band of fragmented shells extends from 2.4 - 3.2 m.
I-Q2	5																				Small size gravel present.
TS2	5 to 10	< 1																			
I-Q3	10																				
TS3	10 to 15	< 5					F	M	M												
I-Q4	15	20					31 (2%)[1]	24									1 (0.3%)[2]				
TS4	15 to 20	25 to 50					< 5	A				S					A				Substrate mixed gravel and cobble.
I-Q5	20	15					37 (4%)[1]	18									1 (0.3%)[2]				
TS5	20 to 25	5 to 25					< 5	M	F								A				Substrate mixed cobble and gravel and mixed sand and silt.
I-Q6	25	2						5													Cobble size substrate composed of fragmented hard pan/ bedrock. Sand and silt are well mixed.
	29.5																				
TS6	25 to 30	< 5					< 1	S									A				Loose substrate overlying hardpan. Cobble and gravel simialr in size and composed of fragmented hardpan. Sand and silt well mixed. Clam squirts observed (squirts of water from clams burrowed into substrate).
S-Q1	30	< 1								2											Sand and silt well mixed.
TS7	30 to 35			S	S					M					S		M				
S-Q2	35									8											Silt vaneer overlying bedrock. Piddock clams small in size.
TS8	35 to 40									M											Silt vaneer overlying bedrock. Seafloor obscured by algae.
S-Q3	40															P					Brittle star legs observed emerging from sediment.
TS9	40 to 45									F								S	S		Seafloor obscured by algae. *Ulva* spp. observed at shallower depths.
S-Q4	45									2	1								< 1		Quadrat obscured by algae. *Rhodymenia* spp. displays cystocarps.
TS10	45 to 50					F				F				S						S	Seafloor obscured by algae.
S-Q5	50	< 1						1						2					< 1		Quadrat obscured by algae.
TS11	50 to 52		F							F			S								

Notes
Waterline at 29.3m @ 13:10
* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For August 28, 2012 (Tide at 9:15 = -0.2 m, Tide at 11:00 = 0.39 m, Tide at 12:00 = 1.1 m)
I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)
Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect
Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.
Transect segment observations were recorded every 5m.
Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : < 1 %, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.
Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)
Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes

[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

[2] Percent cover for Pink-tipped Anemone (*Anthopleura elengatissima*) was determined during survey *in situ* or using the average size per anemone as 15mm x 15mm or 0.3% of the total quadrat area

Data Entered By: Michelle Spani on Dec 13, 2012
Data Checked By: Andrew Rippington on December 18, 2012

Appendix B
Rich Passage Biophysical Surveys
Location: Point Glover West
Site/Transect Number: 10B
Date: May 20, 2012

Project Number: 11393490/200/220

Transect Lat,Long Onshore/Offshore (ddmm.mmm):
47 35.216, 122 33.734/47 35.237,122 33.752

					Substrate Type (% Areal Cover)									Green Algae (Phylum Chlorophyta) (% Areal Cover)	Brown Algae (Phylum Ochrophyta) (% Areal Cover)						Red Algae (Phylum Rhodophyta) (% Areal Cover)														Arthropods					Molluscs							Echinoderms		Cnidarians (% Areal Cover)	Worms	
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/ Intertidal Slope	Corrected Elevation (m)*	Time	Bedrock	Concrete	Boulder (> 25 cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand (0.006 to 0.2 cm)	Sand / Silt (<0.2 cm)	Sand / Shell fragments	Shell fragments	Sea lettuce (*Ulva/ Ulvaria* spp.)	Rockweed (*Fucus* sp.)	Wireweed (*Sargassum muticum*)	*Agarum* sp.	Sea cauliflower (*Leathesia difformis*)	*Scytosiphon lomentaria*	Filamentous Brown algae (Unidentified species)	*Microcladia borealis*	*Gelidium* sp.	Turkish towel (*Chondracanthus exasperatus*)	Encrusting coralline algae (Unidentified species)	*Sarcodiotheca gaudochaudii*	*Hymenena* sp.	*Rhodymenia pacifica*	*Plocamium* sp.	*Mazzaella* spp.	*Porphyra* spp.	*Prionitis* spp.	*Polysiphonia* spp.	*Endocladia* spp.	Red algae (Unidentified species)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Isopod (*Idotea wosnessenskii*)	Amphipod (Order Amphipoda)	Hermit crab (Unidentified species)	Kelp crab (*Pugettia* sp.)	Mussels (Mytilus sp.) (Count & % Areal Cover)	Snail (Class Gastropoda)	Limpets (Family Lottiidae)	Piddock clam (*Zirphaea pilsbryi*)	False jingle shell (*Pododesmus macrochisma*) (% Areal Cover)	Opalescent nudibranch (*Hermissenda crassicornis*)	Periwinkle (*Littorina* spp.)	Sunflower star (*Pycnopodia helianthoides*)	Ochre star (*Pisaster ochraecus*)	Pink-tipped anemone (*Anthopleura elegantissima*) (Count & % Areal Cover)	Nereid worm (Family Nereidae)	Comments
I-Q1	0	13%/8˚	4.43	10:40	15			20	40				25																																						Detrital algae and wood drebris present, bone fragment observed in quadrat.
TS1	0 to 5				<5	<5		25 to 50	5 to 25	50 to 75			5 to 25																																						Detrital algae and wood drebris present. Fragmented concrete/old bulkhead observed on beach. Substrate included sand mixed with shell and cobble sized sandstone plates.
I-Q2	5	13%/8˚	3.79	10:42				75	15				10																1						2																Encrusting *Mazzealla* spp. on cobble.
TS2	5 to 10					<5	5 to 25	50 to 75	5 to 25	<5			<5		<5								<1						<1						<5											M					Substrate mainly boulder, cobble and gravel with interstitial sand and shell.
I-Q3	10	13%/8˚	3.14	10:55			20	35	40	1			4	<1	3								<1						<1						5		1					<1				6					Boulder composed of fragmented concrete.
TS3	10 to 15				5 to 25		5 to 25	25 to 50	25 to 50	5 to 25			5 to 25	<1	5 to 25			<5					<1						<1	<1					25 to 50		S			A		F				M			F		Bedrock begins at 14m along transect. Sand and shell interstitial in coarse substrate.
I-Q4	15	13%/8˚	2.5	11:02	85			5			10		<1	<1				5			<1		<1						<1						15					30 (%2)^{1}						42			4 (%<1)^{2}		Approx. 2 cm thick vaneer overlying bedrock.
TS4	15 to 20				75 to 100			<5	<5	<5			<5	5 to 25	25 to 50			5 to 25	<1		5 to 25													<1	25 to 50	S				M		M							M		Bedrock mainly sandstone with pinnacles in the lower intertidal. Sand and shell observed in bedrock pockets.
I-Q5	20	13%/8˚	1.85	11:20	90							10		3	5			8		<1	10								5		<1				3					8 (<1%)^{1}		8							4 (1%)^{2}		Sand/shell vaneer overlying bedrock.
TS5	20 to 25				75 to 100					<5			5 to 25	5 to 25	5 to 25			5 to 25		<1	5 to 25	<1	<1									<5%	<1	<1	5 to 25					A		M							M		Sand and shell in bedrock pockets.
I-Q6	25	13%/8˚	1.3	11:32	95							5		5	15			4			5		<1												60					52 (4%)^{1}		1							1 (<1%)^{2}		
TS6	25 to 30				75 to 100			<5	<1	5 to 25			<5	5 to 25	25 to 50			<5			5 to 25					<1		<1	<1					<1	50 to 75					A		M							M		
I-Q7	30	13%/8˚	0.56	11:45	60			20	10			2	8	35				< 1			10			10					< 1						15						2	1									
TS7	30 to 35				75 to 100		5 to 25	5 to 25	5 to 25	< 5				25 to 50	5 to 25			< 1			< 5		< 5		< 1				< 1		< 5			< 1											S			S			Gravel has shell in it.
I-Q8	35	13%/8˚	-0.08	12:02	100									90	2	< 1		< 1					3						< 1					< 1											1						Bedrock has thin sand veneer; reefy.
TS8	35 to 40			12:25	75 to 100						5 to 25			50 to 75		5 to 25							< 5						< 1		< 1			< 5									M					S			Many piddock siphons could be seen; generally poor visibility due to observations being taken at tide line.
S-Q1	40	0.5	-0.62	12:25	100									8		8		<1					4	5	20		2		< 1						< 1							1									Quadrat taken on top of reefy fold.
TS9	40 to 45			12:36	75 to 100						5 to 25		< 5				25 to 50																	50 to 75 bladed; 5 to 25 generic																	Bedrock is hard shale/mudstone; Very poor visibility; Snails on kelp.
S-Q2	45	1.8	-1.71	12:53	70			5			25		< 1				40						40	30		3	2	3							< 1			1	1					2			1			1	Sand/ silt over bedrock.
TS10	45 to 50			13:09	25 to 50		< 5	5 to 25			25 to 50		< 5				75 to 100							5 to 25										5 to 25 bladed generic																	Poor visibility made it difficult to categorize ranges for algal cover and identify faunal species. Bedrock is mainly hard shale/mudstone. Boulders and cobble are broken off pieces of dominant hardpan substrate.

Notes
* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For May 20, 2012 (Tide at 10:30 = - 10:30 m= -0.08 m, Tide at 13:00 = -0.12 m)
I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)
Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect
Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.
Transect segment observations were recorded every 5m.
Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : <1%, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.
Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)
Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes
[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area
[2] Percent cover for Pink-tipped Anemone (*Anthopleura elengatissima*) was determined during survey *in situ* or using the average size per anemone as 15mm x 15mm or 0.3% of the total quadrat area

Data Entered By: Andrew Rippington on Oct 23, 2012
Data Checked By: Andrew Rippington (on Nov 20, 2012); Michelle Spani (on Dec 7, 2012)

Appendix B
Rich Passage Biophysical Surveys
Location: Point Glover West
Site/Transect Number: 10B
Date: August 28, 2012

Project Number: 11393490/200/220

Transect Lat,Long Onshore/Offshore (ddmm.mmm):
47 35.216, 122 33.734/47 35.237,122 33.752

					Substrate Type (% Areal Cover)								Other (% Areal Cover)	Green Algae (Phylum Chlorophyta) (% Areal Cover)	Brown Algae (Phylum Ochrophyta) (% Areal Cover)					Red Algae (Phylum Rhodophyta) (% Areal Cover)											Arthropods							Molluscs							Echinoderms			Cnidarians (% Areal Cover)	Bryozoan (% Areal Cover)	
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/ Intertidal Slope	Corrected Elevation (m)*	Time	Bedrock/hardpan (Shale-like hardpan)	Boulder (> 25 cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand (0.006 to 0.2 cm)	Silt (<0.006 cm)	Sand / Shell fragments	Shell fragments	Detrital algae	Sea lettuce (*Ulva/ Ulvaria* spp.)	Rockweed (*Fucus* sp.)	Wireweed (*Sargassum muticum*)	*Agarum* sp.	*Laminaria* spp.	Sea cauliflower (*Leathesia difformis*)	Turkish towel (*Chondracanthus exasperatus*)	Turkish washcloth (*Mastocarpus* spp.)	Encrusting coralline algae (Unidentified species)	*Sarcodiotheca gaudichaudii*	*Gracilaria* sp.	*Endocladia* spp.	*Palmaria* spp.	*Porphyra* spp.	*Prionitis* spp.	Red algae (Class Florideophyceae)	Red algae (Unidentified species)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Isopod (Order Isopoda)	Shrimp (*Pandalus* sp.)	Helmet crab (*Telmessus* sp.)	Kelp crab (*Pugettia* sp.)	Shore crab (Hemigrapsus spp.)	Red Rock crab (*Cancer productus*)	Mussels (Mytilus sp.) (Count & % Areal Cover)	Whelk (Unidentified species)	Limpets (Family Lottiidae)	Piddock clam (*Zirphaea pilsbryi*)	False jingle shell (*Pododesmus macrochisma*) (% Areal Cover)	Frosted nudibranch (*Dirona albolineata*)	Periwinkle (*Littorina* spp.)	Sunflower star (*Pycnopodia helianthoides*)	Mottled star (*Evasterias troschelii*)	Ochre star (*Pisaster ochraceus*)	Pink-tipped anemone (*Anthopleura elegantissima*) (Count & % Areal Cover)	Bryozoan (Phylum Bryozoa)	Comments
I-Q1	0	16%/9˚	4.19				25	74	1				25																																					
TS1	0 to 5					< 5	5 to 25	50 to 75	< 1				5 to 25																		< 5																			
I-Q2	5	14%/8˚	3.40				15	85				25																			< 1																			
TS2	5 to 10					< 5	25 to 50	50 to 75							< 1																< 5									F										
I-Q3	10	14%/8˚	2.71				25	75																							10																			
TS3	10 to 15				< 5	<5	25 to 50	5 to 25	< 5				< 5	< 1	< 5						< 1										5 to 25							M		M								M		Slope change at 14 m . Cobble changes to hardpan downslope.
-	14	15%/8.5˚	2.12																																															
I-Q4	15	15%/8.5˚	1.97		95		1	2	1			1	< 1						2	35	< 1										< 5							54 (2.7%)^1		14								10 (3%)^2		
TS4	15 to 20				75 to 100	< 1	< 5		< 1				< 5	25 to 50					< 1	25 to 50											5 to 25							A		M				F				M		
I-Q5	20	9%/5˚	1.52	10:34	85			15				6		23	< 1													1	22		15							120 (12%)^1										36 (10.8%)^2		
TS5	20 to 25				75 to 100		< 5	5 to 25	< 5			< 5		5 to 25	< 5					< 1							< 5		25 to 50		25 to 50	F				F		A		A				F				A		
I-Q6	25	8%/4.5˚	1.12	10:32	100									9	9												3				96							~1100 (55%)^1		45								9 (2.7%)^2		Mussels all less than 3cm long.
TS6	25 to 30				75 to 100		< 5	< 5							5 to 25								< 1								25 to 50							A		M								M		
I-Q7	30	12%/7˚	0.53	10:08	90		6	4						28	45					1	2								17		2	1				1		24 (1.2%)^1												
TS7	30 to 35				50 to 75	< 5	5 to 25	5 to 25				5 to 25		5 to 25	5 to 25											< 1					5 to 25							< 1	S	M					S		S	F		Siphon holes observed along transect segment. Many Ochre stars observed approx. 5 m from transect.
I-Q8	35	12%/7˚	-0.07	9:56	55	20				23		2		32	3			3			8								20		< 1									7										Bedrock covered with silt vaneer.
TS8	35 to 40				75 to 100		5 to 25	5 to 25		5 to 25				75 to 100	< 5	5 to 25				< 5										5 to 25				S	F						M		S				S			Hard substrate covered with silt vaneer.
S-Q1	40	0.3	-0.37	10:18	40		20	20		20	6	2		25				2		25	2		< 1	< 1	5			5																					2	Gravel and cobble size substrate composed of fragmented hard pan/ bedrock.
TS9	40 to 45				50 to 75	25 to 50	5 to 25	5 to 25	5 to 25					5 to 25		5 to 25	5 to 25			50 to 75													F		S										S				P	Seafloor obscured by algal blades.
S-Q2	45	1.7	-1.77	9:59	30		5		60		5					2	70			5		2						2									1					<1%							1	Calcareous tubeworm casings (Family Serpulidae).
TS10	45 to 49				75 to 100		5 to 25	5 to 25	5 to 25								75 to 100			< 5		5 to 25								5 to 25	< 5			F	S											S				Bottom obscured by algal blades.

Notes
* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For August 28, 2012 (Tide at 10:00 = -0.07 m)
I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)
Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect
Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.
Transect segment observations were recorded every 5m.
Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : < 1 %, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.
Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)
Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes

[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

[2] Percent cover for Pink-tipped Anemone (*Anthopleura elengatissima*) was determined during survey *in situ* or using the average size per anemone as 15mm x 15mm or 0.3% of the total quadrat area

Data Entered By: Michelle Spani on Dec 12 2012
Data Checked By: Andrew Rippington on December 18, 2012

Appendix C
Rich Passage Biophysical Surveys
Location: Illahee
Site/Transect Number: 11B
Date: May 23, 2012

Project Number: 11393490/200/220

Transect Lat/Long Onshore/Offshore (ddmm.mmm):47 36.257, 122 35.869 /47 36.248, 122 35.819

					Substrate Type (% Areal Cover)					Other (% Areal Cover)	Green Algae (Phylum Chlorophyta) (% Areal Cover)		Brown Algae (Phylum Ochrophyta) (% Areal Cover)		Red Algae (Phylum Rhodophyta) (% Areal Cover)						Arthropods					Molluscs						Echinoderms	Worms		
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/Intertidal Slope	Corrected Elevation (m)*	Time	Boulder (> 25 cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand / Silt (<0.2 cm)	Shell fragments	Detrital algae	Sea lettuce (*Ulva/ Ulvaria* spp.)	*Entromorpha* sp.	Acid-weed (*Desmerestia ligulata*)	*Laminaria* spp.	*Sarcodiotheca* spp.	*Gracilaria* sp.	*Mazzaella* spp.	*Porphyra* spp.	Red Algae (Unidentified species)	Red hair algae (Unidentified species)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Shore crab (*Hemigrapsus* spp.)	Dungeness crab (*Cancer magister*)	Helmet crab (*Telmessus* sp.)	Hermit crab (*Pagarus* spp.)	Mussels (*Mytilus* sp.) (Count & % Areal Cover)	Periwinkle (*Littorina* spp.)	Whelk (Unidentified species)	False jingle shell (*Pododesmus* sp.)	Limpets (Family Lottiidae)	Opalescent nudibranch (*Hermissenda crassicornis*)	Ochre star (*Pisaster ochraceus*)	Jointed tubeworm (*Spiochaetopterus costarum*)	Tubeworm (Unidentified species)	Comments
I-Q1	0	11%/6.5˚	3.33	13:41		2	53	10	35	< 1											2														
TS1	0 to 5					< 5	50 to 75	< 1	5 to 25	< 1											< 1						F								
I-Q2	5	11%/6.5˚	2.78	14:31		5	93	1	1	< 1											5						2			1					
TS2	5 to 10				< 5	25 to 50	50 to 75	< 5	< 5	< 1											5 to 25						A			F					Few barnacles present above 6.4m along transect line.
I-Q3	10	11%/6.5˚	2.23	14:24		10	88	< 1	2								< 1				20						9			1					
TS3	10 to 15				< 5	5 to 25	75 to 100		5 to 25	< 1											5 to 25						M								
I-Q4	15	11%/6.5˚	1.69	14:20		5	80		15												15						16								
TS4	15 to 20					5 to 25	50 to 75	< 5	5 to 25	< 1											50 to 75					F	A								
I-Q5	20	11%/6.5˚	1.14	14:16		10	85		5												25						62								Periwinkle snails were all very small, ~3mm across shell.
TS5	20 to 25					5 to 25	50 to 75	< 5	5 to 25	< 1							< 1				50 to 75					F	A								
I-Q6	25	11%/6.5˚	0.59	13:58		12	70	4	15	< 1							< 1				30	1				2 (0.1%)^1	56								
TS6	25 to 30				< 5	5 to 25	50 to 75	< 5	5 to 25									< 1			50 to 75	F				M	F	F							
I-Q7	30	11%/6.5˚	0.05	13:50		10	60	5	25		5	< 1									45	3				2 (0.1%)^1		1							
	33	11%/6.5˚	-0.28																																Slope consistent from 0m to 33m .
TS7	30 to 35					5 to 25	50 to 75	< 5	5 to 25	< 1	< 5	< 5					< 1				50 to 75				M	F		F	F	M				P	Few worm casings. Whelk eggs nearby.
S-Q1	35	0.1	-0.145	13:48		25	75														50														Poor visibility; Quadrat ~10cm below water surface.
TS8	35 to 40					25 to 50	25 to 50	25 to 50			5 to 25			< 5							50 to 75						M	S							Some silt in the sand.
S-Q2	40	0.3	-0.345	14:18		20	60	20	< 1												75									2					Gravel overlying silt and sand; Poor visibility.
TS9	40 to 45			14:22		5 to 25	25 to 50	25 to 50	5 to 25		50 to 75		< 5	50 to 75					< 5		5 to 25														Gravel/ cobble overlying silt and sand; Poor visibility.
S-Q3	45	1	-1.045	14:24		10	20	70			30			30							2														Poor visibility;Blades of *Laminaria* spp. and *Ulva* spp. obscuring view of quadrat.
TS10	45 to 50					< 5	25 to 50	25 to 50			50 to 75			25 to 50					< 5													S			Gravel overlying silt and sand; Blades of *Laminaria* spp. and *Ulva* spp. obscuring view of transect section.
S-Q4	50	1.5	-1.545	14:30		10	15	70	5		10			10	1	1					4														Gravel overlying silt and sand; Blades of *Laminaria* spp. and *Ulva* spp. obscuring view of quadrat.
TS11	50 to 55			14:37		5 to 25	5 to 25	50 to 75	5 to 25		75 to 100			5 to 25					< 5		< 5		S									F			Gravel/ cobble overlying silt and sand.
S-Q5	55	1.8	-1.845	14:38		1	2	95	2		10			5		1																			Unattached *Ulva* spp. algal mat covering seabed.
TS12	55 to 60					< 5	< 5	75 to 100	< 5		75 to 100			5 to 25					< 5		< 5			F	S						S	F			Unattached *Ulva* spp. algal mat covering seabed.
S-Q6	60	2.4	-2.445	14:47		2	1	95	2		5			1	< 1	< 1					< 1				1								18		Unattached Ulva spp. algal mat covering ~90% of quadrat.
TS13	60 to 65					< 5	< 5	75 to 100	< 5		75 to 100		< 5	5 to 25					< 5				F	F	S							S			Unattached *Ulva* spp. algal mat covering seabed.
S-Q7	65	3	-3.045	14:56				98	2		10					5				< 1															Unattached L*aminaria* spp.

Notes

* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For May 23, 2012 (Tide at 14:00 = -0.28 m, Tide at 15:00 = 0.19 m)

Poor underwater visibility was experienced during dive surveys.

I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)

Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect

Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.

Transect segment observations were recorded every 5m.
Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : <1%, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.

Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)
Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes

Red hair algae refers to species that exhibit visual traits similar to *Polysiphonia paniculata*

[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

Data Entered By: Andrew Rippington on November 15, 2012
Data Checked By:Andrew Rippington (on November 20, 2012); Michelle Spani (on Dec 7, 2012)

Appendix B
Rich Passage Biophysical Surveys
Location: Illahee North
Site/Transect #: 11B
Date: August 29, 2012

Project Number: 11393490/200/220

Transect Lat,Long Onshore/Offshore(ddmm.mm): 47 36.257/ 122 35.869 /47 36.248/ 122 35.819

					Substrate Type (% Areal Cover)						Other (% Areal Cover)	Green Algae (Phylum Chlorophyta) (% Areal Cover)		Brown Algae (Phylum Ochrophyta) (% Areal Cover)	Red Algae (Phylum Rhodophyta) (% Areal Cover)						Arthropods									Molluscs								Echinoderms	Worms	Vertebrates		
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/Intertidal Slope	Corrected Elevation (m)*	Time	Boulder (> 25 cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand (0.006 to 0.2 cm)	Silt (<0.006 cm)	Shell fragments	Detrital algae	Encrusting Green algae (Unidentified species)	Sea lettuce (*Ulva/ Ulvaria* spp.)	*Laminaria* spp.	*Gracilaria* sp.	Turkish washcloth (*Mastocarpus* spp.)	*Palmaria* spp.	*Polysiphonia* spp.	*Rhodymenia* sp.	Red algae (Unidentified species)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Amphipod (Order Amphipoda)	Graceful crab (*Cancer gracilis*)	Helmet crab (Telmessus sp.)	Hermit crab (*Pagarus* sp.)	Kelp crab (*Pugettia* sp.)	Shore crab (*Hemigrapsus* spp.)	Shrimp (*Crangon* sp.)	Shrimp (*Pandalus* sp.)	Mussels (*Mytilus* sp.) (Count & % Areal Cover)	Chiton (*Tonicella / Mopalia* sp.)	False jingle shell (*Pododesmus* sp.)	Limpets (Family Lottiidae)	Periwinkle (*Littorina* spp.)	Snail (Order Gastropoda)	Whelk (Unidentified species)	Horse clam (*Tresus* sp.)	Mottled star (*Evasterias troschelii*)	Jointed tubeworm (*Spiochaetopterus costarum*)	Gunnel (Family Pholidae)	Plainfin midshipman (*Porichthys notatus*)	Comments
I-Q1	0	12%/6.5°	3.89	8:56		7	30	33		30	1										< 1																					
TS1	0 to 5					25 to 50	25 to 50	< 5		5 to 25	< 1										< 1																					Cobble and gravel increase in size at 2.3 m.
I-Q2	5	12%/6.5°	3.30	9:01		40	58	2		< 1											< 1																					Substrate mainly small cobble mixed with large gravel.
TS2	5 to 10				< 5	50 to 75	25 to 50	< 5		< 5											< 5						M						M	A								Barnacle abundance increased towards waterline. Limpits, periwinkles and shore crabs observed on and under rocks.
I-Q3	10	12%/6.5°	2.70	9:14		12	80	5	2	2		< 1				< 1					8												4	16								Cobble small in size.
TS3	10 to 15				< 5	25 to 50	25 to 50	5 to 25		5 to 25						< 5					5 to 25						M						A	A								Cobble and gravel well mixed. Limpits, periwinkles and shore crabs observed on and under rocks.
I-Q4	15	12%/6.5°	2.11	9:20		24	56	15		5											40	P					P						15	220								Shell fragments small in size. Amphipods and shore crabs observed under rocks.
TS4	15 to 20					25 to 50	50 to 75	5 to 25		5 to 25						< 1					25 to 50						A			F			F	A								Gravel and cobble similar in size and well mixed. 1000+ periwinkles on rocks. Mussels were small in size.
I-Q5	20	12%/6.5°	1.51	9:28		20	30	20		30						2					31									2 (< 1%)[1]			10	240								
TS5	20 to 25				< 1	5 to 25	50 to 75	5 to 25		5 to 25								< 1			25 to 50						M			M			F	A		S						Shore crabs observed under rock.
I-Q6	25	12%/6.5°	0.92	9:36		10	65	7		18						4		< 1			40						1			2 (< 1%)[1]			9	220								
TS6	25 to 30				< 5	5 to 25	50 to 75	5 to 25		25 to 50			5 to 25					< 5									M			M			M	A								Shore crabs observed under rock.
I-Q7	30	12%/6.5°	0.32	9:50		15	60	4		20			15					5			8												8	2								Graceful crab carapace observed.
	34.2	12%/6.5°	-0.18	9:51																																						
TS7	30 to 35					5 to 25	50 to 75	< 5		5 to 25			75 to 100			< 1		< 5			5 to 25						S				S	M	M			M		S				Seafloor obscured by algae (mainly *Ulva / Ulvaria* spp.). Clam squirts observed (squirts of water from clams burrowed into substrate).
S-Q1	35	3.3	-0.15	15:52		60	30	5		4			30			<1					30				2								18	1		3						
TS8	35 to 40				< 5	50 to 75	5 to 25	< 5	< 5	< 5			75 to 100								5 to 25		S		M						F	F	M			M		F				
S-Q2	40	3.7	-0.55	15:41		40	30	10	10	10			50								20		1								1		5			50+		1				Seafloor obscured by algae (mainly *Ulva / Ulvaria* spp.). 50+ snails/whelks observed on drift algae.
TS9	40 to 45					25 to 50	25 to 50	5 to 25	5 to 25	5 to 25			75 to 100	< 5						< 5	< 5		S									F				F		S		S		Seafloor obscured by algae (mainly *Ulva / Ulvaria* spp.).
S-Q3	45	4.1	-0.95	15:23		5	40	25	25	5			20		15						< 1				3																	Silt and sand well mixed. Seafloor obscured by algae (mainly *Ulva / Ulvaria* spp.). Vacant worm casings observed.
TS10	45 to 50					5	25 to 50	25 to 50	25 to 50	5 to 25			75 to 100	< 5	5 to 25						< 5		S									F									S	Seafloor obscured by algae (mainly *Ulva / Ulvaria* spp.).
S-Q4	50	4.3	-1.15	15:17			25	30	30	15			5		15		< 1		< 1		< 1		1		6			4	3						8				8			Seafloor obscured by algae (mainly *Ulva / Ulvaria* spp.). Sand and silt well mixed. Potentially greater numbers of molluscs but algal mat prevented accurate counts.
TS11	50 to 55					< 5	5 to 25	25 to 50	25 to 50	5 to 25			75 to 100	< 5	5 to 25						< 5																					Seafloor obscured by algae (mainly Ulva / Ulvaria spp.). Sand and silt well mixed. Potentially greater numbers of molluscs but algal mat prevented accurate counts.
S-Q5	55	4.6	-1.72	14:54		2	3	45	45	5			10	10	< 1						< 1			1	1				2								1		P	1		Seafloor obscured by algae (mainly Ulva / Ulvaria spp.). Sand and silt well mixed. Potentially greater numbers of molluscs but algal mat prevented accurate counts.
TS12	55 to 60						< 5	25 to 50	25 to 50	< 5			75 to 100	5 to 25						< 5						S																Seafloor obscured by algae (mainly Ulva / Ulvaria spp.). Sand and silt well mixed. Potentially greater numbers of molluscs but algal mat prevented accurate counts.
S-Q6	60	5	-2.12	14:45			4	50	50	4														1					2										P			Seafloor obscured by algae (mainly Ulva / Ulvaria spp.). Sand and silt well mixed. Potentially greater numbers of molluscs but algal mat prevented accurate counts.
TS13	60 to 65					< 5	< 5	25 to 50	25 to 50	< 5			75 to 100	5 to 25						< 5	< 5					S			S													Seafloor obscured by algae (mainly Ulva / Ulvaria spp.). Sand and silt well mixed. Potentially greater numbers of molluscs but algal mat prevented accurate counts.
S-Q7	65	5.2	-2.65	14:34																																						
TS14	65+					< 5	< 5	25 to 50	25 to 50	< 5			75 to 100	5 to 25						< 5	< 5			S																		Seafloor obscured by algae (mainly *Ulva / Ulvaria* spp.). Sand and silt well mixed.

Notes
* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For August 29, 2012 (Tide at 10:00 = -0.18 m, Tide at 14:30 = 2.55 m, Tide at 15:00 = 2.88 m, Tide at 15:30 = 3.15 m)
Poor underwater visibility was experienced during dive surveys.
I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)
Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect
Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.
Transect segment observations were recorded every 5m.
Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : < 1 %, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.
Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)
Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes

[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

Data Entered By: Michelle Spani on Dec 14, 2012
Data Checked By: Andrew Rippington on Decmeber 20, 2012

Appendix B
Rich Passage Biophysical Surveys
Location: Crystal Springs
Site/Transect Number: 12B
Date: May 22, 2012

Project Number: 11393490/200/220

Transect Lat/Long Onshore/Offshore (ddmm.mmm):
47 36.411, 122 34.532/ 47 36.415, 122 34.569

					Substrate Type (% Areal Cover)					Other (% Areal Cover)	Green Algae (Phylum Chlorophyta) (% Areal Cover)			Brown Algae (Phylum Ochrophyta) (% Areal Cover)			Red Algae (Phylum Rhodophyta) (% Areal Cover)							Arthropods				Molluscs						Echinoderms	Cnidarians (% Areal Cover)	
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/Intertidal Slope	Corrected Elevation (m)*	Time	Boulder (> 25 cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand / Silt (<0.2 cm)	Shell fragments	Detrital algae	*Acrosiphonia* spp.	Sea lettuce (*Ulva/ Ulvaria* spp.)	*Enteromorpha intestinalis / Ulva intestinalis*	Acid-weed (*Desmerestia* sp.)	Filamentous Brown algae (Unidentified species)	*Laminaria* spp.	*Sarcodiotheca* spp.	*Gracilaria* sp.	*Mazzaella* spp.	Tar spot (*Mastocarpus* spp.)	Turkish towel (*Chondracanthus exasperatus*)	*Porphyra* spp.	Red algae (Unidentified species)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Shore crab (*Hemigrapsus* spp.)	Red Rock crab (*Cancer productus*)	Hermit crab (*Pagarus* spp.)	Mussels (*Mytilus* sp.) (Count & % Areal Cover)	Periwinkle (*Littorina* spp.)	Dogwinkle (*Nucella* spp.)	False jingle shell (*Pododesmus* sp.)	Limpets (Family Lottiidae)	Chiton (*Tonicella / Mopalia* sp.)	Ochre star (*Pisaster ochraceus*)	Stubby rose anemone (*Urticina* sp.)	Comments
I-Q1	0	13%/7˚	2.72	10:32			15	75	10	2																										Basalt rip-rap; transect begins 1m up from bottom boulders in dominant substrate.
TS1	0 to 5				< 5	< 1	25 to 50	25 to 50	5 to 25	< 1														< 1					M			F				Shell band 2.0m - 3.3m; gravel 75 to 100% below 3.3m; sand 0-2.0m Barnacles and Littorinas on boulder.
I-Q2	5	13%/7˚	2.07	10:42		4	96		< 1	< 1														< 1												Small cobble; gravel sizes well represented.
TS2	5 to 10					5 to 25	75 to 100		< 1	< 1														< 5	S				M							Large gravel at 5m; cobble gravel well-mixed. Slope changes from 13% to 10% at 7.0m.
I-Q3	10	10%/6˚	1.51	10:51		6	86		8															4					17							Lots of shell beneath surface substrate.
TS3	10 to 15					5 to 25	75 to 100		< 5															5 to 25	S				A			S				
I-Q4	15	10%/6˚	1.02	10:57		5	85		10	1														5				1 (0.05%)^1	25							
TS4	15 to 20				< 5	25 to 50	50 to 75		< 5															25 to 50	S			F	A			S				
I-Q5	20	10%/6˚	0.52	11:22		5	90		5	1														10				5 (0.25%)^1	88							
TS5	20 to 25				< 5	5 to 25	75 to 100	< 1	< 5	< 1									< 1					25 to 50	F		F	M	A	F		F				Slope consistent from 7.0m through to 21.0m at 10%.
I-Q6	25	0	-0.15	11:34		6	86		8	12											< 1			15	3			3 (0.15%)^1	15			3				Large blade *Laminaria saccharina* detritus.
TS6	25 to 30					5 to 25	75 to 100	< 5	< 1	< 5	< 1	< 5				< 1			< 1	< 1	< 1	< 1		5 to 25	F		S	F	M	M	F	M				Large cobble. Many clam squirts.
I-Q7	30	0.15	-0.05	11:10		40	45	10	5		< 1	3	1						< 1	2		<1		3						4		4				Very poor visibility, quadrat redone when tide was lower.
TS7	30 to 35					75 to 100	5 to 25	< 5				< 5												5 to 25												Subtidal. Poor visibility.
S-Q1	35	0.15	-0.3	11:18		95		4	< 1			3	1							1				3							4	2	1			Poor visibility.
TS8	35 to 40					75 to 100	5 to 25	5 to 25	5 to 25			< 5				< 5							< 5	25 to 50		S					F	F				Difficult to differentiate between large gravel and small cobble through to deepest survey quadrat.
S-Q2	40	0.9	-1.05	11:24		35	5	35	25			5				25	5														4	2				Poor visibility.
TS9	40 to 45					50 to 75		25 to 50	5 to 25			5 to 25				25 to 50							< 5	25 to 50							M				S	Poor visibility.
S-Q3	45	0.9	-1.05	11:37		50	5	40	5			10		< 1	< 1	5	2	2						25			1				5	5				Poor visibility.
TS10	45 to 50					25 to 50	5 to 25	25 to 50	< 5			25 to 50				25 to 50							< 5	25 to 50										F		Poor visibility.
S-Q4	50	1.5	-1.65	11:50		10	10	75	5			25				40	< 1							4							2					Poor visibility.

Notes

* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For May 22, 2012 (Tide at 10:30 = 0.42 m, Tide at 11:30 = - 0.15 m)

Poor underwater visibility was experienced during dive surveys.

I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)

Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect

Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.

Transect segment observations were recorded every 5m.
Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : <1%, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.
Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)
Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes

[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

Data Entered By: Michelle Spani on July 20, 2012
Data Checked By: Andrew Rippington (on Nov 20, 2012); Michelle Spani (on Dec 7, 2012)

Appendix B
Rich Passage Biophysical Surveys
Location: Crystal Springs
Site/Transect Number: 12B
Date: August 29, 2012

Project Number: 11393490/200/220

Transect Lat/Long Onshore/Offshore (ddmm.mmm):
47 36.411, 122 34.532/ 47 36.415, 122 34.569

					Substrate Type (% Areal Cover)						Other (% Areal Cover)	Green Algae (Phylum Chlorophyta) (% Areal Cover)	Brown Algae (Phylum Ochrophyta) (% Areal Cover)	Red Algae (Phylum Rhodophyta) (% Areal Cover)									Arthropods							Molluscs							Echinoderms		Worms		Vertebrates	
Quadrat (Q#) / Transect Segment (TS#)	Transect Distance (m)	Gauge Depth (m)/Intertidal Slope	Corrected Elevation (m)*	Time	Boulder (> 25 cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Sand (0.006 to 0.2 cm)	Silt (< 0.006 cm)	Shell fragments	Detrital algae	Sea lettuce (*Ulva*/ *Ulvaria* spp.)	*Laminaria* spp.	Red algae (Class Florideophyceae)	*Gracilaria* sp.	Turkish washcloth (*Mastocarpus* spp.)	*Microcladia coulteri*	*Osmundea* spp.	*Polysiphonia* spp.	*Porphyra* spp.	Red algae (Unidentified species)	Filamentous Red algae (Unidentified species)	Barnacles (Suborder Balanomorpha) (% Areal Cover)	Graceful crab (*Cancer gracilis*)	Helmet crab (Telmessus sp.)	Hermit crab (*Pagarus* spp.)	Kelp crab (*Pugettia* sp.)	Red Rock Crab (*Cancer productus*)	Shore crab (*Hemigrapsus* spp.)	Chiton (*Tonicella* / *Mopalia* sp.)	False jingle shell (*Pododesmus* sp.) (% Areal Cover)	Limpets (Family Lottiidae)	Mussels (*Mytilus* sp.) (Count & % Areal Cover)	Pacific oyster (*Crassostrea gigas*)	Periwinkle (*Littorina* spp.)	Whelk (Unidentified species)	Brittle star (Family Ophiuroidea)	Mottled star (*Evasterias troschelii*)	Slime-tubed feather duster worm (*Myxicola infundibulum*)	Spaghetti worm (Family Terebellidae)	Gunnel (Family Pholidae)	Comments
I-Q1	0	14%/8˚	3.62	10:38			15	80		5	8																															
TS1	0 to 5						75 to 100	5 to 25		< 5	< 1												< 5																			Rip rap present above OHWM (0 m along transect).
I-Q2	5	14%/8	2.93			8	90	2		<1	< 1												< 1																			
TS2	5 to 10					5 to 25	75 to 100	< 5		5 to 25	< 1												< 5												A							
I-Q3	10	11%/6.5˚	2.38			12	83			5	< 1												2																			
TS3	10 to 15				< 5	5 to 25	50 to 75	< 1		5 to 25						< 1							5 to 25			A			M						A							Shore crabs and hermit crabs observed under boulder and cobble. Barnacles on large substrate only.
I-Q4	15	12%/7˚	1.79			20	68			2	< 1												8																			
TS4	15 to 20				< 5	5 to 25	50 to 75	< 1		< 5	< 1			< 1		< 1				< 1			25 to 50						S				M	S	A							
I-Q5	20	9%/5˚	1.34			20	63	5		12	< 1												15									2	1		42							
TS5	20 to 25				< 5	25 to 50	50 to 75	< 5		5 to 25	< 5					< 1							25 to 50									M	M		M							Clam squirts observed (squirts of water from clams burrowed into substrate).
I-Q6	25	9%/5˚	0.89			35	60	1		4		10				2							30			2						8	3 (< 1%)^1		3	1						Abundant detrital *Ulva* spp. near quadrat. Whelks small in size, could be Littorines.
TS6	25 to 30					25 to 50	25 to 50	< 5		< 5		50 to 75		< 1		< 5							5 to 25						M			M	F			M						More gravel than cobble, fine shell fragments, barnacles near 25 m. *Hemigrapsus* spp. found beneath cobble.
I-Q7	30	15%/9˚	0.15	10:43		40	50	8		2	20	25				< 1							< 1			1					< 1	15	1 (<1%)^1									
-	31.8	15%/9˚	-0.12	10:42																																						
TS7	30 to 35					25 to 50	25 to 50	5 to 25		< 5		50 to 75				< 1						< 1	< 5								F	M				F						Transect submerged below 33m. Fair visibility.
S-Q1	35	1.5	-0.18	13:05		50	30	20				40			< 1	< 1														1	<1	22										Abundant drift *Ulva* /*Ulvaria* spp. observed along transect.
TS8	35 to 40				< 5	25 to 50	25 to 50	5 to 25				75 to 100	< 5								< 5		5 to 25	S	S						M	M										Seaflor obscured by algae (mainly *Ulva / Ulvaria* spp.)
S-Q2	40	1.7	-0.38	12:50	25	15	20	40		10		30			20	< 1		3				15	10					S			2	3					P		S	S		Abundant drift algae observed in quadrat. Brittle star legs observed emerging from sediment.
TS9	40 to 45					25 to 50	25 to 50	25 to 50		5 to 25		75 to 100	5 to 25								< 5										F										S	Seafloor obscured by algae (mainly *Ulva/Ulvaria* spp.)
S-Q3	45	1.7	-0.79	12:33		10	5	80		5			15		5		1						15								<1						P	S				A worm casing and brittle star legs observed.
TS10	45 to 50					5 to 25	5 to 25	50 to 75		< 5		75 to 100	5 to 25								< 5		20				F											S	S			Seafloor obscured by algae (mainly *Ulva/Ulvaria* spp.)
S-Q4	50	2	-1.09	12:23		15	30	25	25	5		20	5						< 1				20								6	5					P					Seafloor obscured by algae (mainly drift *Ulva/Ulvaria* spp.). Brittle star legs observed emerging from sediment.
TS10	50 to 52			12:08		5 to 25	5 to 25	25 to 50	25 to 50	5 to 25		75 to 100	5 to 25								< 5		5 to 25		S	S						M										Seafloor obscured by algae (mainly drift *Ulva* /*Ulvaria* spp.).

Notes
* Elevations were calculated using slope measurements and diver recorded (gauge) depths. Elevations were corrected to chart datum using Nobeltec Tides and Currents Pro for Tides in Clam Bay (NOAA), Washington For August 29, 2012 (Tide at 10:30 = -0.12 m, Tide at 12:00 = 0.55 m, Tide at 13:00 = 1.32 m)
Poor underwater visibility was experienced during dive surveys.
I-Q indicates quadrat data collected from intertidal surveys (exposed by tide). S-Q indicates quadrat data collected from the intertidal/subtidal by divers (underwater)
Quadrats were 0.5m x 0.5m (0.25 m^2) placed at 5 m intervals along transect
Areal coverage for substrate, algae and selected sessile invertebrates (barnacles etc.) and the number of individual fauna were recorded for each quadrat.
Transect segment observations were recorded every 5m.
Areal coverage along transect segment for substrate, flora, and select sessile invertebrates : < 1 %, < 5%, 5 to 25%, 25 to 50%, 50 to 75%, 75 to 100%.
Abundance codes for invertebrates and fish along transect segments are defined as: Present (P); Single (S); Few 2-10 (F); Many 11-100 (M); Abundant >100 (A)
Within transect segments (i.e. 0m - 5m) where multiple species of red algae were present and any one species did not dominate the segment, percent areal cover was generalized as "Red Algae" for categorical profile purposes

[1] Percent cover for mussel in quadrats was determined during survey *in situ* or using the average size per mussel as 15mm x 8mm or 0.05% of the total quadrat area

Data Entered By: Michelle Spani on Dec 13 2012
Data Checked By: Andrew Rippington on December 20, 2012

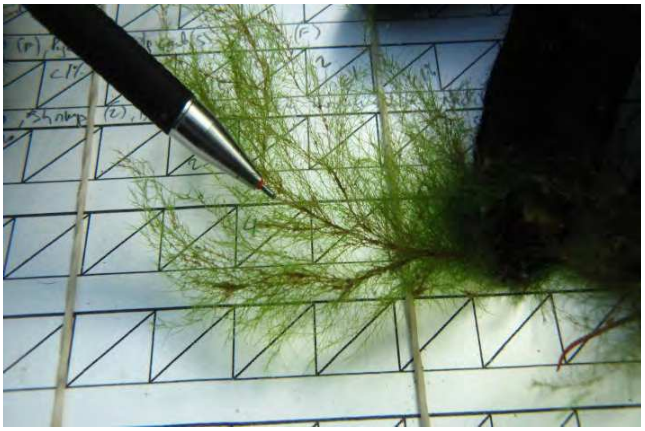
APPENDIX D

Photographs

Photograph 1: Transect 1B - Intertidal zone, showing beach and transect location, May 18, 2012.

Photograph 2: Transect 1B - Intertidal zone, showing beach and backshore, August 26, 2012.

Photograph 3: Transect 1B - Graceful crab (*Cancer gracilis*); Sea lettuce (*Ulva* sp.); *Gracilaria* sp. and *Mazzaella* spp., Aug 26, 2012.



Photograph 4: Transect 1B - *Derbesia* spp. with transect data sheet in background, Aug 26, 2012.

Photograph 5: Transect 1B - *Sarcodiotheca* spp. and a Spiny pink star (*Pisaster brevispinus*) within the quadrat, Aug 26, 2012.

Photograph 6: Transect 1B - Rockweed (*Fucus* sp.), May 18, 2012.

Photograph 7: Transect 1B - Pink-tipped Anemone (*Anthopleura elegantissima*) and Jointed tubeworms (*Spiochaetopterus costarum*), Aug 26, 2012.

Photograph 8: Transect 1B - Coonstriped Shrimp (*Pandalus danae*); Sea lettuce (*Ulva* spp.) and Red cup (*Constantinea* sp.), Aug 26, 2012.

Photograph 9: Transect 3B - Point White intertidal zone, showing transect location, beach and backshore, May 19, 2012.

Photograph 10: Transect 3B - Point White intertidal zone, showing transect location, beach and backshore, August 27, 2012.

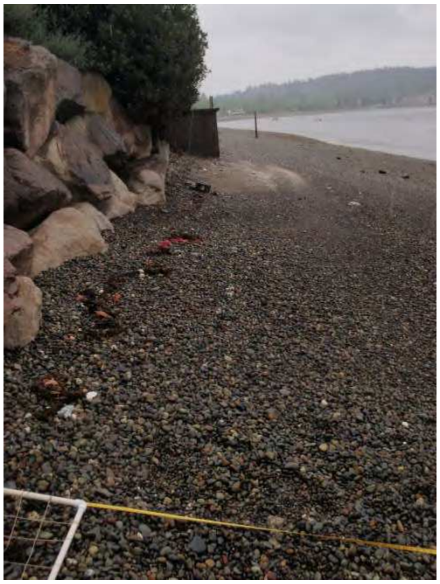
Photograph 11: Transect 3B - Siphon of horse clam (*Tresus* sp.) next to Turkish towel (*Chondracanthus exasperates*) and *Polyneura* spp., Aug 27, 2012.

Photograph 12: Transect 3B - *Sarcodiotheca* spp. and Sea lettuce (*Ulva* spp.), Aug 27, 2012.

Photograph 13: Transect 3B - Turkish towel (*Chondracanthus exasperates*) and encrusting coralline algae, Aug 27, 2012.

Photograph 14: Transect 3B - *Mazzaella* spp., Aug 27, 2012.

Photograph 15: Transect 3B - *Plocamium* sp., Aug 27, 2012.



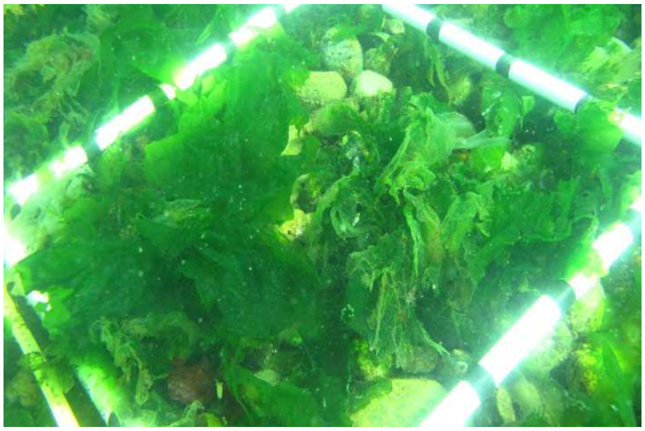
Photograph 16: Transect 5D - Point White intertidal zone, showing beach, backshore and transect location, May 21, 2012.

Photograph 17: Transect 5D - Point White intertidal zone showing beach and backshore, May 21, 2012.

Photograph 18: Transect 5D - Wireweed (*Sargassum muticum*), May 21, 2012.

Photograph 19: Transect 5D - Calcareous tubeworm (Family Serpulidae) and Chiton (*Tonicella*/*Mopalia* sp.), May 21, 2012.

Photograph 22: Transect 5D - Red rock crab *(Cancer productus*) with encrusted barnacles feeding, Aug 27, 2012.



Photograph 20: Transect 5D - Sea lettuce (*Ulva* spp.) and cobbles within quadrat, Aug 27, 2012.

Photograph 23: Transect 5D - *Sarcodiotheca* spp. with Coonstriped shrimp (*Pandalus danae*) in the background among the cobbles, Aug 27, 2012.

Photograph 21: Transect 5D - Turkish towel (*Chondracanthus exasperates*) and Sea lettuce (*Ulva* spp.) within quadrat, Aug 27, 2012.

Photograph 24: Transect 9B - Point Glover intertidal zone, showing beach and backshore, May 21, 2012.

Photograph 25: Transect 9B - Point Glover intertidal zone, showing beach and backshore, August 30, 2012.

Photograph 26: Transect 9B - Eelgrass (*Zostera marina*) and *Sarcodiotheca* spp., Aug 30, 2012.

Photograph 27: Transect 9B – Red algae (*Palmaria* spp.), Aug 30, 2012.

Photograph 28: Transect 9B - Eelgrass (*Zostera marina*) covered in detritus and epiphytic red algae (*Smithora naiadum*), Aug 30, 2012.

Photograph 29: Transect 9B - Wireweed (*Sargassum muticum)* and Sea lettuce (*Ulva* spp.) within quadrat, Aug 30, 2012.

Photograph 30: Transect 9B - Sea lettuce (*Ulva* spp.) and *Sarcodiotheca* spp., Aug 30, 2012.

Photograph 31: Transect 9D - Point Glover intertidal zone, showing beach and backshore, May 22, 2012.

Photograph 32: Transect 9D - Point Glover intertidal zone, showing beach, backshore and transect location, August 28, 2012.

Photograph 33: Transect 9D - Red rock crab (*Cancer productus*) covered by *Laminaria* spp., May 22, 2012.

Photograph 34: Transect 9D - Two nudibranchs (*Janolus* spp.), Aug 28, 2012.

Photograph 35: Transect 9D - Red cup (*Constantinea* sp.) with attached Bryozoan, Aug 28, 2012.

Photograph 36: Transect 9D - Piddock clam siphons (*Zirphaea pilsbryi*) among Sea lettuce, Aug 28, 2012.

Photograph 37: Transect 9D - Colony of pink-tipped anemones (*Anthopleura elegantissima*), Aug 28, 2012.

Photograph 38: Transect 9D - Blades of *Laminaria* spp., Aug 28, 2012.

Photograph 39: Transect 10B - *Agarum* sp. blades covered in detritus, Aug 28, 2012.

Photograph 40: Transect 10B - Point Glover intertidal zone, showing beach and transect location, May 20, 2012.

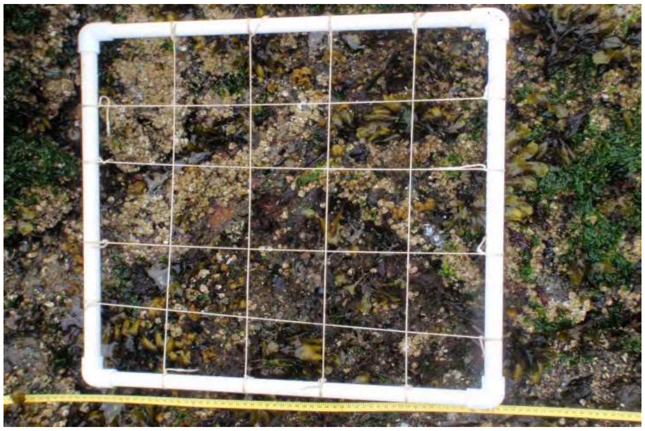
Photograph 41: Transect 10B - Point Glover intertidal zone, showing beach and transect location, August 28, 2012.

Photograph 42: Transect 10B - Kelp crab (*Pugettia* sp.) and a Frosted nudibranch (*Dirona albolineata*) among Turkish towel, Aug 28, 2012.

Photograph 43: Transect 10B - Wireweed (*Sargassum muticum*), Aug 28, 2012.

Photograph 44: Transect 10B - Piddock clam siphons (*Zirphaea pilsbryi*) among Sea lettuce (*Ulva* spp.), Aug 28, 2012.

Photograph 45: Transect 10B - Kelp crab (*Pugettia* sp.), Aug 28, 2012.



Photograph 46: Transect 10B - Intertidal zone with Barnacles and Rockweed (*Fucus* sp.), May 20, 2012.

Photograph 47: Transect 11B - Illahee North (reference site) intertidal zone, May 24, 2012.

Photograph 48: Transect 11B - Illahee North (reference site) intertidal zone, August 29, 2012.

Photograph 49: Transect 11B - Helmet crab (*Telmessus cheiragonus*) among various algae, Aug 29, 2012.

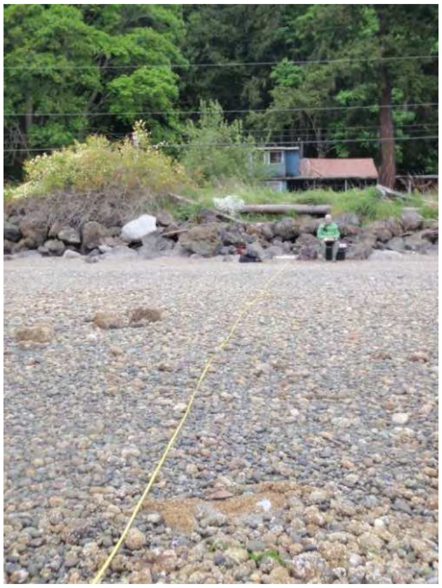
Photograph 50: Transect 11B - Horse clam siphon (*Tresus* sp.), Aug 29, 2012.

Photograph 51: Transect 11B - Jointed tubeworm (*Spiochaetopterus costarum*) next to Sea lettuce (*Ulva* spp.) and *Gracilaria* sp., Aug 29, 2012.

Photograph 52: Transect 11B - Sea lettuce (*Ulva* spp.) and *Gracilaria* sp. covered in detritus, Aug 29, 2012.

Photograph 53: Transect 11B - Graceful crab (*Cancer gracilis*) and Mottled star (*Evasterias troschelii*) among sea lettuce, Aug 29, 2012.

Photograph 54: Transect 11B - Cobble with a Chiton and Barnacles, Aug 29, 2012.



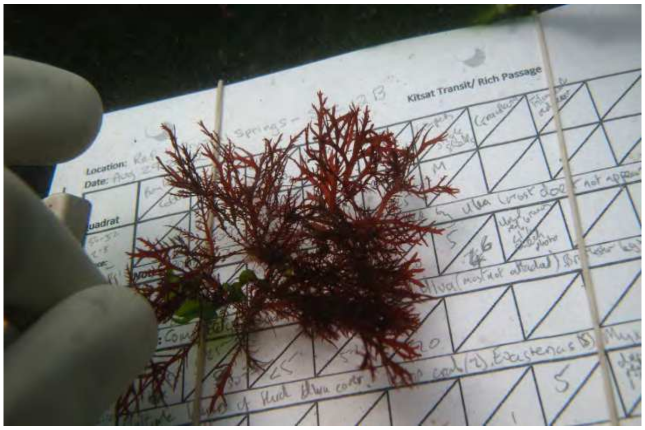
Photograph 55: Transect 12B - Intertidal zone showing backshore and transect location, May 22, 2012.

Photograph 56: Transect 12B - Intertidal zone showing backshore and transect location, August 29, 2012.

Photograph 57: Transect 12B - Crystal Springs *Polysiphonia* spp., Aug 29, 2012.

Photograph 58: Transect 12B - Kelp crab (*Pugettia* sp.) among Sea lettuce (*Ulva* spp.), Aug 29, 2012.

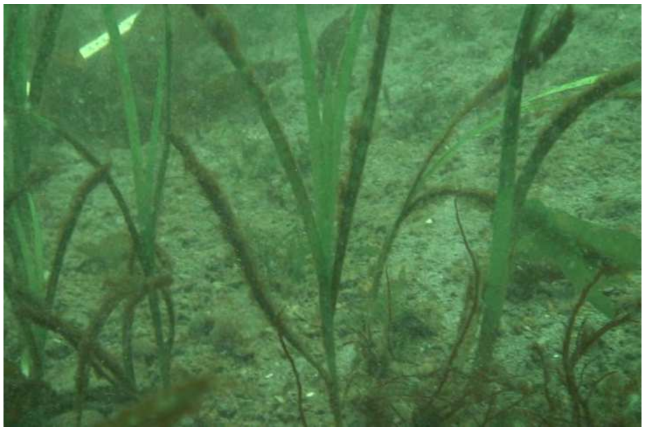
Photograph 59: Transect 12B - *Gracilaria* sp. and Sea lettuce (*Ulva* spp.), Aug 29, 2012.



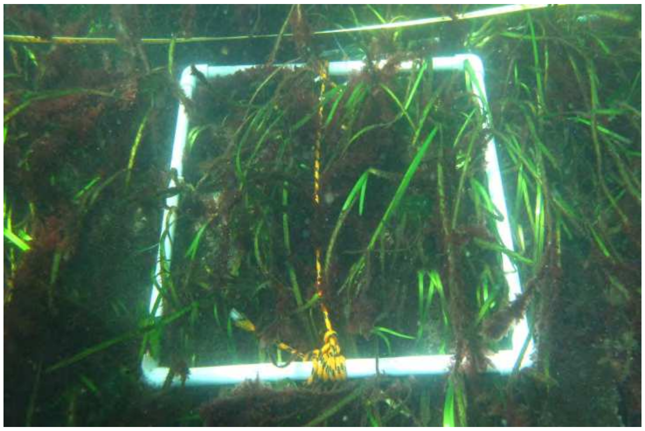
Photograph 60: Transect 12B - *Osmundea* spp. with transect data sheet in background, Aug 29, 2012.

Photograph 61: Transect 12B - Slime-tubed feather duster worm casing (*Myxicola infundibulum*), Aug 29, 2012.

Photograph 62: Transect 12B - Cobble with limpets attached (Family Lottidae), Aug 29, 2012.



Photograph 63: Port Orchard Eelgrass survey - Eelgrass shoot density at 6 m along transect, May 24, 2012.



Photograph 64: Port Orchard Eelgrass survey - Quadrat at 6 m along transect, Aug 24, 2012.

Photograph 65: Fort Ward Eelgrass survey - Eelgrass bed at a depth of 11 feet, May 22, 2012.

Photograph 66: Fort Ward Eelgrass survey - Quadrat at 32 m along transect, Aug 26, 2012.

APPENDIX E

Summary Statistics

Summary Table for Transect and Qudrat Surveys, Presenting The Total Number of Taxa Observed, Taxonomic Richness and Diversity Metrics for Study Sites Surveyed in Fall 2011, May and August 2012.

	Fauna Taxonomic Richness						Fauna Taxonomic Diversity						Macrophyte Taxonomic Diversity						Macrophyte Taxonomic Richness						Total Taxa Observed		
	Fall 2011		May-12		Aug-12		Fall 2011		May-12		Aug-12		Fall 2011		May-12		Aug-12		Fall 2011		May-12		Aug-12		Fall 2011	May-12	Aug-12
	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error			
Tr1B	1.59	0.33	2.31	0.44	3.25	0.54	0.24	0.08	0.60	0.15	0.75	0.14	0.72	0.14	0.67	0.14	0.65	0.15	2.76	0.47	3.13	0.63	3.75	0.82	24	33	40
Tr3B	1.88	0.69	3.38	0.94	3.25	0.84	0.32	0.18	0.61	0.28	0.85	0.20	0.45	0.18	0.30	0.21	0.54	0.27	1.75	0.73	1.50	0.93	2.63	1.08	17	27	26
Tr5D	1.63	0.65	3.25	0.62	2.75	0.59	0.26	0.15	0.76	0.21	0.71	0.17	0.43	0.21	0.46	0.24	0.37	0.16	2.00	0.80	2.38	1.28	2.63	0.86	17	26	23
Tr9B	0.60	0.21	1.27	0.25	1.40	0.36	0.13	0.07	0.20	0.09	0.38	0.13	0.61	0.11	0.74	0.14	0.48	0.11	2.67	0.43	3.47	0.52	2.53	0.49	19	28	25
Tr9D	0.91	0.31	2.09	0.61	1.91	0.49	0.20	0.11	0.19	0.09	0.53	0.16	0.87	0.18	0.81	0.22	0.80	0.17	3.36	0.72	5.00	1.58	4.00	1.01	23	37	32
Tr10B	1.70	0.34	2.90	0.59	2.30	0.47	0.35	0.11	0.71	0.19	0.43	0.14	0.79	0.18	1.00	0.20	0.66	0.18	3.20	0.68	4.80	0.81	3.30	0.84	22	29	24
Tr11B	-	-	1.93	0.35	4.00	0.57	-	-	0.34	0.09	0.85	0.15	-	-	0.35	0.12	0.33	0.10	-	-	1.43	0.42	1.46	0.35	-	15	26
Tr12B	2.73	0.45	2.64	0.43	3.27	0.69	0.63	0.11	0.68	0.13	0.58	0.16	0.27	0.10	0.51	0.19	0.31	0.12	1.27	0.41	2.00	0.71	1.64	0.53	18	21	21

Notes

Shannon Diversity Indices were calculated for each quadrat. The average diversity was calculated for each transect using the quadrat data to provide to provide an estimate of average diversity for fauna and macrophytes per site.

Shannon Diversity Indices were calculated using counts for all taxa, except macroalgae (algae and eelgrass), barnacles and pink-tipped anemones (percent cover was used as an estimate of abundance for these taxa).

APPENDIX F

DVD of Underwater Towed Video Footage

APPENDIX G

Benthic Infauna Data

Appendix G
Rich Passage Benthic Data Table

GroupName	Family or Higher Taxonomic Level	Species Name - or Higher Taxonomic Level	Jun-12																								Aug-12																							
			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)		
			10B-1	10B-2	10B-3	11B-1	11B-2	11B-3	12B-1	12B-2	12B-3	1B-1	1B-2	1B-3	3B-1	3B-2	3B-3	5D-1	5D-2	5D-3	9B-1	9B-2	9B-3	9D-1	9D-2	9D-3	10B-1	10B-2	10B-3	11B-1	11B-2	11B-3	12B-1	12B-2	12B-3	1B-1	1B-2	1B-3	3B-1	3B-2	3B-3	5D-1	5D-2	5D-3	9B-1	9B-2	9B-3	9D-1	9D-2	9D-3
CRUSTACEA	Ampeliscidae	Ampeliscidae sp (in part)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Ampithoidae	Amphithoe dalli	6	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Ampithoidae	Amphithoe sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	2	0	0	0
CRUSTACEA	Aoridae	Aoroides sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
CRUSTACEA	Caprellidae	Caprellidae sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Caprellidae	Metacaprella anomala	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Caridea	Caridea sp (in part)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Chironomidae	Chironomidae sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
CRUSTACEA	Cirripedia	Cirripedia sp	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59	49	7	5	392	39	3	1	0	0	1	0	3	8	22	288	19	38	0	0	0	0	11	6
CRUSTACEA	Collembola	Collembola sp	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Corophiidae	Americorophium brevis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Corophiidae	Monocorophium acherusicum	0	6	0	26	28	41	0	0	1	19	9	9	1	0	0	0	0	0	0	2	0	0	1	0	1	1	0	98	175	109	2	0	2	9	4	4	0	0	0	0	0	0	2	13	3	1	0	2
CRUSTACEA	Corophiidae	Monocorophium insidiosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	21	15	10	0	0	0
CRUSTACEA	Corophiidae	Monocorophium nr acherusicum	0	0	0	20	27	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	24	64	0	0	1	0	0	4	0	0	0	0	0	0	15	18	11	1	0	0
CRUSTACEA	Crangonidae	Crangon dalli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Diptera sp	Diptera sp	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Dogielinotidae	Allorchestes angusta	12	1	2	1	17	18	0	0	0	1	0	1	0	1	0	1	0	0	3	2	76	3	0	0	0	0	0	141	184	20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Gammaridea	Gammaridea sp	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0
CRUSTACEA	Idoteidae	Idotea (Pentidotea) schmitti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0
CRUSTACEA	Ischyroceridae	Ischyrocerus litotes	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Ischyroceridae	nr Ischyroceridae sp (in part)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Isopoda	Isopoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
CRUSTACEA	Lampropidae	Lamprops nr quadriplicata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Lampropidae	Lamprops sp	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Leptocheliidae	Leptochelia dubia	0	11	0	0	0	0	1	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
CRUSTACEA	Leptocheliidae	Leptochelia savignyi	48	57	3	1	0	2	1	0	1	25	28	17	3	1	4	0	0	2	4	2	10	6	1	1	59	27	1	1	0	2	4	0	0	17	0	1	4	6	0	0	0	0	1448	1636	1440	10	6	8
CRUSTACEA	Nannastacidae	Cumella vulgaris	4	17	1	79	52	86	1	0	0	35	8	20	2	0	0	1	0	0	19	25	43	1	1	1	42	6	3	58	16	28	0	2	1	8	16	11	0	0	0	0	0	0	114	59	52	0	0	1
CRUSTACEA	Nebaliidae	Nebalia sp	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Paguridae	Pagurus granosimanus	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	13	1	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Paguridae	Pagurus hirsutiusculus	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
CRUSTACEA	Paguridae	Pagurus sp juv	3	2	1	18	10	10	2	0	0	2	0	0	8	1	1	1	4	0	1	0	0	1	0	1	2	2	0	4	0	0	0	0	0	0	0	0	1	0	0	1	3	1	0	0	0	1	0	0
CRUSTACEA	Panopeidae	Lophopanopeus bellus	0	0	0	0	3	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Philomedidae	Euphilomedes carcharondonta	40	0	0	0	0	0	0	0	0	6	8	3	0	0	0	0	0	0	1	1	6	1	1	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	1	0	0	0	2
CRUSTACEA	Phoxocephalidae	Foxiphalus cognates/similis	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Phoxocephalidae	Foxiphalus falciformis	0	0	0	0	0	0	0	0	0	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Phoxocephalidae	Foxiphalus sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Phoxocephalidae	Eobrolgus spinosus/chumashi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	78	87	64	0	0	0
CRUSTACEA	Phoxocephalidae	Phoxocephalidae sp (in part)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Pinnotheridae	Pinnixa littoralis	0	0	0	0	0	0	0	0	0	1	2	1	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Pinnotheridae	Pinnixa schmitti	0	0	0	4	0	0	4	3	7	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	1	8	1	0	0	0	0	1	0	0	6	2	0	0	0	0	0	0
CRUSTACEA	Pinnotheridae	Pinnixa spp juv	0	0	1	4	1	5	1	0	4	0	0	0	2	2	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Pontogeneiidae	Paramoera sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
CRUSTACEA	Pontogeneiidae	Pontogeneia nr intermedia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	9	5	5	0	0	0	0	0	0	0	0	0	0	3	4	0	0	0	2	1	1	1	0	0
CRUSTACEA	Pycnogonida	Pycnogonida sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUSTACEA	Sphaeromatidae	Exosphaeroma amplicauda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2
CRUSTACEA	Sphaeromatidae	Gnorimosphaeroma oregonense	290	232	89	62	54	58	0	1	0	42	7	11	21	4	9	0	0	0	6	3	20	85	25	50	16	17	10	3	0	0	1	0	0	2	2	1	1	1	3	1	0	3	2	4	1	34	8	54
CRUSTACEA	Sphaeromatidae	Gnorimosphaeroma/ Exosphaeroma s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	394	102	223	13	20	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	9	31
CRUSTACEA	Varunidae	Hemigrapsus oregonensis	0	0	0	5	2	1	0	0	0	0	0	0	0	6	2	12	14	8	0	0	0	0	0	0	2	3	0	5	4	2	3	0	0	0	0	0	5	6	6	14	10	1	0	0	0	3	0	0
MOLLUSCA	Aglajidae	Melanochlamys diomedea	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA	Caecidae	Fartulum occidentale	0	0	13	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA	Calyptraeidae	Crepipatella dorsata	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA	Cardiidae	Clinocardium nuttallii	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	1
MOLLUSCA	Cardiidae	Clinocardium sp juv	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	4	0	1	0
MOLLUSCA	Hiatellidae	Hiatella arctica	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	1	0	0
MOLLUSCA	Lasaeidae	Neaeromya spp juv	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0	0	4	0	0	2	0	2	0	3	0	0	0
MOLLUSCA	Lasaeidae	Rochefortia tumida	119	58	106	59	24	51	123	33	241	190	367	265	18	4	10	23	21	24	1	4	4	56	42	45	43	58	27	9	34	20	40	137	45	158	94	33	11	19	18	52	54	72	117	187	240	58	52	106
MOLLUSCA	Littorinidae	Lacuna vincta	5	3	2	0	0	0	1	0	0	40	4	18	1	0	1	0	0	0	14	6	29	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
MOLLUSCA	Littorinidae	Littorina scutulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA	Lottiidae	Lottia pelta	2	0	6	1	9	2	0	0	1	0	0	0	10	2	0	11	0	0	0	0	0	1	0	0	4	11	1	0	11	4	1	0	1	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0
MOLLUSCA	Lottiidae	Lottia scutum	0	0	0	1	1	1	2	6	5	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA	Lottiidae	Lottia spp juv	4	0	0	3	0	2	1	1	0	0	0	0	4	1	0	8	0	0	0	0	0	1	0	0	5	8	0	0	2	0	0	0	3	0	0	0	2	0	0	4	4	3	0	0	0	0	1	0
MOLLUSCA	Lucinidae	Parvilucina tenuisculpta	0	1	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0
MOLLUSCA	Mactridae	Sinomactra falcata	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA	Margaritidae	Margarites pupillus	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
MOLLUSCA	Muricidae	Nucella lamellosa	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA	Muricidae	Nucella spp juv	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA	Myidae	Cryptomya californica	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
MOLLUSCA	Myidae	Mya sp juv	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MOLLUSCA	Mytilidae	Modiolus sp juv	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA	Mytilidae	Mytilidae spp juv	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	17	0	0	0	0	0	3	2	0	1	1	0	1	3	0
MOLLUSCA	Mytilidae	Mytilus spp complex	22	9	20	1	4	1	0	0	0	1	0	0	5	9	2	40	12	13	0	0	0	10	1	5	3	23	1	1	5	1	0	0	0	0	2	0	4	1	2	11	10	1	3	0	3	2	4	5
MOLLUSCA	Pyramidellidae	Odostomia spp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	0	0	0	1	1	0	0
MOLLUSCA	Rissoidae	Alvania compacta	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA	Schilbeidae	Alia tuberosa	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA	Tellinidae	Macoma inquinata	2	5	1	4	0	0	0	0	1	0	1	1	5	11	11	14	20	23	0	0	0	0	0	0	0	2	1	0	0	0	0	3	1	0	0	0	1	4	0	27	12	20	0	11	7	0	0	5
MOLLUSCA	Tellinidae	Macoma spp juv	0	0	0	1	0	0	0	0	1	0	0	4	2	0	0	1	0	0	0	0	0	0	0	0	4	0	3	3	8	17	7	2	8	6	9	1	2	3	0	3	9	6	3	0	0	1	2	1
MOLLUSCA	Tellinidae	Tellina modesta	0	0	0	0	0	0	0	0	0	11	11	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	4	4	0	0	0	0	0	0	2	1	0	0	0	0
MOLLUSCA	Trochidae	Lirularia spp (broken)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA	Trochidae	Lirularia succincta	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
MOLLUSCA	Veneridae	Leukoma staminea	1	2	2	5	4	9	0	2	4	1	2	0	2	4	2	2	0	1	0	0	0	3	0	1	1	2	1	6	6	5	3	8	8	6	4	0	2	1	5	4	1	1	0	0	0	0	3	0
MOLLUSCA	Veneridae	Nutricola cf tantilla	15	2	8	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
MOLLUSCA	Veneridae	Nutricola spp juv	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	6	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	3	0	0	0
MOLLUSCA	Veneridae	Saxidomus gigantea	1	3	0	0	0	1	0	0	0	2	1	2	0	2	2	2	0	6	0	0	0	0	1	1	2	2	0	0	0	2	0	1	0	0	0	0	1	1	1	5	1	4	0	1	0	2	5	2
MOLLUSCA	Veneridae	Veneridae sp juv	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	0	3	1	0	0	0	0	3	0
MOLLUSCA	Veneridae	Venerupis philippinarum	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Ampharetidae	Ampharetidae	0	0	0	0	1	0	4	5	10	0	0	0	2	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	2	0	4	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Capitellidae	Capitella capitata complex	4	0	0	2	4	3	0	1	0	0	2	1	6	34	6	0	0	0	16	49	2	0	0	0	1	1	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Capitellidae	Capitellidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Capitellidae	Mediomastus californiensis	4	5	5	1	5	1	4	5	10	1	0	0	2	3	8	6	12	21	0	0	0	4	0	2	10	7	0	1	2	1	2	6	2	0	0	0	2	7	7	53	14	15	10	17	8	3	3	1
POLYCHAETA	Capitellidae	Notomastus hemipodus	2	18	22	80	108	13	34	14	74	28	36	15	5	6	4	5	23	26	0	0	0	0	0	0	9	11	3	34	35	12	95	14	61	3	16	4	11	6	2	10	27	2	18	6	20	5	0	0
POLYCHAETA	Chaetopteridae	Chaetopteridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Chaetopteridae	Phyllochaetopterus sp	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Chaetopteridae	Spiochaetopterus pottsi	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Cirratulidae	Caulleriella hamata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	1	3	0	0	0	0	0	0	0	0	0
POLYCHAETA	Cirratulidae	Chaetozone sp	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix G
Rich Passage Benthic Data Table

			Jun-12																								Aug-12																							
			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)			Replicates (1through 3)		
GroupName	Family or Higher Taxonomic Level	Species Name - or Higher Taxonomic Level	10B-1	10B-2	10B-3	11B-1	11B-2	11B-3	12B-1	12B-2	12B-3	1B-1	1B-2	1B-3	3B-1	3B-2	3B-3	5D-1	5D-2	5D-3	9B-1	9B-2	9B-3	9D-1	9D-2	9D-3	10B-1	10B-2	10B-3	11B-1	11B-2	11B-3	12B-1	12B-2	12B-3	1B-1	1B-2	1B-3	3B-1	3B-2	3B-3	5D-1	5D-2	5D-3	9B-1	9B-2	9B-3	9D-1	9D-2	9D-3
POLYCHAETA	Cirratulidae	Cirratulidae	0	0	0	0	0	0	4	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Cirratulidae	Cirratulus robusta	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	13	0	2	1	0	0	0	0	0	0
POLYCHAETA	Dorvilleidae	Dorvillea rudolphi	0	0	0	2	1	1	2	9	16	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	6	1	11	0	0	0	3	6	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Dorvilleidae	Pettibonia sp	0	1	1	4	0	1	0	0	1	0	0	0	1	1	4	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Dorvilleidae	Protodorvillea gracilis	0	1	1	3	3	0	4	2	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	7	6	0	0	0	5	9	4	0	0	0	4	0	0	1	1	2
POLYCHAETA	Glyceridae	Glycera americana	0	0	1	2	0	1	1	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	2	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
POLYCHAETA	Glyceridae	Glycera nana	26	35	57	1	7	0	0	0	0	0	2	1	3	3	3	19	16	20	0	0	0	15	13	29	20	9	19	3	2	3	0	0	0	0	0	0	3	4	6	14	14	19	6	2	6	13	7	13
POLYCHAETA	Goniadidae	Glycinde picta	7	11	2	10	13	12	4	2	2	36	24	19	7	7	5	1	1	1	0	5	1	0	0	0	2	5	1	2	3	0	1	3	1	9	6	7	2	5	5	5	0	0	9	13	14	0	1	2
POLYCHAETA	Hesionidae	Micropodarke dubia	2	2	0	2	1	0	5	3	3	3	1	0	6	10	6	1	1	2	0	0	0	0	0	0	5	3	0	3	5	10	13	12	6	2	1	0	26	31	20	0	0	2	2	0	0	0	0	0
POLYCHAETA	Hesionidae	Podarke pugettensis	0	0	0	8	0	1	7	9	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	3	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Hesionidae	Podarkeopsis perkinsi	0	0	0	3	0	0	0	0	0	0	0	1	3	0	3	0	0	1	0	0	1	0	0	0	0	0	0	1	0	3	1	1	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Lumbrineridae	Lumbrineridae	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	8	1	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Maldanidae	Maldanidae	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Maldanidae	Nichomache personata	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Nephtyidae	Nephtys caeca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Nephtyidae	Nephtys caecoides	0	0	0	0	0	0	0	0	0	5	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	1	0	0	0
POLYCHAETA	Nereididae	Nereis neoneanthes	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Nereididae	Nereis procera	0	0	0	1	7	1	2	3	2	3	2	0	0	0	0	0	0	0	1	1	3	0	0	0	0	0	0	1	0	0	4	5	1	0	0	1	0	0	0	0	0	1	3	6	5	0	0	1
POLYCHAETA	Nereididae	Platynereis bicanaliculata	1	0	0	0	1	0	1	1	0	3	0	2	0	1	0	0	0	0	0	0	0	0	0	0	1	3	0	0	6	1	0	1	0	1	0	0	0	0	1	1	0	0	26	31	21	0	1	0
POLYCHAETA	Oligochaeta	Oligochaeta	31	7	1	2	7	3	0	1	0	0	0	0	3	3	3	0	0	0	0	1	4	2	1	0	74	5	2	0	0	0	0	3	1	0	0	0	0	2	1	0	0	0	0	0	0	0	1	0
POLYCHAETA	Onuphidae	Onuphidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
POLYCHAETA	Onuphidae	Onuphis iridescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Opheliidae	Armandia brevis	72	12	1	252	222	227	81	55	40	24	13	8	57	66	37	3	19	5	0	0	0	2	2	1	22	22	4	42	86	121	42	64	31	1	3	0	20	17	13	72	22	17	1	5	2	7	4	5
POLYCHAETA	Orbiniidae	Leitoscoloplos pugettensis	0	0	0	0	0	0	4	1	1	9	2	7	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	4	1	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Oweniidae	Galathowenia oculata	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Oweniidae	Owenia fusiformis	3	11	3	0	0	0	2	0	0	0	1	0	3	1	2	0	2	13	0	0	0	0	0	1	2	0	0	1	0	0	2	1	0	2	1	0	7	16	5	9	15	1	2	1	1	1	1	1
POLYCHAETA	Pectinariidae	Pectinaria californiensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Pholoidae	Pholoe sp N-1	0	0	0	4	0	2	3	2	5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	3	3	4	0	0	0	1	0	0	0	0	1	0	0	0	0	0	3
POLYCHAETA	Phyllodocidae	Eteone sp	0	0	0	0	6	0	0	0	0	0	1	0	4	0	1	0	0	1	118	76	173	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0
POLYCHAETA	Phyllodocidae	Eulalia sp	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
POLYCHAETA	Phyllodocidae	Phyllodoce hartmanae	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Phyllodocidae	Phyllodoce sp	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	2	0	0	0
POLYCHAETA	Phyllodocidae	Phyllodocidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0
POLYCHAETA	Polynoidae	Harmothoe imbricata	1	0	0	0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0
POLYCHAETA	Polynoidae	Polynoidae	1	0	0	0	4	0	3	7	5	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	3	4	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
POLYCHAETA	Sigalionidae	Pholoides aspera	0	0	0	0	2	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0	0
POLYCHAETA	Spionidae	Dipolydora caulleryi	1	0	0	0	15	1	0	0	0	0	0	1	7	4	3	42	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	6	1	2	0	0	0	0	0	0
POLYCHAETA	Spionidae	Laonice cirrata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Spionidae	Polydora sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Spionidae	Prionospio jubata	3	0	0	0	0	0	0	1	0	9	0	0	45	20	20	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7	3	0	1	2	0	0	0	1	0	0
POLYCHAETA	Spionidae	Prionospio multibranchiata	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Spionidae	Prionospio sp	0	0	0	0	0	0	1	0	1	0	1	1	2	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
POLYCHAETA	Spionidae	Pygospio elegans	7	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Spionidae	Rhynchospio arenicola	0	0	0	0	0	0	0	0	0	6	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	40	29	1	0	0
POLYCHAETA	Spionidae	Scolelepis foliosa	6	8	0	2	1	2	0	0	3	4	2	4	2	0	11	3	4	9	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Spionidae	Spio filicornis	0	0	0	0	0	0	0	0	0	5	3	0	6	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	2	3	4	0	1	1	0	0	0
POLYCHAETA	Spionidae	Spionidae	2	1	0	0	0	0	0	0	0	2	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	1	0	0	0	0
POLYCHAETA	Spionidae	Spiophanes bombyx	0	0	0	0	0	0	0	0	0	18	2	9	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Spionidae	Streblospio benedicti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	Syllidae	Syllidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	1	0	0	0	0	0	2	3	1	0	0	0	0	0	1	2	1	0
POLYCHAETA	Syllidae	Typosyllis sp	0	0	0	0	0	0	2	3	8	0	0	0	0	0	0	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	5	2	4	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
POLYCHAETA	Terebellidae	Terebellidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	Acoela	Acoela	0	0	0	13	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	Actiniidae	Anthopleura artemisia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
MISCELLANEOUS	Amphiuridae	Amphiodia occidentalis	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MISCELLANEOUS	Amphiuridae	Amphiuridae	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	Athenaria	Athenaria	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	Dendrasteridae	Dendraster excentricus	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
MISCELLANEOUS	Edwardsiidae	Edwardsia juliae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	Edwardsiidae	Edwardsia sp	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
MISCELLANEOUS	Golfingiidae	Golfingia sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	6	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	Halcampidae	Halcampa decemtentaculata	0	0	0	0	0	0	4	3	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	Leptoplanidae	Leptoplanidae	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	1	2	0	0	0	0	0	0	0	1	3	2	0	0	0	0	0	0	0	0
MISCELLANEOUS	Lineidae	Micrura sp	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	Nemertea	Nemertea	17	18	4	42	4	2	5	9	15	28	4	17	9	81	32	2	6	8	0	1	0	21	0	0	30	72	7	25	3	22	13	7	11	6	10	0	34	235	56	23	38	11	12	4	2	0	13	32
MISCELLANEOUS	Ophiurida	Ophiurida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MISCELLANEOUS	Phoronidae	Phoronopsis harmeri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
MISCELLANEOUS	Sipunculidae	Sipunculida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	Synaptidae	Leptosynapta sp	0	1	0	0	0	0	1	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	2	1	0	3	0	1	0	1	0	0	0
MISCELLANEOUS	Typhloplanoida	Typhloplanoida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes

Due possible sample bias and inaccuarcies in counts, the following taxa were removed from the dataset prior to analysis:

Calanoida	Copepoda - calanoida
Cyclopoida	Copepoda - cyclopoida
Nematoda	Nematoda

APPENDIX H

Benthic Infauna Summary Statistics

Appendix H

Summary Statistics Table for Benthic Data

Summary Table for Benthic Data Collected at Study Sites During June and August Surveys

	1B		3B		5D		9B		9D		10B		11B		12B	
	μ	δ	μ	δ	μ	δ	μ	δ	μ	δ	μ	δ	μ	δ	μ	δ
June																
Abundance (ind/m^2)	20846	1361	10365	1128	8164	450	9726	2522	5977	1515	21940	4777	26419	2382	13659	3578
Species Richness	30.00	1.53	29.67	0.67	23.33	1.20	17.00	0.58	15.00	2.52	26.67	1.45	27.33	1.67	30.67	2.19
Diversity	2.14	0.30	2.89	0.13	2.82	0.04	1.71	0.13	1.74	0.16	2.28	0.09	2.40	0.12	2.44	0.17
Relative Abundance (%)	*Rochefortia sp.*	50.12	*Armandia sp.*	20.08	*Rochefortia sp.*	10.85	*Eteone sp.*	49.13	*Gnorimosphaeroma sp.*	34.63	*Gnorimosphaeroma sp.*	35.90	*Armandia sp.*	34.08	*Rochefortia sp.*	37.21
August																
Abundance (ind/m^2)	6992	2105	10612	2969	15000	4753	79453	2781	7943	1753	22148	6622	27109	6879	10833	1221
Species Richness	21.67	4.10	29.33	2.03	26.33	0.67	29.33	1.20	22.33	0.33	26.33	4.91	27.00	1.73	29.67	3.18
Diversity	2.00	0.06	2.59	0.26	2.50	0.22	1.40	0.04	2.35	0.11	2.19	0.35	1.96	0.34	2.47	0.08
Relative Abundance (%)	*Rochefortia sp.*	52.68	*Nemertea*	39.68	*Cirripedia sp.*	29.64	*Leptochelia sp.*	63.96	*Rochefortia sp.*	35.12	*Gnorimosphaeroma sp.*	41.13	*Cirripedia sp.*	20.94	*Rochefortia sp.*	25.08

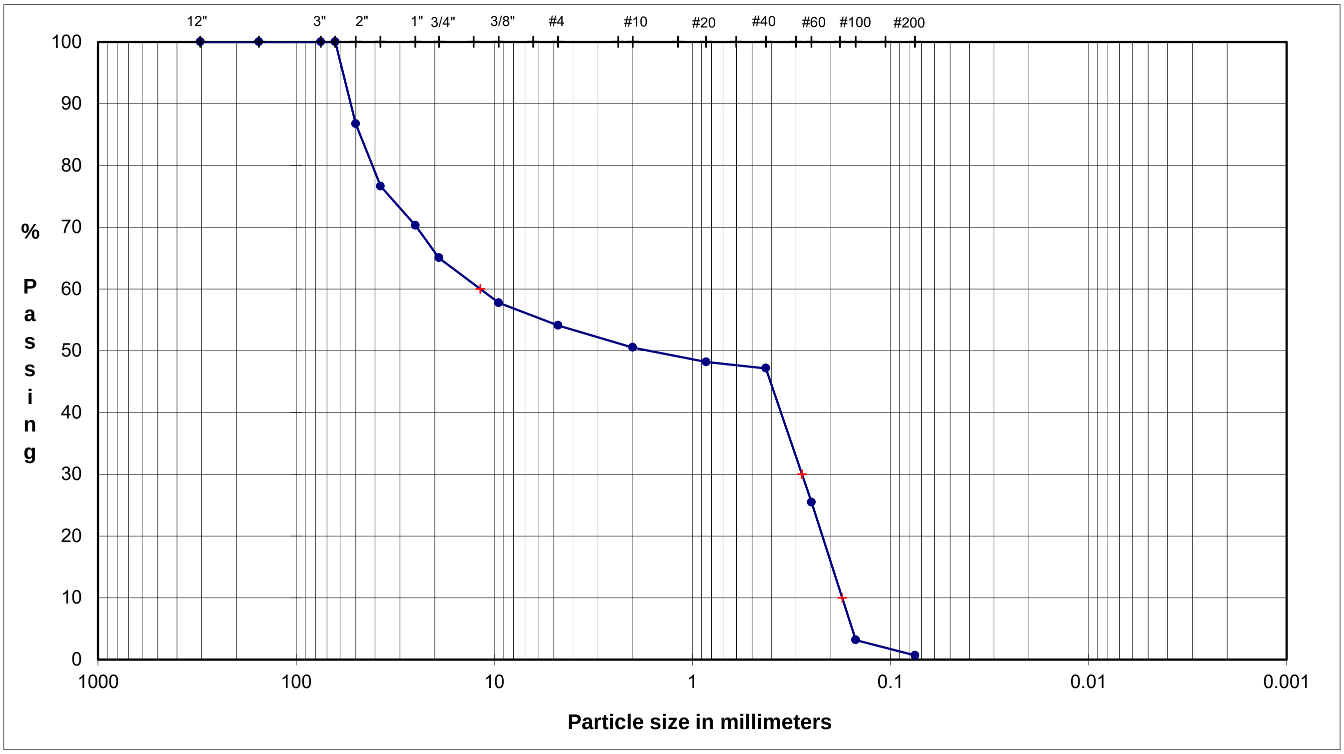
APPENDIX I

Grain Size Data

PARTICLE SIZE DISTRIBUTION

ASTM D421, D422, D4318

PROJECT NAME: **Kitsap County / Rich Passage / WA**
SAMPLE ID: **1B** **0** Depth: **0**
TYPE: **-**



	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
COBBLES	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	**100.0**	Cobbles	**0.0**
6.0"	154.2	**100.0**		
3.0"	75	**100.0**		
2.5"	63.5	**100.0**	Coarse Gravel	**34.9**
2.0"	50	**86.8**		
1.5"	37.5	**76.6**		
1.0"	25	**70.3**		
0.75"	19	**65.1**		
0.375"	9.5	**57.8**	Fine Gravel	**11.0**
#4	4.75	**54.1**		
#10	2.00	**50.5**	Coarse Sand	**3.5**
#20	0.85	**48.2**	Medium Sand	**3.4**
#40	0.43	**47.2**		
#60	0.25	**25.5**	Fine Sand	**46.5**
#100	0.15	**3.2**		
#200	0.075	**0.7**		
			Fines	**0.7**

Moisture Content
14.79

D_{60}= 11.74	D_{30}= 0.28	D_{10}= 0.18

Cu = D60/D10 =	**66.9**	> 6
Cc = D30^2/(D10*D60) =	**0.0**	< 1

DESCRIPTION: C-F SAND and C-F GRAVEL
trace silt

USCS: SP

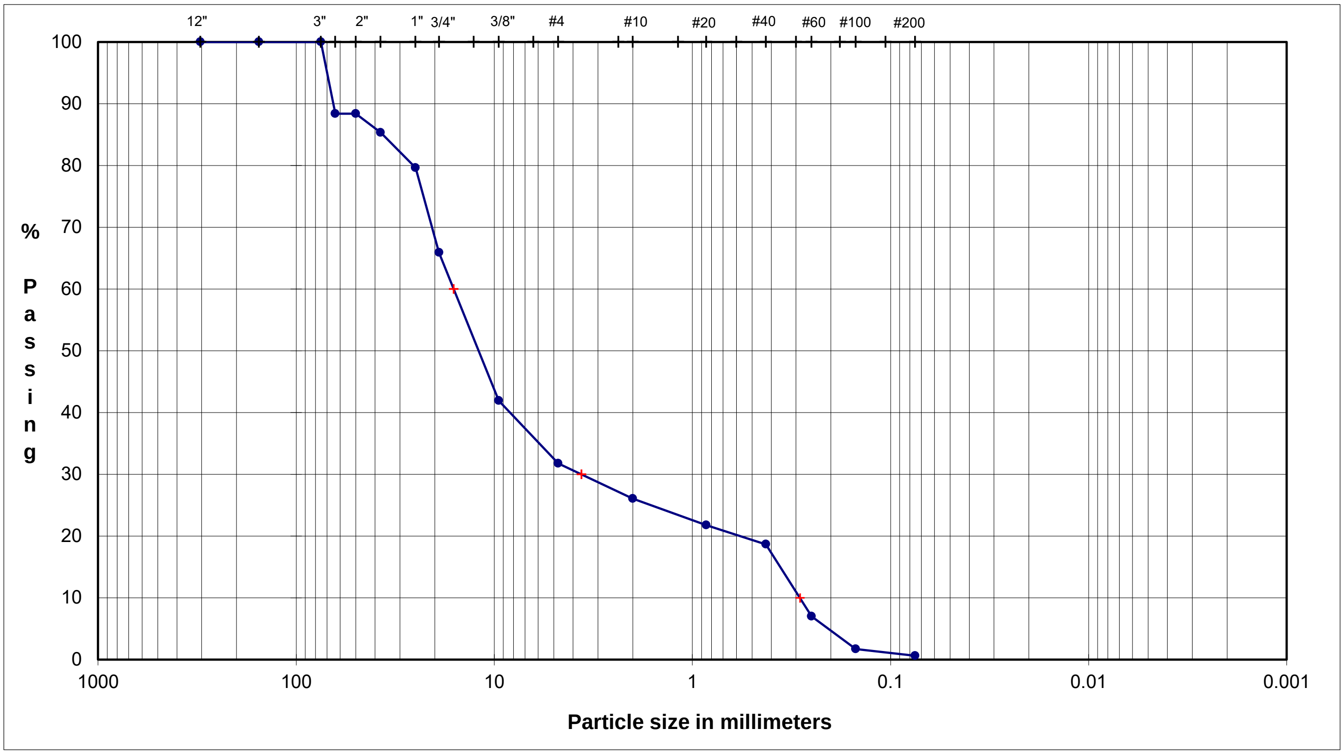
TECH	TCM
DATE	9/4/12
CHECK	TCM
REVIEW	

9/4/12 113-93490.200

PARTICLE SIZE DISTRIBUTION

ASTM D421, D422, D4318

PROJECT NAME:	**Kitsap County / Rich Passage / WA**		
SAMPLE ID:	**3**	**0** Depth:	**0**
TYPE:	**-**		



	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
COBBLES	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	**100.0**	Cobbles	**0.0**
6.0"	154.2	**100.0**		
3.0"	75	**100.0**		
2.5"	63.5	**88.4**	Coarse Gravel	**34.1**
2.0"	50	**88.4**		
1.5"	37.5	**85.3**		
1.0"	25	**79.6**		
0.75"	19	**65.9**		
0.375"	9.5	**41.9**	Fine Gravel	**34.1**
#4	4.75	**31.8**		
#10	2.00	**26.1**	Coarse Sand	**5.7**
#20	0.85	**21.8**	Medium Sand	**7.4**
#40	0.43	**18.7**		
#60	0.25	**7.0**	Fine Sand	**18.0**
#100	0.15	**1.7**		
#200	0.075	**0.6**		
			Fines	**0.6**

Moisture Content
9.03

D_{60}= 16.01	D_{30}= 3.63	D_{10}= 0.29
Cu = D60/D10 =	**55.9**	> 4
Cc = D30^2/(D10*D60) =	**2.9**	> 1

DESCRIPTION: C-F GRAVEL and C-F SAND
trace silt

USCS: GW

TECH	TCM
DATE	9/4/12
CHECK	TCM
REVIEW	

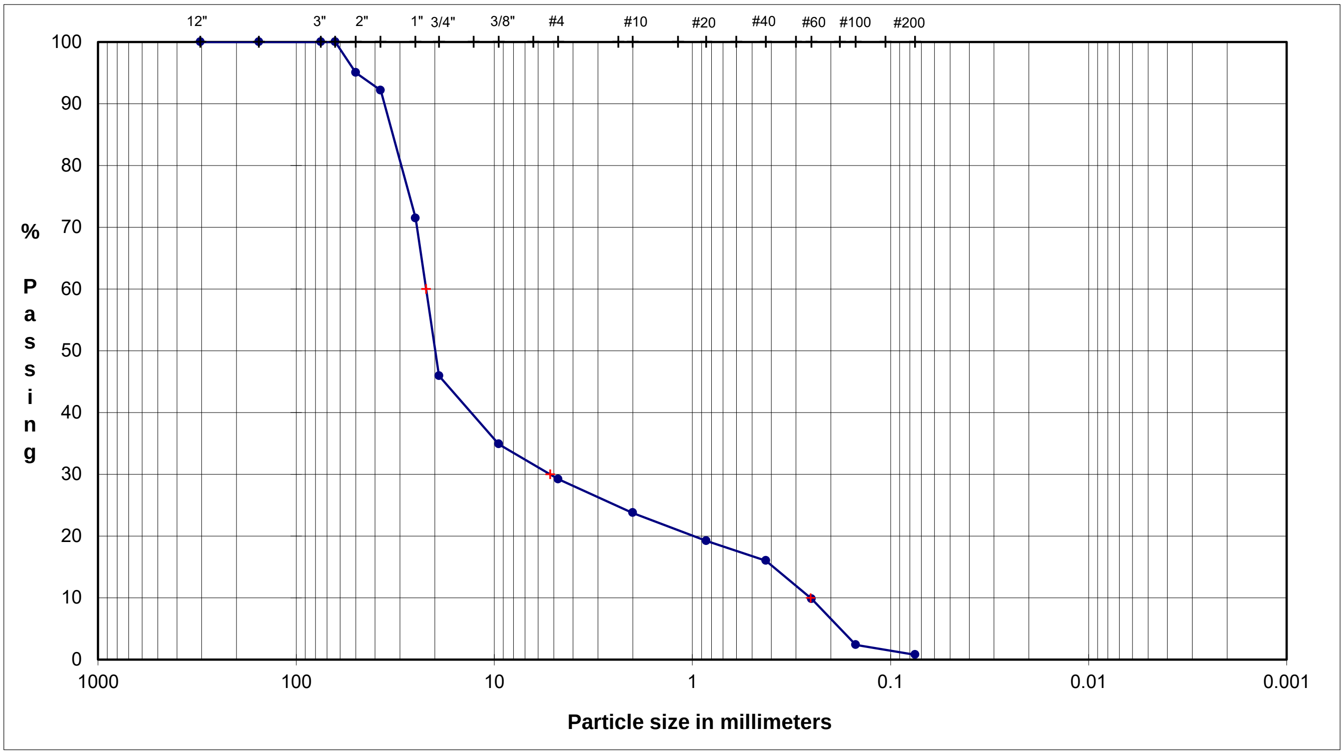
Golder Associates Inc.

9/4/12 **113-93490.200**

PARTICLE SIZE DISTRIBUTION

ASTM D421, D422, D4318

PROJECT NAME: **Kitsap County / Rich Passage / WA**
SAMPLE ID: **5D** **0** Depth: **0**
TYPE: **-**



	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
COBBLES	GRAVEL		SAND			FINES

Moisture Content: 7.57

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	**100.0**	Cobbles	**0.0**
6.0"	154.2	**100.0**		
3.0"	75	**100.0**		
2.5"	63.5	**100.0**	Coarse Gravel	**54.0**
2.0"	50	**95.1**		
1.5"	37.5	**92.2**		
1.0"	25	**71.5**		
0.75"	19	**46.0**		
0.375"	9.5	**34.9**	Fine Gravel	**16.7**
#4	4.75	**29.2**		
#10	2.00	**23.8**	Coarse Sand	**5.5**
#20	0.85	**19.2**	Medium Sand	**7.8**
#40	0.43	**16.0**		
#60	0.25	**9.8**	Fine Sand	**15.2**
#100	0.15	**2.4**		
#200	0.075	**0.8**		
			Fines	**0.8**

D_{60}= 22.10	D_{30}= 5.22	D_{10}= 0.25

Cu = D60/D10 =	**87.2**	> 4
Cc = D30^2/(D10*D60) =	**4.9**	> 3

DESCRIPTION: C-F GRAVEL
some c-f sand, trace silt

USCS: GP

TECH	TCM
DATE	9/4/12
CHECK	TCM
REVIEW	

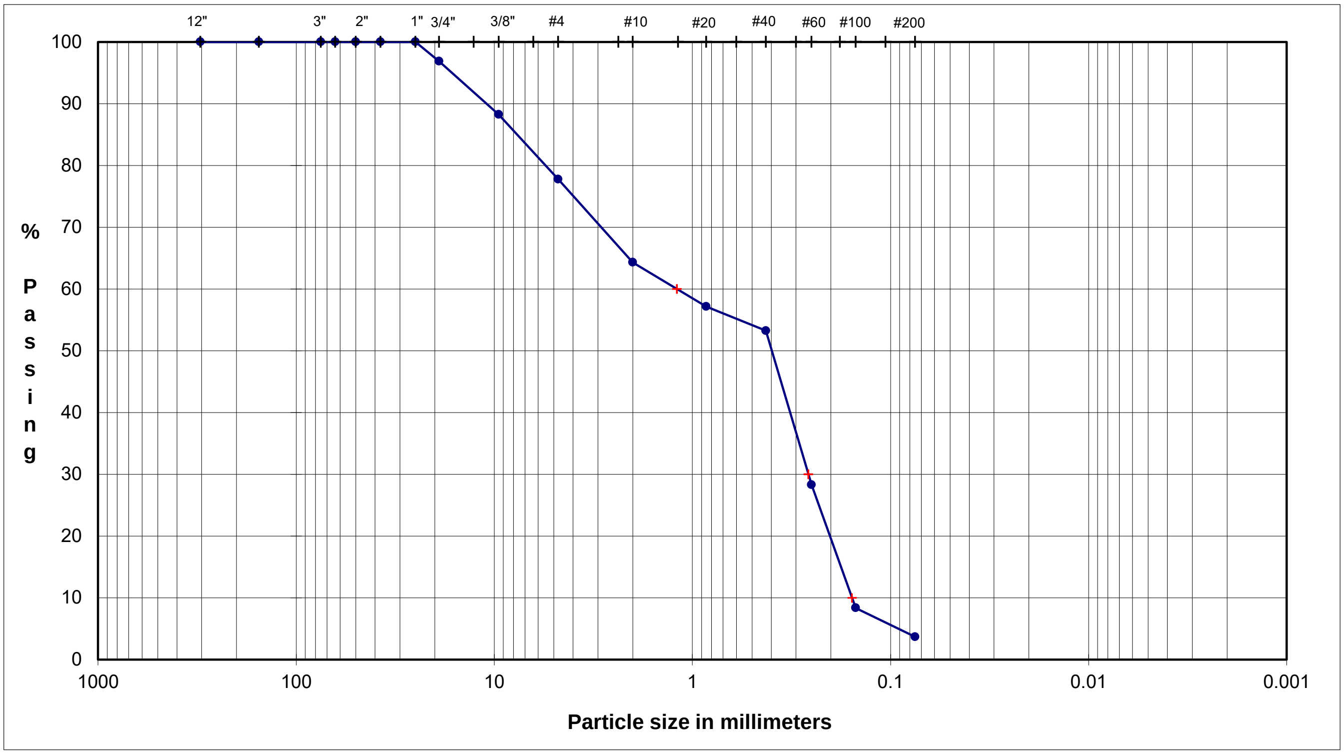
Golder Associates Inc.

9/4/12 113-93490.200

PARTICLE SIZE DISTRIBUTION

ASTM D421, D422, D4318

PROJECT NAME: **Kitsap County / Rich Passage / WA**
SAMPLE ID: **9B** **0** Depth: **0**
TYPE: **-**



	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
COBBLES	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	**100.0**	Cobbles	**0.0**
6.0"	154.2	**100.0**		
3.0"	75	**100.0**		
2.5"	63.5	**100.0**	Coarse Gravel	**3.1**
2.0"	50	**100.0**		
1.5"	37.5	**100.0**		
1.0"	25	**100.0**		
0.75"	19	**96.9**		
0.375"	9.5	**88.2**	Fine Gravel	**19.1**
#4	4.75	**77.8**		
#10	2.00	**64.3**	Coarse Sand	**13.5**
#20	0.85	**57.1**	Medium Sand	**11.1**
#40	0.43	**53.3**		
#60	0.25	**28.3**	Fine Sand	**49.6**
#100	0.15	**8.4**		
#200	0.075	**3.7**		
			Fines	**3.7**

Moisture Content: 36.11

D_{60}= 1.20	D_{30}= 0.26	D_{10}= 0.16

Cu = D60/D10 =	**7.6**	> 6
Cc = D30^2/(D10*D60) =	**0.4**	< 1

DESCRIPTION: C-F SAND
some c-f gravel, trace silt

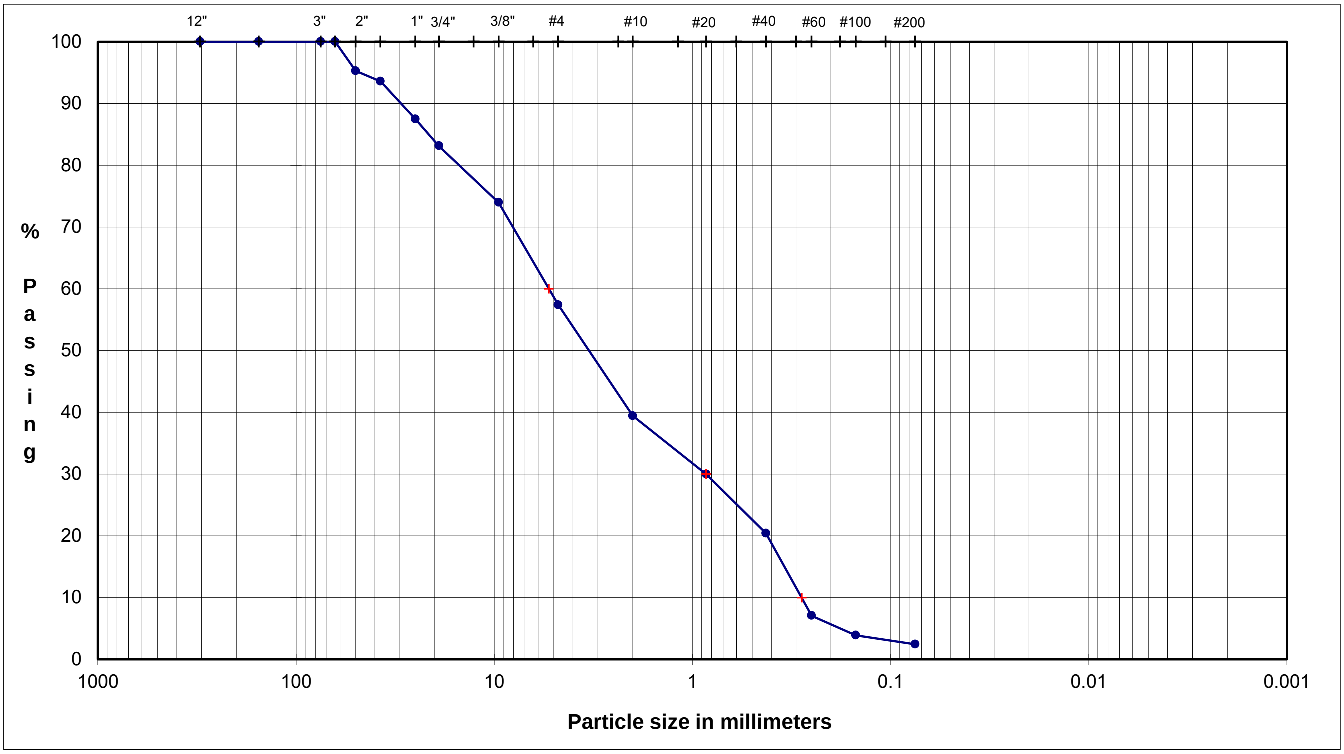
USCS: SP

TECH	TCM
DATE	9/4/12
CHECK	TCM
REVIEW	

PARTICLE SIZE DISTRIBUTION

ASTM D421, D422, D4318

PROJECT NAME:	**Kitsap County / Rich Passage / WA**			
SAMPLE ID:	**9D**	**0**	Depth:	**0**
TYPE:	**-**			



	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
COBBLES	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Particle Size Percentage
12.0"	304.8	**100.0**	Cobbles	**0.0**
6.0"	154.2	**100.0**		
3.0"	75	**100.0**		
2.5"	63.5	**100.0**	Coarse Gravel	**16.9**
2.0"	50	**95.3**		
1.5"	37.5	**93.6**		
1.0"	25	**87.5**		
0.75"	19	**83.1**		
0.375"	9.5	**74.0**	Fine Gravel	**25.7**
#4	4.75	**57.4**		
#10	2.00	**39.4**	Coarse Sand	**18.0**
#20	0.85	**30.0**	Medium Sand	**19.0**
#40	0.43	**20.4**		
#60	0.25	**7.1**	Fine Sand	**18.0**
#100	0.15	**3.9**		
#200	0.075	**2.4**		
			Fines	**2.4**

Moisture Content
31.24

D_{60}= 5.30	D_{30}= 0.85	D_{10}= 0.28
Cu = D60/D10 =	**18.9**	> 6
Cc = D30^2/(D10*D60) =	**0.5**	< 1

DESCRIPTION: C-F SAND and C-F GRAVEL
trace silt

USCS: SP

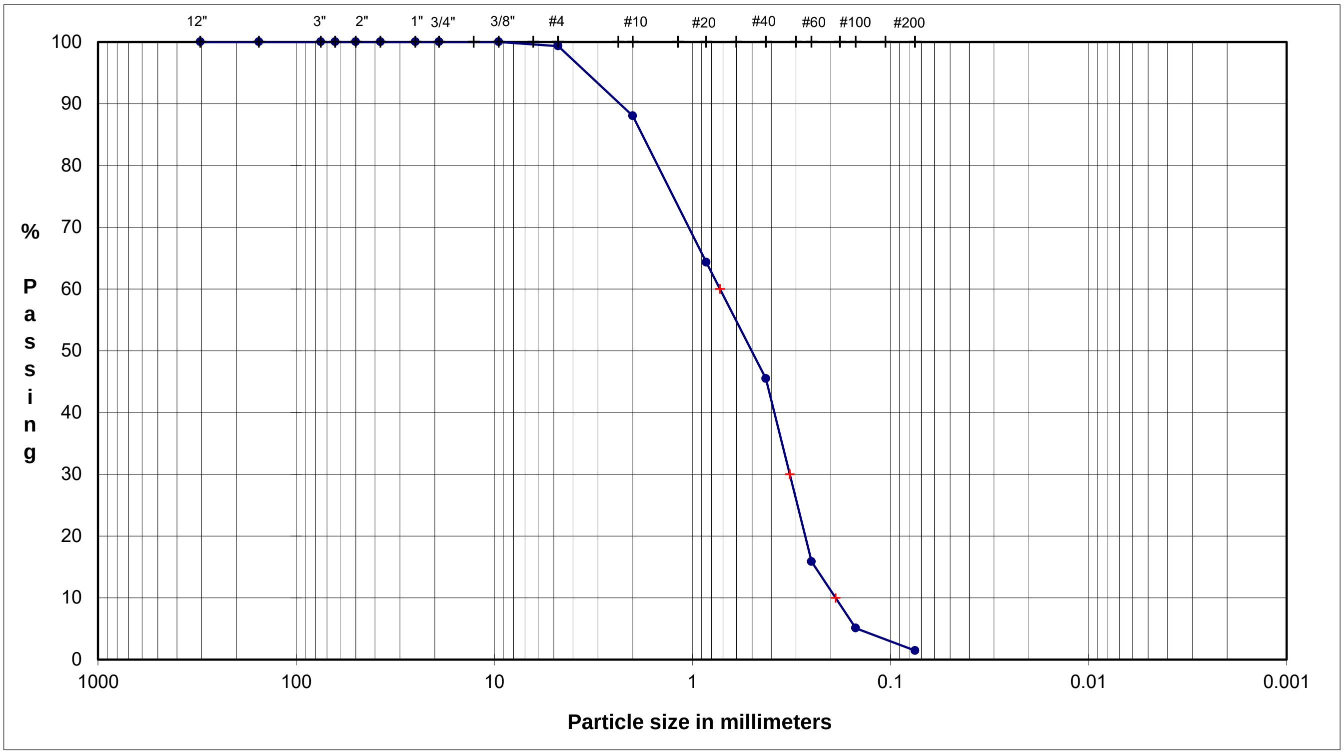
TECH	TCM
DATE	9/4/12
CHECK	TCM
REVIEW	

9/4/12 113-93490.200

PARTICLE SIZE DISTRIBUTION

ASTM D421, D422, D4318

PROJECT NAME: **Kitsap County / Rich Passage / WA**
SAMPLE ID: **10B** **0** Depth: **0**
TYPE: **-**



	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
COBBLES	GRAVEL		SAND			FINES

Moisture Content: 50.50

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	**100.0**	Cobbles	**0.0**
6.0"	154.2	**100.0**		
3.0"	75	**100.0**		
2.5"	63.5	**100.0**	Coarse Gravel	**0.0**
2.0"	50	**100.0**		
1.5"	37.5	**100.0**		
1.0"	25	**100.0**		
0.75"	19	**100.0**		
0.375"	9.5	**100.0**	Fine Gravel	**0.6**
#4	4.75	**99.4**		
#10	2.00	**88.0**	Coarse Sand	**11.3**
#20	0.85	**64.3**	Medium Sand	**42.5**
#40	0.43	**45.5**		
#60	0.25	**15.9**	Fine Sand	**44.0**
#100	0.15	**5.1**		
#200	0.075	**1.5**		
			Fines	**1.5**

D_{60}= 0.72	D_{30}= 0.32	D_{10}= 0.19
Cu = D60/D10 =	**3.8**	< 6
Cc = D30^2/(D10*D60) =	**0.8**	< 1

DESCRIPTION: C-F SAND
trace silt, trace f gravel

USCS: SP

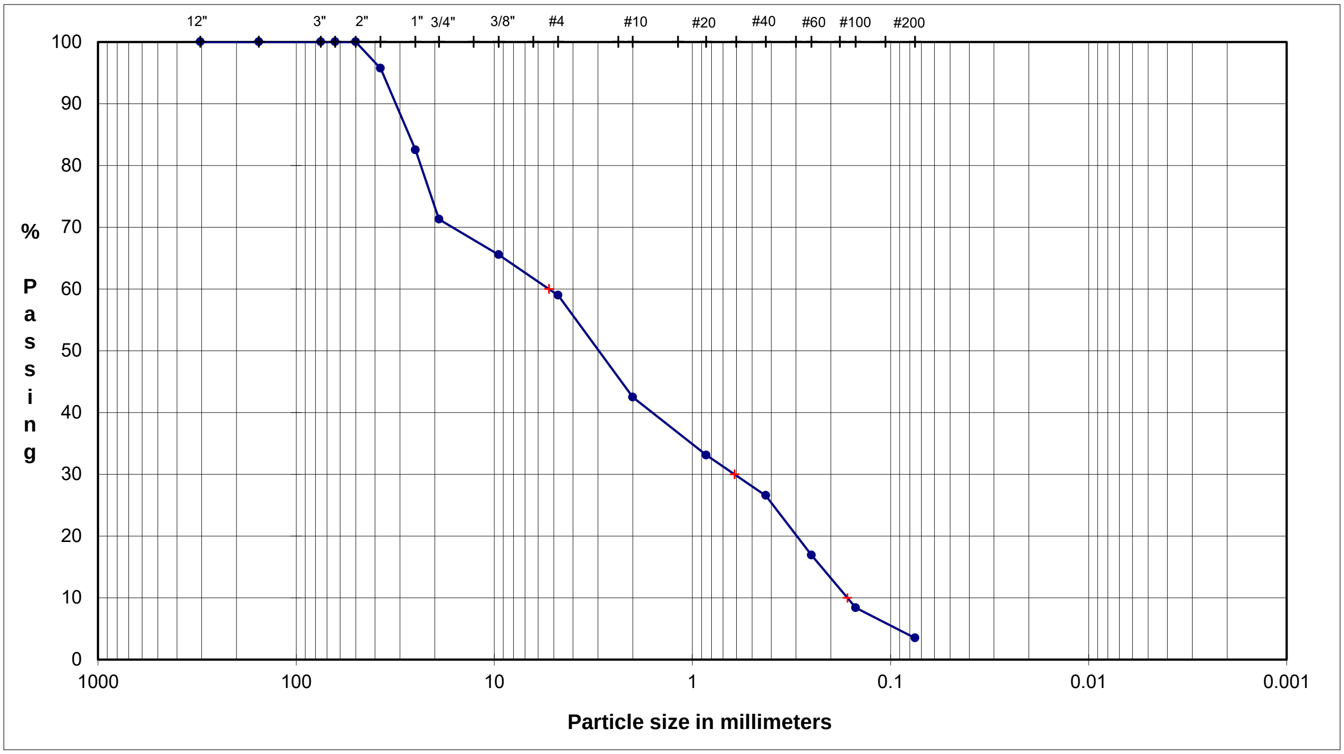
TECH	TCM
DATE	9/4/12
CHECK	TCM
REVIEW	

9/4/12 113-93490.200

PARTICLE SIZE DISTRIBUTION

ASTM D421, D422, D4318

PROJECT NAME:	**Kitsap County / Rich Passage / WA**			
SAMPLE ID:	**11B**	**0**	Depth:	**0**
TYPE:	**-**			



	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
COBBLES	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers

	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	**100.0**	Cobbles	**0.0**
6.0"	154.2	**100.0**		
3.0"	75	**100.0**		
2.5"	63.5	**100.0**	Coarse Gravel	**28.7**
2.0"	50	**100.0**		
1.5"	37.5	**95.7**		
1.0"	25	**82.5**		
0.75"	19	**71.3**		
0.375"	9.5	**65.5**	Fine Gravel	**12.3**
#4	4.75	**59.0**		
#10	2.00	**42.5**	Coarse Sand	**16.5**
#20	0.85	**33.1**	Medium Sand	**15.9**
#40	0.43	**26.6**		
#60	0.25	**16.9**	Fine Sand	**23.1**
#100	0.15	**8.4**		
#200	0.075	**3.5**		
			Fines	**3.5**

Moisture Content

20.85

D_{60}= 5.28	D_{30}= 0.61	D_{10}= 0.17
Cu = D60/D10 =	**31.9**	> 6
Cc = D30^2/(D10*D60) =	**0.4**	< 1

DESCRIPTION: C-F SAND and C-F GRAVEL
trace silt

USCS: SP

TECH	TCM
DATE	9/4/12
CHECK	TCM
REVIEW	

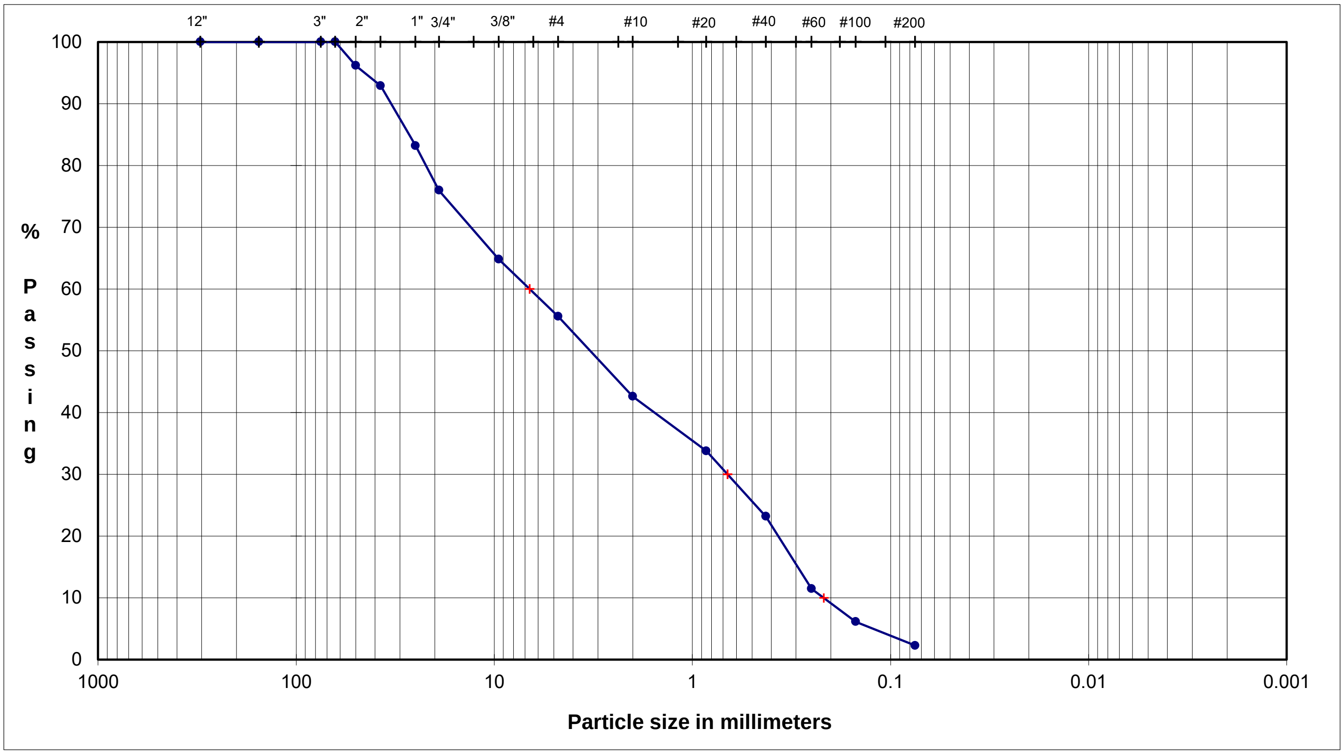
Golder Associates Inc.

9/4/12 113-93490.200

PARTICLE SIZE DISTRIBUTION

ASTM D421, D422, D4318

PROJECT NAME:	**Kitsap County / Rich Passage / WA**		
SAMPLE ID:	**12B**	**0** Depth:	**0**
TYPE:	**-**		



	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay
COBBLES	GRAVEL		SAND			FINES

U.S. Standard Sieves Sizes and Numbers	Particle Size (mm)	% Passing	Particle Size Classification	Percentage
12.0"	304.8	**100.0**	Cobbles	**0.0**
6.0"	154.2	**100.0**		
3.0"	75	**100.0**		
2.5"	63.5	**100.0**	Coarse Gravel	**24.0**
2.0"	50	**96.2**		
1.5"	37.5	**92.9**		
1.0"	25	**83.2**		
0.75"	19	**76.0**		
0.375"	9.5	**64.8**	Fine Gravel	**20.4**
#4	4.75	**55.5**		
#10	2.00	**42.6**	Coarse Sand	**12.9**
#20	0.85	**33.8**	Medium Sand	**19.4**
#40	0.43	**23.2**		
#60	0.25	**11.5**	Fine Sand	**20.9**
#100	0.15	**6.1**		
#200	0.075	**2.3**		
			Fines	**2.3**

Moisture Content: 17.20

D_{60}= 6.62	D_{30}= 0.66	D_{10}= 0.22
Cu = D60/D10 =	**30.5**	> 6
Cc = D30^2/(D10*D60) =	**0.3**	< 1

DESCRIPTION: C-F SAND and C-F GRAVEL
trace silt

USCS: SP

TECH	TCM
DATE	9/4/12
CHECK	TCM
REVIEW	

APPENDIX J

Eelgrass Survey Data

Appendix J - Monitoring of Eelgrass (*Zostera marina*) at the Point Glover bed (Conducted May 24, 2012)

Transect # (location)	**Bed Width (m)**	**Quadrat #**	**Distance along Transect (m)**	**Time**	**Gauge Depth (m)**	**Corrected Depth to Chart Datum (m)**	**Number of Eelgrass Shoots Counted (per 0.25 m^2)**	**Comments**
1 (west)	40	1	6	9:47	2.4	-0.8	41	High current
		2	7	9:49	2.5	-0.9	34	
		3	16	9:51	2.8	-1.2	45	
		4	20	9:53	3.1	-1.5	25	
		5	21	9:54	3.1	-1.5	16	
		6	30	9:56	3.6	-2	27	
		7	39	9:59	5.5	-3.9	22	
		8	29	10:04	3.4	-1.8	31	
		9	28	10:05	3.3	-1.7	27	
		10	17	10:07	2.8	-1.2	48	
2 (central)	42	1	3	10:25	1.9	-0.62	15	
		2	5	10:27	2	-0.72	32	
		3	8	10:29	2.1	-0.82	27	
		4	10	10:30	2.1	-0.82	40	
		5	15	10:32	2.3	-1.02	34	
		6	21	10:32	2.4	-1.12	40	
		7	27	10:33	2.7	-1.42	26	
		8	28	10:34	2.7	-1.42	16	
		9	31	10:35	2.9	-1.62	21	
		10	33	10:36	3.1	-1.82	26	
3 (east)	29	1	1	10:52	2.4	-1.47	5	Very high current
		2	2	10:53	2.4	-1.47	13	
		3	7	10:53	2.6	-1.67	5	
		4	9	10:56	2.9	-1.97	0	
		5	10	10:52	2.9	-1.97	15	
		6	14	10:57	3.2	-2.27	22	
		7	15	10:58	3.3	-2.37	24	
		8	21	11:00	4	-3.07	2	
		9	24	11:01	4.4	-3.47	0	
		10	28	11:02	4.5	-3.57	9	

Mean Bed Density = 22.93
Mean Standard Error 2.43

Notes:
A 0.25 m^2 quadrat (0.5m x 0.5m) was used for monitoring
Data enterered by James Mortimor on November 30, 2012
Data checked by Michelle Spani on January 14, 2013

Appendix J - Monitoring of Eelgrass (*Zostera marina*) at the Point Glover bed (Conducted May 24, 2012)

Transect # (location)	Bed Width (m)	Quadrat #	Distance along Transect (m)	Time	Gauge Depth (m)	Corrected Depth to Chart Datum (m)	Number of Eelgrass Shoots Counted (per 0.25 m²)	Comments
1 (south)	76	1	7	11:52	<0.5	-0.15	46	Shallow (difficult for dive computer to measure depth). Poor visibility - may have double counted some shoots
		2	11	12:00	-		36	Shallow (difficult for dive computer to measure depth). Poor visibility.
		3	22	12:08	1.2	-1.3	21	
		4	25	12:11	1.3	-1.4	24	
		5	26	12:13	1.5	-1.6	21	
		6	31	12:15	1.7	-1.8	24	
		7	34	12:18	1.9	-2.19	19	
		8	44	12:21	2.3	-2.59	15	
		9	46	12:23	2.3	-2.59	8	
		10	55	12:25	2.5	-2.79	10	
2 (central)	67	1	17	12:59	<0.5	-0.49	11	Shallow (difficult for dive computer to measure depth). Poor visibility.
		2	19	13:02	~0.5	-0.89	2	Poor visibility
		3	20	13:04	~0.5	-0.89	11	Poor visibility
		4	25	13:08	0.6 (<1.0)	-0.99	8	Poor visibility
		5	27	13:11	0.7 (<1.0)	-1.9	13	
		6	50	13:15	1.3	-1.69	29	
		7	43	13:18	1.2	-1.59	11	
		8	45	13:21	1.1	-1.49	16	
		9	57	13:23	1.4	-1.79	25	
		10	56	13:24	1.7	-2.09	13	
3 (north)	77	1	10	14:00	<0.3	-0.58	0	Random number generator was for 9m distance; however this was too shallow to survey, so quadrat moved to 10m. Poor visibility (could not feel eelgrass shoots). Quadrat excluded from density count.
		2	14	14:12	<0.3	-0.58	0	Quadrat excluded from density count
		3	15	14:15	<0.3	-0.58	3	
		4	32	14:20	<1.0	-0.98	40	
		5	40	14:21	<1.0	-0.98	36	
		6	46	14:23	~1.0	-1.08	38	
		7	50	14:26	~1.5	-1.58	30	
		8	56	14:29	~1.5	-1.58	32	
		9	72	14:34	1.9	-1.98	11	
		10	76	14:36	2.2	-2.28	3	

Mean Bed Density =	19.86
Mean Standard Error	2.31

Notes:

A 0.25 m² quadrat (0.5m x 0.5m) was used for monitoring

Data enterered by James Mortimor on November 30, 2012

Data checked by Michelle Spani on January 14, 2013

Appendix J - Monitoring of Eelgrass (*Zostera marina*) at the Point Glover bed (Conducted May 24, 2012)

Transect # (location)	Bed Width (m)	Quadrat #	Distance along Transect (m)	Time	Gauge Depth (m)	Corrected Depth to Chart Datum (m)	Number of Eelgrass Shoots Counted (per 0.25 m²)	Comments
3 (east)	22	1	3	13:54	4.2	-1.28	17	
		2	9	13:58	4.3	-1.38	17	
		3	11	14:00	4.4	-1.48	13	
		4	12	14:02	4.7	-1.78	13	
		5	18	14:03	5.4	-2.48	19	
		6	19	14:10	6.1	-3.18	6	
		7	15	14:12	5.4	-2.48	17	
		8	13	14:15	5.1	-2.18	22	
		9	6	14:17	4.3	-1.46	28	
		10	5	13:55	4.2	-1.36	15	
2 (central)	36	1	3	14:33	3.4	-0.56	0	Quadrat excluded from density count
		2	4	14:34	3.4	-0.56	4	
		3	6	14:35	3.5	-0.66	38	
		4	8	14:38	3.4	-0.56	48	
		5	13	14:40	3.7	-0.86	35	
		6	18	14:42	3.8	-0.96	30	
		7	24	14:45	4.1	-1.38	28	
		8	26	14:46	4.3	-1.58	23	
		9	28	14:48	4.6	-1.88	17	
		10	32	14:51	5.1	-2.38	7	
1 (west)	45	1	2	17:00	2.4	-0.2	0	Quadrat excluded from density count
		2	5	17:01	2.5	-0.3	33	
		3	14	17:04	3.1	-0.9	17	
		4	16	17:06	3.2	-1	56	
		5	28	17:10	3.5	-1.3	50	
		6	29	17:12	3.7	-1.5	41	
		7	34	17:15	4	-1.8	35	
		8	35	17:17	4	-1.88	15	
		9	36	17:18	4.2	-2.08	26	
		10	38	17:20	4.4	-2.28	24	

Mean Bed Density =	24.79
Mean Standard Error	2.53

Notes:

A 0.25 m² quadrat (0.5m x 0.5m) was used for monitoring
Some "new" shoots apparent in quadrats on all three transects
Data enterered by James Mortimor on November 30, 2012
Data checked by Michelle Spani on January 14, 2013

Transect # (location)	**Bed Width (m)**	**Quadrat #**	**Distance along Transect (m)**	**Time**	**Gauge Depth (m)**	**Corrected Depth to Chart Datum (m)**	**Number of Eelgrass Shoots Counted (per 0.25 m²)**	**Comments**
north	75	1	5	15:10	3.1	0.01	35	
		2	15	15:13	3.5	-0.39	60	
		3	21	15:15	3.6	-0.49	50	
		4	34	15:18	3.7	-0.65	59	
		5	40	15:20	4.1	-1.05	48	
		6	48	15:23	4.4	-1.35	30	
		7	49	15:25	4.4	-1.35	41	
		8	56	15:27	4	-0.95	46	
		9	63	15:31	4.7	-1.65	52	
		10	69	15:37	5	-1.95	40	
central	78.5	1	7	13:39	3.4	-0.31	65	Lots of new shoots
		2	10	13:42	3.5	-0.41	57	
		3	28	13:46	4.2	-1.11	38	
		4	32	13:49	4.2	-1.11	41	
		5	42	13:54	4.5	-1.41	53	
		6	49	13:58	4.9	-1.81	38	
		7	52	14:00	4.9	-1.81	54	
		8	57	14:03	5	-1.91	41	
		9	60	14:05	5.1	-2.01	31	
		10	64	14:09	5.2	-2.11	0	Quadrat excluded from density count
south	74.5	1	3	14:28	3.7	-0.58	83	
		2	4	14:31	3.7	-0.58	77	
		3	18	14:35	4.7	-1.58	33	
		4	21	14:37	4.8	-1.68	32	
		5	34	14:40	5.4	-2.28	21	
		6	36	14:42	5.5	-2.38	18	
		7	46	14:44	5.8	-2.68	19	
		8	59	14:47	5.9	-2.78	9	
		9	70	14:49	6.1	-2.98	2	
		10	71	14:50	6.1	-2.98	18	

Mean Bed Density =	41.069
Mean Standard Error =	3.52225

Notes:

A 0.25 m² quadrat (0.5m x 0.5m) was used for monitoring

New shoots apparent

Eeelgrass blades are narrower at the inshore end

Data enterered by James Mortimor on November 30, 2012

Data checked by Michelle Spani on January 14, 2013

APPENDIX K

Spearman Rank Correlation Statistics

Appendix K

Speaman Rank Correlation

Species	**Correlation Coefficient [r]**	
	Dimension 1	**Dimension 2**
Acoela	0.15183	-0.26924
Anthopleura artemisia	-0.14743	-0.12113
Melanochlamys diomedea	-0.14743	-0.06847
Ampeliscidae sp (in part)	0.04739	0.0158
Ampharetidae	0.48374	-0.39673
Amphiodia occidentalis	0.18334	-0.14599
Amphiuridae	0.13459	-0.09581
Amphithoe dalli	-0.25249	0.27195
Amphithoe sp	-0.28041	-0.05494
Aoroides sp	0.22641	0.08953
Athenaria	0.1157	-0.21669
Fartulum occidentale	-0.03606	0.01819
Crepipatella dorsata	0.28932	-0.33165
Capitella capitata complex	-0.22392	-0.12963
Capitellidae	-0.20192	0.34639
Mediomastus californiensis	**0.56953**	0.21064
Notomastus hemipodus	0.29801	**-0.54552**
Caprellidae sp	0.17376	-0.01053
Metacaprella anomala	0.10531	0.03687
Clinocardium nuttallii	-0.3771	-0.1238
Clinocardium sp juv	-0.27552	-0.14507
Caridea sp (in part)	0.18955	-0.24753
Chaetopteridae	-0.1211	-0.17906
Phyllochaetopterus sp	-0.24086	-0.10916
Spiochaetopterus pottsi	-0.16322	-0.0948
Chironomidae sp	-0.14752	0.06257
Caulleriella hamata	0.34443	-0.04128
Chaetozone sp	0.21588	-0.21593
Cirratulidae	0.40096	-0.39851
Cirratulus robusta	0.43753	-0.02098
Cirripedia sp	0.35846	0.14215
Collembola sp	0.08654	-0.12325
Americorophium brevis	-0.30107	0.20704
Monocorophium acherusicum	-0.43215	**-0.52074**
Monocorophium insidiosum	-0.23464	0.03643
Monocorophium nr acherusicum	-0.19879	-0.3874
Crangon dalli	-0.24086	-0.29738
Dendraster excentricus	-0.30446	-0.09012
Diptera sp	0.08656	0.08281
Allorchestes angusta	-0.27434	-0.10529
Dorvillea rudolphi	0.43473	**-0.55736**
Pettibonia sp	0.00352	-0.0698
Protodorvillea gracilis	0.38588	-0.3113

Species	**Correlation Coefficient [r]**	
	Dimension 1	**Dimension 2**
Edwardsia juliae	0.11184	-0.02486
Edwardsia sp	-0.12615	-0.02652
Gammaridea sp	0.22409	0.27003
Glycera americana	0.17376	-0.06175
Glycera nana	0.18935	**0.82108**
Golfingia sp	0.40615	0.27735
Glycinde picta	-0.3294	-0.44389
Halcampa decemtentaculata	0.43103	-0.43331
Micropodarke dubia	**0.56644**	-0.42345
Podarke pugettensis	0.2771	**-0.59656**
Podarkeopsis perkinsi	0.16822	-0.17384
Hiatella arctica	0.43774	0.39408
Idotea (Pentidotea) schmitti	-0.36072	-0.02875
Ischyrocerus litotes	0.10531	-0.22646
nr Ischyroceridae sp (in part)	0.07898	0.05267
Isopoda	0.00658	0.30892
Lamprops nr quadriplicata	-0.21588	-0.237
Lamprops sp	-0.16322	-0.0948
Neaeromya spp juv	0.24418	-0.2884
Rochefortia tumida	-0.2201	-0.16067
Leptochelia dubia	0.19416	-0.15299
Leptochelia savignyi	**-0.54695**	0.12451
Leptoplanidae	0.38413	-0.04743
Micrura sp	0.18955	-0.24753
Lacuna vincta	**-0.59267**	0.00599
Littorina scutulata	0.23694	0.18433
Lottia pelta	0.23797	0.03128
Lottia scutum	0.33675	-0.3883
Lottia spp juv	0.38281	0.13107
Parvilucina tenuisculpta	-0.09207	-0.16682
Lumbrineridae	0.22222	-0.13627
Sinomactra falcata	-0.19965	-0.19366
Maldanidae	0.2067	-0.20066
Nichomache personata	-0.06318	0.10533
Margarites pupillus	-0.01129	-0.20327
Nucella lamellosa	0.2376	-0.22135
Nucella spp juv	0.10914	-0.24468
Cryptomya californica	-0.05714	-0.06532
Mya sp juv	-0.14743	-0.12113
Modiolus sp juv	0.24747	0.13166
Mytilidae spp juv	0.00667	0.01954
Mytilus spp complex	0.29109	0.62403
Cumella vulgaris	**-0.70032**	-0.32846

Species	**Correlation Coefficient [r]**	
	Dimension 1	**Dimension 2**
Nebalia sp	0.21075	-0.11669
Nemertea	0.4416	-0.01512
Nephtys caeca	-0.1211	-0.17906
Nephtys caecoides	-0.36634	-0.26105
Nereis neoneanthes	-0.06318	0.10533
Nereis procera	-0.24442	**-0.53757**
Platynereis bicanaliculata	-0.10151	-0.26093
Oligochaeta	-0.02062	0.17798
Onuphidae	0.00527	0.21593
Onuphis iridescens	0.17376	-0.01053
Armandia brevis	**0.53254**	-0.34966
Ophiurida	0.1369	0.10533
Leitoscoloplos pugettensis	-0.05862	**-0.55505**
Galathowenia oculata	-0.06318	0.10533
Owenia fusiformis	0.3654	0.21967
Pagurus granosimanus	0.26208	-0.09756
Pagurus hirsutiusculus	0.25868	0.1025
Pagurus sp juv	0.1391	0.2027
Lophopanopeus bellus	0.29239	-0.49517
Pectinaria californiensis	-0.01207	-0.0058
Euphilomedes carcharondonta	**-0.59092**	0.1407
Pholoe sp N-1	0.41846	-0.43658
Phoronopsis harmeri	0.32666	0.1534
Foxiphalus cognates/similis	0.08654	-0.12325
Foxiphalus falciformis	-0.2859	-0.12953
Foxiphalus sp	-0.13163	-0.2054
Eobrolgus spinosus/chumashi	-0.32316	-0.10895
Phoxocephalidae sp (in part)	0.18441	0.01882
Eteone sp	-0.2416	-0.05863
Eulalia sp	0.20951	0.07893
Phyllodoce hartmanae	-0.16322	-0.0948
Phyllodoce sp	-0.11186	0.0204
Phyllodocidae	0.04353	-0.16057
Pinnixa littoralis	-0.07492	-0.01004
Pinnixa schmitti	**0.63251**	-0.26302
Pinnixa spp juv	0.2184	-0.16384
Harmothoe imbricata	0.28385	-0.20554
Polynoidae	0.42471	-0.29509
Paramoera sp	0.22641	0.08953
Pontogeneia nr intermedia	0.04157	0.22498
Pycnogonida sp	-0.00527	0.12113
Odostomia spp	0.17685	0.14493
Alvania compacta	-0.32517	-0.18423

Speaman Rank Correlation

Species	**Correlation Coefficient [r]**	
	Dimension 1	**Dimension 2**
Alia tuberosa	-0.00753	-0.16187
Pholoides aspera	0.25464	-0.02031
Sipunculida	0.23694	0.18433
Exosphaeroma amplicauda	-0.02287	0.3757
Gnorimosphaeroma oregonense	**-0.53905**	0.42761
Gnorimosphaeroma/ Exosphaeroma spp juv	0.06424	0.19524
Dipolydora caulleryi	0.41468	0.25436
Laonice cirrata	0.07898	0.05267
Polydora sp	0.24747	0.13166
Prionospio jubata	0.34664	0.20273
Prionospio multibranchiata	0.12419	0.18069
Prionospio sp	0.03638	-0.21344
Pygospio elegans	-0.14925	0.02893
Rhynchospio arenicola	-0.40005	0.00301
Scolelepis foliosa	0.02509	0.08326
Spio filicornis	0.18095	0.01974
Spionidae	-0.16759	-0.01441
Spiophanes bombyx	-0.20462	-0.09928
Streblospio benedicti	0.06974	-0.11111
Syllidae	0.19255	0.14853
Typosyllis sp	**0.59112**	-0.19035
Leptosynapta sp	0.32993	-0.30003
Macoma inquinata	0.42373	0.31072
Macoma spp juv	0.25661	-0.24649
Tellina modesta	-0.49574	-0.37803
Terebellidae	0.24462	-
Lirularia spp (broken)	-0.10004	0.24753
Lirularia succincta	-0.34006	0.15398
Typhloplanoida	0.09046	-0.23012
Hemigrapsus oregonensis	**0.65759**	0.1752
Leukoma staminea	0.37502	-0.34483
Nutricola cf tantilla	-0.03718	0.16844
Nutricola spp juv	0.07145	0.10276
Saxidomus gigantea	0.22779	0.47292
Veneridae sp juv	0.20511	0.13011
Venerupis philippinarum	0.10252	0.19577

Notes: Taxa which had moderate to strong correlations are bolded (*i.e.* , $|r_s| > 0.5$)

APPENDIX L

Bull Kelp (*Nereocystis luetkeana*) Technical Memorandum

TECHNICAL MEMORANDUM

DATE	June 9, 2015	**PROJECT No.**	113-93490-200-210
TO	Kitsap Transit		
FROM	Golder Associates Ltd.	**EMAIL**	Andrew_Rippington@golder.com

TECHNICAL REPORT – HISTORICAL PRESENCE OF KELP IN RICH PASSAGE, WASHINGTON

1.0 INTRODUCTION

Puget Sound, the second largest estuary in the United States, is characterized by nutrient-rich waters which support biologically productive coastal habitats and abundant fish and wildlife populations (USGS 2006). Increased urban development along the coast has been tied to degradation in the overall health of the Puget Sound nearshore ecosystem, including declines in fish and wildlife populations, water-quality issues, and changes in coastal habitats (USGS 2006). However, the complex role of geological, biological, and hydrological processes in maintaining nearshore ecosystem health remains poorly understood (Gelfenbaum et al. 2006). Further, the effects of anthropogenic-associated reductions in water quality and invasion by non-native aquatic plants on nearshore vegetated habitats are difficult to assess (Thom and Hallum 1990; Coelho et al. 2000).

Shallow rocky habitats occurring in the nearshore subtidal zone of Puget Sound are dominated by large brown algae of the orders Laminariales and Fucales. These algae are commonly referred to as kelp[1], although the term technically refers to Laminariales only (Druehl 1969; Gabrielson et al. 2006). The high productivity and complex biological structure of kelp assemblages make them particularly important members of the subtidal ecological community (Dayton 1985). Within Washington State alone, there are over 26 species of kelp identified (Druehl 1969; PSAT 2007; WSDNR 2013a). A descriptive account of all kelp species in Puget Sound is beyond the scope of this memorandum. The objective of this report is limited to providing a background on bull kelp (*Nereocystis luetkeana*) in Rich Passage and the surrounding Puget Sound area, including information on morphology and development, ecological function, historical distribution, and potential environmental effects on bull kelp survivorship.

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[1] Kelp species can be grouped by their growth forms: floating kelp produces buoyant bulbs and blades that spread out on the water surface, while understory kelp canopies extend horizontally near the bottom (PSAT 2007).

2.0 FORM AND FUNCTION

Bull kelp is the structurally dominant, canopy-forming, macroalgal species in the Pacific Northwest. This annual brown macroalgae is found along rocky shorelines between California and Alaska, as far west as Umnak Island, part of the eastern Aleutian chain (Miller and Estes 1989), from just below the lowest low tide to a maximum depth of about 18 m (Kruckeberg 1991). It is one of the largest and fast-growing kelp species in the world, with stem (stipe) lengths averaging ~10 m (O'Clair and Lindstrom 2000) and capable of reaching lengths of up to 25 m (Nicholson 1970).

Bull kelp is typically found in nearshore habitats characterized by high wave energy and unstable substrata (Maxwell and Miller 1996; Springer et al. 2006). Compared to other large kelps, bull kelp is relatively resistant to dislodgement due to several morphological advantages (Koehl and Wainwright 1977). It attaches to the seafloor using a root-like structure called a holdfast, which has many finger-like projections that firmly adhere to rocky substrate. From the holdfast, the flexible stem-like stipe extends to the surface, gradually enlarging to form a single, round hollow float. The upper portion of the stipe is extremely elastic; exposed to wave force, it can stretch more than 38% (Koehl and Wainwright 1977). Numerous ribbon-like blades grow off the long and slim stipe (O'Clair and Lindstrom 2000) forming a horizontal canopy layer at the water’s surface over subtidal assemblages below.

3.0 DEVELOPMENT

Bull kelp is an annual species with a life span generally limited to one year (Springer et al. 2006), although in some populations, individuals that are produced late in the season may successfully overwinter and survive a second year (Chenelot et al. 2001). Individual plants must therefore reproduce prior to death for bull kelp forests to persist from one generation to the next (Springer et al. 2006). Similar to most kelp species, the life cycle of bull kelp consists of an alternation of generations between microscopic gametophytes and large sporophytes (Dayton 1985). The annual cycle of generations are markedly different with the mature sporophyte reaching lengths of 30 m and the gametophyte being a small filamentous plant not visible to the naked eye.

Beginning in the spring and continuing into early summer, mature blades of the sporophytic bull kelp produce and release spores into the marine environment. The spores drift with the currents, eventually settling on the bottom and developing into male and female gametophytes (Druehl 2000). The spores may settle in a variety of locations, however, it is only those locations with favorable conditions which will allow the gametophyte stage to thrive, ultimately creating eggs and sperm which subsequently lead to production of the large sporophyte form.

Bull kelp has a fairly well-defined set of physical conditions required for growth, including high ambient light, hard substrate, low concentrations of suspended sediment[2] in the water column, low water temperatures and moderate to high salinities (Mumford 2007). The gametophyte stage begins on the substrate and only those fertilized zygotes in waters with significant light availability to meet growth requirements (e.g., depth < 20 m) will develop into mature sporophytes (Mumford 2007). Therefore, bull kelp is generally confined to nearshore habitats and will often reach its greatest biomass in the shallow subtidal zone. Within this zone, annual species such as bull kelp are in direct competition with perennial species (e.g., invasive *Sargassum muticum*) (Mumford 2007).

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[2] Suspended sediment can limit the amount of incident light in the water column required for photosynthesis or can result in smothering of the tiny gametophyte stages.

The sporophytes phase of bull kelp, which begins to grow in the early spring, are found attached to bedrock, boulders or large cobbles in the subtidal zone, especially in areas of considerable water movement (either wave exposure or tidal currents). Individuals that attach to small cobbles (< 10 cm) tend to lift their small anchor off of the bottom during significant water movement, and thus be transported, with their anchor, to the shore or into deeper water (Mumford 2007). The kelp attaches to the substrate by a holdfast, which, unlike plant roots, does not penetrate the substrate or transport nutrients from the substrate to the rest of the plant. Rather, the holdfast is simply an anchoring device to hold the plant in place.

4.0 ECOLOGICAL FUNCTION

Because of their three-dimensional structure and rapid growth rate, floating kelp assemblages contribute markedly to the productivity of near shore marine ecosystems by providing valuable habitat for a diverse range of fish and marine invertebrate species (Foster and Schiel 1985; Graham 2004; Berry et al. 2005; Leschine and Peterson 2007; WSDNR 2013a). This includes commercial and sport fish species, as well as federally listed species or species of conservation concern due to declining stocks, such as salmon, rockfish, and northern abalone (Shaffer 2000). Bull kelp is a highly productive annual which produces and incorporates large amounts of carbon into its significant biomass that helps in fuelling nearshore food webs, principally through detrital pathways, and by providing critical three-dimensional structure in otherwise two-dimensional environments (Mumford 2007). Growth rates of marine suspension feeders have been directly linked to the availability of organic detritus produced by local kelp communities; and nearshore food-webs have been shown to openly benefit from carbon fixed during associated photosynthesis processes (Duggins et al. 1989).

Bull kelp is not only integral to organisms that permanently frequent kelp forests, but also by animals that use kelp beds temporarily as foraging grounds (e.g., shore birds, aquatic mammals) or as important rearing habitat such as Pacific herring (*Clupea pallasi*), surf smelt (*Hypomesus pretiosus*), and Pacific sand lance (*Ammodytes hexapterus*) (Springer at al. 2006; Pentilla 2007). Given the ecological importance of this species, bull kelp is considered a Valued Ecosystem Component (VEC) by environmental regulators in Washington State (WSDNR 2013a), as well as by local environmental organizations in the Puget Sound area such as the Puget Sound Partnership (PSP) and the Puget Sound Action Team (PSAT) (PSAT 2007).

5.0 DISTRIBUTION

The ability of bull kelp to re-establish annually is theorized to be a function of multiple variables and interactions between the physical and biological environment (Dayton et al. 1984). However, little information is available on how kelp community structure and bull kelp abundance in Washington State has changed on a decadal scale (Shaffer 2000; Berry et al. 2005). In general, the analysis of historical changes in bull kelp distribution and abundance in Puget Sound is hindered by the general lack of comprehensive and quantitative historical data sets, inconsistencies in data collection methodology, and incomplete time series (e.g., decadal gaps between existing datasets) (Thom and Hallum 1990; Berry 2013 pers. comm.).

Bull kelp was regularly observed in Rich Passage in multiple surveys conducted between 1852 and 1989 (Thom and Hallum 1990). However, the exact dimensions and locations of localized kelp beds over this time were generally not well documented. The most recent account of bull kelp assemblages in Rich Passage was in 1999 during the Rich Passage Wave Action Study (RPWAST 2000). Other reports indicate that bull kelp has not been documented in the Rich Passage area since at least 2000 (GeoEngineers 2006; Grette 2007). Nearshore underwater towed video surveys were completed by Golder during fall 2011 and spring 2012 in

Rich Passage to investigate the presence of bull kelp and eelgrass (*Zostera marina*) along the shoreline, although no bull kelp was observed during this time (Golder 2012). Given the poor historical record of bull kelp in this area, it is difficult to establish exact timing, cause, and effect in the loss of bull kelp assemblages in Rich Passage.

In recent years, the Washington State Department of Natural Resources' (DNR) Nearshore Habitat Program (NHP) has worked extensively to inventory and monitor vegetation along the state coastline (WSDNR 2013a). As part of their focus, the NHP has produced detailed orthophotographs and a digital dataset on the location of canopy-forming kelp beds classified by species. These photos and datasets include central Puget Sound and Rich Passage. The inventory was based on color-infrared 1:12,000 aerial photography, collected at low tide (Berry 2007). The most recent NHP surveys conducted in, and adjacent to, Rich Passage were in 2001 and 2004. These surveys identified a single bull kelp bed located at Wing Point (outside of Rich Passage) on the east side of Bainbridge Island (Inset Figure 1), approximately 7 miles west of downtown Seattle and approximately 5 miles north of Rich Passage. Decreases were observed in bed size and density over the course of the survey period (Mumford 2013 pers. comm).

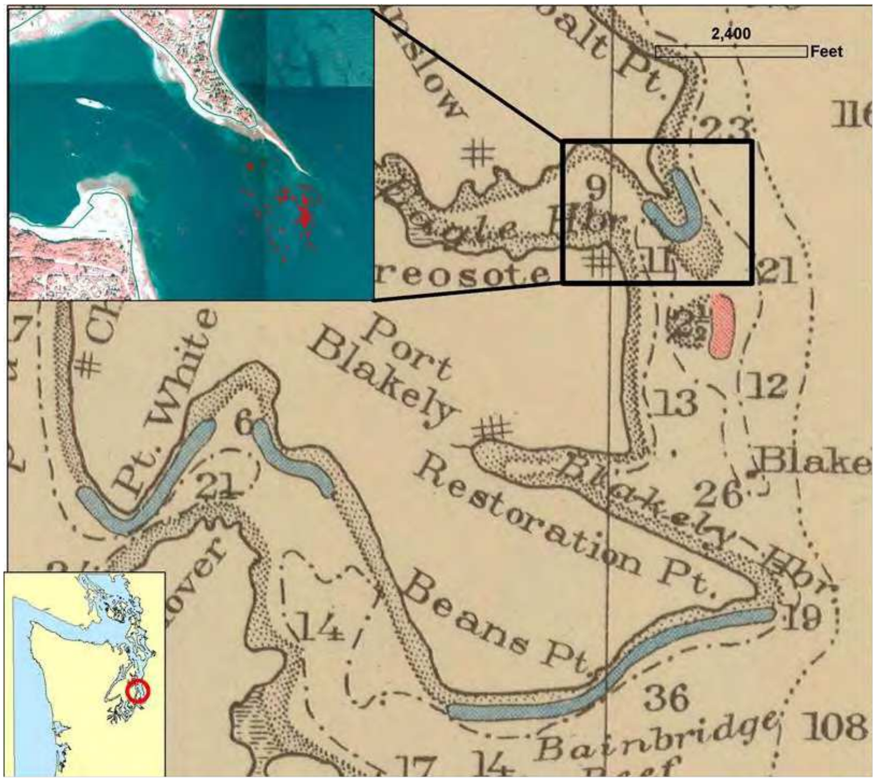

Figure 1: Change in bull kelp distribution over time in southern Bainbridge Island area. Main part of figure shows bull kelp (blue and red polygons) mapped in 1911[3] (Cameron 1915). Inset orthophoto (top left) shows bull kelp (red polygons in orthophoto) present at Wing Point based on imagery collected in 2004 (photo courtesy of WSDNR; Berry 2013 pers. comm.) Note: On Southern Bainbridge Island the Wing Point bull kelp bed represents the last remaining floating kelps.

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[3] The Cameron 1915 report was produced for the U.S. Department of Agriculture for the purpose of gathering information on the abundance and distribution of bull kelp for commercial extraction. There is no indication of the lower limits set by the research team for viable resource areas. It is suspected that smaller kelp beds and individual sightings were not considered valuable commercial areas and therefore not noted in the report (Berry 2013 pers. comm.).

The NHP also investigated long-term trends in the distribution and abundance of bull kelp in areas east of Rich Passage (Berry et al. 2005). Spatial changes in bull kelp canopy area were examined between 1989 and 2004 along the outer coast of the Olympic Peninsula and along the shorelines of the Strait of Juan de Fuca (south coast only) using annual aerial photographs taken at low tide (Berry et al. 2005). Results demonstrated that spatial coverage of bull kelp increased significantly along the outer coast and along the western margin of the Strait, but showed no detectable changes along the eastern margin of the Strait, with the exception of one shoreline section near Protection Island[4] in which bull kelp spatial coverage was shown to have decreased over time. Similar patterns in the distribution of bull kelp beds over time have been reported in Canadian waters, specifically the Strait of Georgia (Berry et al. 2005). Potential causes for observed changes in bull kelp distribution in these areas are currently unknown.

In contrast to patterns observed in the Strait of Juan de Fuca, bull kelp distribution and abundance in Puget Sound has generally displayed a decreasing trend since the 1960s; with the majority of this loss occurring in the 1960s and 1970s (Mumford 2013 pers. comm.; Berry 2013 pers. comm.). Potential causes for observed changes in bull kelp distribution in Puget Sound are currently unknown but given that the widespread losses are not associated with any particular structures, water quality or changes in herbivore density are likely causes (Mumford 2013 pers. comm.).

Overall, the distribution of floating kelp beds (bull kelp and giant kelp) in Puget Sound tends to follow a north-south gradient due to natural environmental conditions in the region, with greatest abundance observed in the San Juan Archipelago and the Strait of Juan de Fuca., and kelp beds decreasing in size and frequency in central and southern Puget Sound (PSP 2007; WSDNR 2013a) (Figure 2).

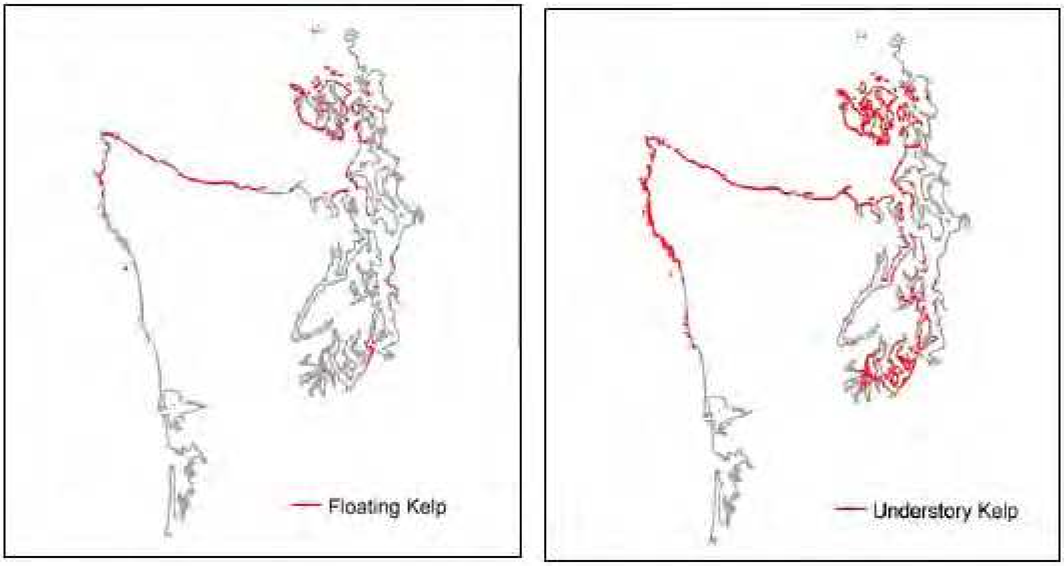

Figure 2: The distribution of canopy-forming kelps (bull kelp and giant kelp) compared to understory kelps (Saccharina, Laminaria, Alaria, Agarum, etc.) in Washington State (DNR 2013b).

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[4] The floating kelp canopy area declined gradually from more than 10 hectares in 1989 and 1990 to less than one hectare annually since 1994.

6.0 POTENTIAL ENVIRONMENTAL EFFECTS ON BULL KELP COMMUNITIES

Multiple factors have been suggested as potentially contributing to changes in bull kelp abundance and distribution along Washington State shorelines, including sedimentation from coastal development (Merrill and Gillingham 1991; Cheney et al. 1994; Shaffer and Parks 1994; Carney et al. 2005), algal community shifts, climate change, changes in the abundance of herbivores (grazers), changes in kelp habitat characteristics (Berry et al. 2005), oil spills (Antrim et al. 1995), shifts in water quality due to increased levels of metals, herbicides, detergents and nutrients in the water column (Chung and Brinkhuis 1986; Shea and Chopin 2007), ultraviolet radiation (UVR) (Swanson and Druehl 2000, Hoffman et al. 2003), and invasions by non-native species (Thom and Hallum 1990; Britton-Simmons 2004).

Anecdotal information provided by residents of Rich Passage suggests that the loss of kelp beds along the shores of Point White on Bainbridge Island occurred in the late 1990s and early 2000s. The timing of this event coincided with the operation of the Chinook-class passenger only fast ferry (POFF) between Bremerton and Seattle, and associated monitoring activities conducted by RPWAST (2000). In October and November of 1999, in response to concerns raised by the public with respect to potential environmental effects from ferry operations, Washington State Ferries conducted kelp bed monitoring (of bed size and condition) along the shoreline at Point White (Figure 3). At the time of monitoring, holdfasts were observed to be strong, intact, and undamaged with no significant holdfast breakage observed and occurring on all suitable substrates. However, some evidence of holdfast burial was observed with a 10% accumulation of loose gravel recorded along the upper portion of the bed (RPWAST 2000). During April and May of 2001 surveys[5] along the eastern shore of Point White no bull kelp was observed from surface. The survey results from spring 2001 were later re-confirmed in August 2001 (AES 2001). Potential causes for the observed losses of bull kelp in Rich Passage were not reported (AES 2001).

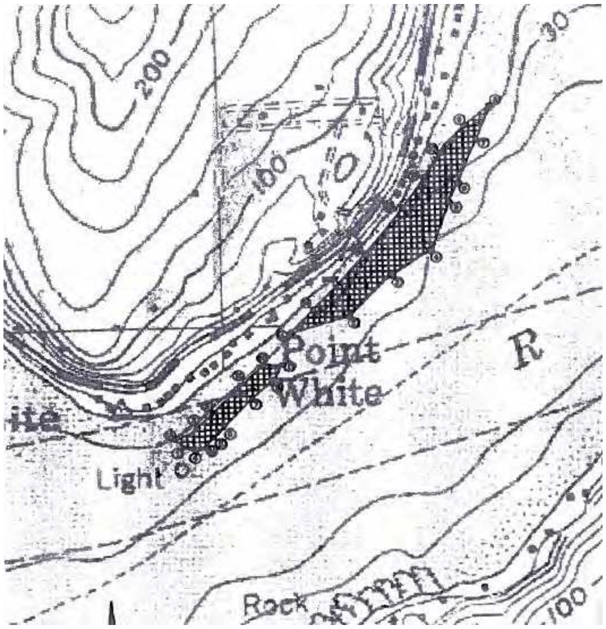

Figure 3: Location of bull kelp beds at Point White in October 1999. Beds are outlined by black hatched area (RPWAST 2000) and occur in two sections, extending approximately 943 m along the shore and ranging between 18 and 27 m in width.

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[5] No diver or underwater observations were made during AES shoreline sampling events (AES 2001).

Mumford (2013 pers. comm.) suggests that direct adverse impacts on bull kelp communities due to increased wave action by vessel wakes are likely only if the wave action is sufficient to move the substrate and abrade the young sporophytes. The species' has a natural tolerance to moderate to high wave energy and tidal currents environments. Unlike other kelps, in Puget Sound bull kelp is typically found in nearshore habitats characterized by moderate to high wave action and/or high tidal currents and this tolerance for higher energy regimes makes bull kelp relatively resistant to dislodgement when compared to other large kelps (Maxwell and Miller 1996; Springer et al. 2006). However, indirect effects of increased wave action on bull kelp, such as increased sedimentation in the water column and the accumulation of smaller-grain size sediment in the host environment, have been linked as potential factors in the loss of bull kelp assemblages in Rich Passage.

The ability for algal spores to establish themselves plays an essential role in adult kelp distribution and abundance patterns and that increases in sedimentation may constrain the success of the spore stages (Deiman et al. 2012). Large inputs of sediment can impede kelp attachment (via holdfast) to hard substrate through direct burial of existing rocky habitat and bull kelp has a reported low tolerance to high sedimentation (Shaffer and Parks 1994). Excess sedimentation can also potentially smother sporophytes during the spring season leading to low survivorship due to smothering during the microscopic gametophyte phase (Schiel et al. 2006). Sedimentation can also lead to changes in substrata boundary layer nutrient chemistry which can greatly affect microflora community structure (Amsler et al. 1992). Not all species react similarly to sedimentation and although increased sediment load has been found to have a negative impact on brown algae spores and zygotes, crustose coralline and *Sargassum* species have been found to be resilient to sedimentation (Roleda et al. 2008). Additionally, laboratory experiments have shown that sedimentation is a key variable regulating algal spore settlement and success, possibly controlling species-specific dominance (Deiman et al. 2012).

Spores will preferentially settle onto suitable substrata in appropriate light and nutrient microenvironments. Increased sediment within the water column coupled with the presence of suitable nutrient content could promote settlement stimulation behavior onto sediment particles or conversely zoospores could remain pelagic choosing not to settle due to unfavorable conditions (Amsler et al. 1992). Additionally, once settled, the physical, chemical and biological conditions at the gametophyte settlement site can have a critical impact on the survival, growth, and successful reproduction of the different life stages (Schoch and Chenelot 2004). High turbidity levels can interfere with the penetration of sunlight through the water column, thus limiting the amount of irradiance available to gametophytes and young sporophytes limiting growth (Drew and Jupp 1976; Han and Kain 1996). Spectral irradiation has the greatest effect on sporophyte stipe elongation; however, photosynthesis alone is not responsible for stipe growth (Duncan 1973).

Vessel wakes have been shown to cause rapid increases in the optical density of sea water from background values thus having the potential to affect kelp (Erm et al. 2009). Suspended sediment in the water column can effectively reduce the amount of light available for photosynthesis, reduce growth rates, and eliminate kelp growth in deeper waters (Mumford 2007). Wakes generated by high speed vessels, including the Chinook-class ferries, are able to transport gravel and small cobble across the shore from the high intertidal to lower in the intertidal, potentially low enough that it will not be transported back up the beach and instead lost from the intertidal beach section (Osborne et al. 2007a; Osborne et al. 2007b). As shown by studies in Rich Passage, low energy waves associated with summer months push sediment from the low intertidal to higher elevations on the beach (Curtiss et al. 2009; PIE 2007) and higher energy waves in the winter flatten the beach (i.e., move sediment from the high intertidal to low intertidal). The potential loss of sediment from the beaches below the low tide level is estimated to be very small because beach profiles and geophysical data from years with Chinook-class ferry service show that most, if not all of the volume change, was accounted for above the low tide level and the beaches on Point White recovered to their pre-POFF volumes above mean tide level after the

POFF ferries were shut down (PIE 2007). It is conceivable, however, that wake action from Chinook-class POFF operations could have resulted in changes to the existing sediment regime along Rich Passage beaches and potentially contributed to less favorable conditions for bull kelp growth in these areas. Abrasion and rolling of substrate could have caused immediate effects on bull kelp health and distribution and increases in turbidity from re-suspension of fine sediments could have been additional indirect factors by blocking light or coating larger substrate surfaces affecting gametophyte survivorship (Mumford 2013 pers. comm.).

With respect to wake energy and trials related to *Rich Passage 1* (RP1), it seems very unlikely that any sediment mobilized on the upper beach by RP1 would be transported offshore to the extent that occurred in Chinook-class days. The much lower levels of wake energy in the RP1 wakes were measured to be an order of magnitude less than the Chinook Class vessels (Golder 2013.). Additionally, studies in a similar estuary to Puget Sound have shown wind waves were the main driving force for both sediment re-suspension and sediment transport in shallower waters (Erm et al. 2009).

Bull kelp is also sensitive to changes in water temperature, light availability, and availability of nutrients, particularly nitrate. Local changes in these conditions are likely determining factors for the continued growth and reproductive maturation of bull kelp beds in coastal areas (Springer et al. 2006). Research on this topic is ongoing and optimal water quality conditions for bull kelp survival and growth remain to be established. However, changes in water quality are suspected to have a pronounced effect on kelp growth (Berry 2013, pers. comm.). and as recently as 2012 parameters such PAHs, chrysene, PCBs, bacteria, dissolved oxygen and temperature within Rich Passage have either been designated as items of concern or recognized by the state as needing remediation (WSDE 2013). Analyses on nutrients and phytoplankton levels in Puget Sound have shown that nitrate and phosphate inputs to the basin have increased dramatically in recent years (Thom and Hallum 1990). Although bull kelp appears to be somewhat tolerant of contamination and sewage discharge (Tomlinson et al. 1980), other contaminants may have unstudied effects on kelp colonization and distribution. Unfortunately, with dwindling populations of kelp occurring throughout the Sound, the effects of changes in water quality, however large, remain uncertain and causes for declines in kelp assemblages continue to be unknown. Thom and Hallum (1990) recommend further study of nutrient requirements for bull kelp in Puget Sound in order to better understand potential long-term changes in the abundance and distribution of this species.

Bull kelp may also adversely respond to competitive interactions with native and non-native kelp species, specifically the invasive *S. muticum.* These interactions are not clearly understood; however, competition has been shown to lead to community shifts among algal species including bull kelp (Berry et al. 2005). Britton-Simmons (2004) demonstrated that native floating kelp species, including bull kelp, were more abundant in research plots from which *S. muticum* had been removed and that the shift in algal composition had substantial impacts to the native subtidal community on multiple trophic levels. The highly invasive seaweed, *S. muticum,* appears to be able to exploit and dominate space in the low intertidal zone; the zone at the upper depth limit of bull kelp (Thom and Hallum 1990). *S. muticum* was found in 2011 and 2012 along the entire shoreline of Point White and in other areas of Rich Passage (Golder 2012).

To compete with perennial species, early sporophytic growth in bull kelp has been shown to be faster (for both stipe and blade elongation) than that observed in *Costaria costata* (five-ribbed kelp), and therefore bull kelp can dominate favorable substrate (Maxwell and Miller 1996). Once established, bull kelp has been shown experimentally to dominate, by shading, the assemblage of understory algal species in a kelp forest and the removal of bull kelp results in a rapid change in the cover of other algal species in the forest (Thom 1978). Shaffer (2000) describes bull kelp understories to be dominated by other Laminariales in the summer while winter beds were dominated by fleshy red algae. This seasonal change effectively represents distinct habitats, even though the overall composition of the dominant understory algal community appeared to stay relatively constant between seasons and years.

Detailed information on the relationship between bull kelp and other Laminariales is relatively unknown. However, potential competition between bull kelp and other native understory kelps, including *Agarum fimbriatum* and *Laminaria spp*., may cause a permanent shift in central Puget Sound algal species assemblages (Mumford 2013, pers. comm.). Though the relationship is not entirely understood, *A. fimbriatum,* a perennial species, occupies a similar substrate niche as bull kelp and may outcompete bull kelp when *A. fimbriatum* beds are established (Mumford 2013, pers. comm.). Additionally, *A. fimbriatum* is resistant to herbivory in comparison to bull kelp (Mumford 2013, pers. comm.). Throughout Rich Passage, extensive mature beds of *A. fimbriatum* have been observed (Golder 2012) up to several hundred metres in length and tens of meters in width. These extensive beds may potentially impede the attachment of juvenile bull kelp (sporophytes) on local substrate. When coupled with a potential shift in benthic faunal composition, conditions may be too limiting for the successful re-establishment of bull kelp along the Rich Passage shoreline.

7.0 CLOSURE

Golder looks forward to continuing to work closely with Kitsap Transit on this Project. If you have any questions or comments regarding this report, please do not hesitate to contact Phil Rouget at +1 250-419-4945 or Dave Munday at +1 250 419-4939.

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