Denny Way/Lake Union CSO Control Project Long-Term Sediment Monitoring Program

Data Report

Years 2006–2010 and 2015

April 2018

Final

King County

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Prepared for:

Wastewater Treatment Division
Department of Natural Resources and Parks

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Department of
Natural Resources and Parks
Water and Land Resources Division

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Acronyms

µg/kg................micrograms/kilogram
BBP ....benzyl butyl phthalate
BEHP ....bis(2-ethylhexyl) phthalate
BO......................Biological Opinion
EPA....................United States Environmental Protection Agency
COC ....chain-of-custody
CSL ....Cleanup Screening Level
CSO....................combined sewer overflow
CVAA ....cold vapor atomic absorption spectroscopy
cy ....cubic yards
DMMP ....Dredge Material Management Program
DWMP..............Denny Way Monitoring Program
dw......................dry weight
GC/ECD ....gas chromatography with electron capture detector
GC/MS..............gas chromatography/mass spectroscopy
HPAHs..............high molecular weight polycyclic aromatic hydrocarbons
ICP-OES ....inductively coupled plasma optical emission spectroscopy
KCEL.................King County Environmental Laboratory
MDL ....minimum detection limit
MDS...................multidimensional scaling
mg/kg ....milligram/kilogram
MLLW..............mean lower low water
NPDES..............National Pollutant Discharge Elimination System
OC ....organic carbon
PAHs.................polycyclic aromatic hydrocarbons
PCBs..................polychlorinated biphenyls
PSD....................particle size distribution
QA/QC..............quality assurance/quality control
RDL ....representative detection limit
RPDs ....relative percent differences
RS.......................Regulator Station
RVRs ....reference value ranges
SDI ....Swartz's Dominance Index

SM......................Standard Method
SMS ....Sediment Management Standards
SQS....................Sediment Quality Standards
TOC ....total organic carbon
WWTS.............wet weather treatment station

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EXECUTIVE SUMMARY

King County is conducting a long-term sediment monitoring program for the Denny Way/Lake Union Combined Sewer Overflow (CSO) Control Project to fulfill requirements of the Biological Opinion (BO) issued by the National Marine Fisheries Service. The chemistry and benthic community data for program monitoring years 1–5 (2006–2010) and Year 10 (2015) are included in this report.

The primary goal of the Denny Way Monitoring Program is to determine whether the implementation of the Denny Way/Lake Union CSO Control Project (completed in 2005) has reduced risk to human health and biological communities in the marine environment surrounding the CSO. The control project included construction of two new outfalls into Elliott Bay, as well as construction of the Elliott West Wet Weather Treatment Station (WWTS). One of two outfalls discharges treated effluent from the treatment station and, the other outfall, referred to as the Denny Way Regulator Station, can discharge untreated combined sewage and stormwater an average of once-per-year.

Monitoring to date indicates the sediment contamination present in the project area is likely related to historic conditions prior to the initiation of the control project. Chemistry data do not show increasing chemical concentrations since discharges from the Elliott West WWTS began and the benthic community data show little discernible impacts from the construction and operation of the outfalls.

Although the monitoring program is not complete yet (monitoring years 15 and 20 will occur in 2020 and 2025), this report evaluates the current status of the Denny Way site with respect to the monitoring objectives. The objectives are to determine the nature and extent of chemicals of concern and the condition of the benthic community in the area surrounding the Denny Way CSO. Chemical concentrations were monitored at 16 stations and benthic community conditions were monitored at 8 stations over all monitoring years.

Chemicals of Concern and the Geographic Extent

The chemicals of concern at the Denny Way site include mercury, total polychlorinated biphenyls (PCBs), bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, total high molecular weight polycyclic aromatic hydrocarbons (HPAHs), and some individual PAH compounds. Concentrations of these chemicals were above the Washington State marine sediment quality standards (SQS) at various sampling stations and times over the monitoring period (in both 0-2 cm and 0-10 cm samples). Chemical concentrations above the SQS were most frequently detected at three monitoring stations: DWMP-01, -08, and -14. Monitoring station DWMP-10 represents sediments in an area of the site cleaned up in 2008. All chemical concentrations above the SQS at station DWMP-10 occurred prior to remedial actions and the area has not re-contaminated since that time.

Benthic Community Condition

The benthic community data indicate average total taxa richness averaged 72 taxa and the total abundance averaged 945 individuals for all years. Annelid taxa had greater total

abundance (generally >50%) relative to Crustacea and Mollusca taxa in shallower, nearshore stations, while Mollusca taxa typically had greater total abundance (generally > 50%) at the deeper stations.

Overall, the benthic community data indicate that no station over the monitoring period was consistently impacted when compared to Puget Sound Reference Value Ranges (RVRs) for multiple benthic community indices. However, benthic community data suggest a periodic impact during some years and locations when compared to RVRs, most notably at Stations DWMP-01, -05, and -09. Station DWMP-09 stands out as the most impacted station based on the benthic community diversity indices (Pielou's Evenness, Shannon Wiener Diversity and Swartz's Dominance Index). Low benthic diversity was characteristic at this station before discharges from the new wet weather treatment station outfall began.

Additional Findings

A key assessment of this monitoring effort was to determine the likelihood that chemical concentrations above the SQS or any benthic community impacts were caused by discharges from the Denny Way/ Lake Union CSO Control Project outfalls. This was accomplished through comparison of conditions prior to and following construction and operation of the outfalls.

Based on the chemistry comparisons to Sediment Management Standards and trend analysis, sediment contamination is likely related to historic conditions, rather than treated effluent discharges from the WWTS outfall or discharges from the new Denny Way Regulator Station outfall. For example, the trend analysis indicated that sediment chemical concentrations at stations near both outfalls did not increase since the discharges began. Total PCB concentrations in the top 2 cm of sediment have significantly decreased over time at stations that are both near (DWMP-06, -08 and -11) and farther away (DWMP-07, -09, and -12) from the WWTS outfall. Total PCB concentrations also decreased for the site as a whole (based on an aggregate of all 16 stations); however, significant decreases were not detected at the group of stations nearer to Regulator Station outfall (DWMP-01, -05, -10, and -13). There were no differences in rates at which chemical concentrations change between stations closer to either the Wet Weather Treatment Station outfall or Regulator Station Overflow outfall compared to those stations further removed from the outfalls. Thus, the chemistry data do not show any clear evidence of increasing contamination since discharges from the outfalls began.

Benthic community data were also evaluated to further evaluate potential impacts from discharges from the outfalls. Trend analysis indicated the only significant decreasing trends in benthic community indices were for 1) Mollusca richness at stations DWMP-08 and -09 (near WWTS outfall); 2) Crustacea richness at stations DWMP-01 and DWMP-05 (nearshore and south of the Denny Way Regulator Station outfall); 3) Pielou's Evenness at all stations when evaluated in aggregate; and 4) Annelida abundance at nearshore stations DWMP-01 and -05. There were significant increasing trends for Annelida richness and Mollusca abundance across all stations and for total abundance at stations DWMP-08 and -09. The lowest Swartz's Dominance Index values were observed at stations DWMP-08 and -09. However Swartz's Dominance index values at these two stations were low prior to

construction of the WWTS outfall, suggesting that either historic contamination or other site conditions were the likely cause of low scores. Overall, the benthic community data showed little discernible impacts from construction and operation of the outfalls, and most observed impacts predated outfall operations.

The BO includes two more monitoring events: 2020 (Year 15) and 2025 (Year 20). A final monitoring data report will be developed following these monitoring events that address all BO objectives. In addition, the BO monitoring plan indicates the County will develop a remediation plan to address identified areas of contamination. King County completed a sediment cleanup in 2008 for one area of the site and will develop a cleanup action plan to address the remaining areas of historic sediment contamination in the Denny Way project area. Sediment cleanup approaches for the site are discussed further in County's Sediment Management Plan.

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1.0 INTRODUCTION

This report presents chemistry and benthic community data from work performed to date by King County under the long-term sediment monitoring program for the Denny Way/Lake Union Combined Sewer Overflow (CSO) Control Project. This work has been performed to fulfill requirements of the Biological Opinion (BO) WSB-00-039 issued by the National Marine Fisheries Service on June 19, 2000 (NMFS 2000).

1.1 Project Background

The Denny Way/Lake Union CSO Control Project was a joint effort of King County's Wastewater Treatment Division and Seattle Public Utilities to control City and County CSO discharges into Lake Union, as well as from the Denny Way CSO into Elliott Bay. The project included construction of two new outfalls into Elliott Bay, as well as construction of the Elliott West Wet Weather Treatment Station (WWTS)[1]. A 490-foot outfall at a depth of -63 feet (referenced to mean lower low water [MLLW]) discharges treated effluent from the Elliott West WWTS during moderately heavy storm events. A 100-foot extension of the former Denny Way Regulator Station overflow[2] outfall to a depth of -20 feet MLLW discharges untreated combined sewage and stormwater to Elliott Bay on average, once-per-year when flows exceed the WWTS and system capacity (King County, City of Seattle, and EPA 1998). Construction of the outfalls was completed in 2002 and the Elliott West WWTS came on-line in spring 2005.

Pursuant to the BO, King County, in cooperation with Washington State Department of Ecology (Ecology) and the National Marine Fisheries Service developed a monitoring plan for the marine environment in the area of the new outfalls. The primary goal of the monitoring program is to produce scientific data of known quality to determine whether implementation of the Denny Way/Lake Union CSO Control Project has led to a reduction in risk to human health and to the biological communities in the marine environment surrounding the Denny Way CSO control project outfalls. If operation of the outfalls causes increased contamination of marine sediments to levels that exceed Washington State marine sediment quality standards (SQS) of the Sediment Management Standards (SMS) (WAC 173-204-300), the monitoring program will identify such contamination and help King County and associated agencies develop a response plan.

The monitoring program includes sediment chemistry and benthic community analysis over a 20-year period following construction and operation of the new Elliott West WWTS and two marine outfalls discussed above. This report documents monitoring results for Years 1–5 and Year10[3]. King County previously produced a Post-Construction Sediment Monitoring Report that included monitoring data representing conditions for pre- and

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[1] The BO and previous reports referred to this facility as Elliott West CSO Treatment Facility.
[2] The BO and previous reports referred to this discharge as Denny Way CSO.
[3] Year 1 begins in 2006, which is after construction and operation of the Elliott West WWTS began.

post-construction of the new outfalls (King County 2005). Monitoring results for years 15 and 20 will be reported following the Year 20 monitoring event.

1.2 Site Description and Project History

The Elliott West WWTS outfall and Denny Way Regulator Station overflow outfall are located on the northeast side of Elliott Bay, adjacent to Myrtle Edwards Park in Seattle, Washington (Figure 1). The Denny Way Regulator Station overflow previously discharged from an outfall at the shoreline, which was heavily armored with riprap. The shoreline near the new Regulator Station outfall is still heavily armored with rip-rap with the exception of a small cove with some natural beach characteristics. Bathymetry in the area is moderately sloping.

In the past, discharges from the Denny Way Regulator Station overflow were the largest in King County's system with large volumes of combined storm water runoff and untreated sewage being discharged at the shoreline (1983 baseline discharge was approximately 500 million gallons [King County 2002]). Prior to becoming a CSO in 1968, raw sewage was discharged from this outfall starting in early 1900s.[4] In 1986, the Municipality of Metropolitan Seattle or Metro (later incorporated into King County) began a trial program to identify and further reduce toxicant inputs to the sewer system discharging through the Denny Way CSO.

The Denny Way Sediment Cap project was instigated in 1990 as a demonstration project to remediate nearby contaminated sediments. The cap is a 3-foot thick layer of clean sediment placed over three acres of contaminated sediment offshore of the outfall beginning at the depth determined to not be subject to wave erosion. Additionally, the Denny Way/Lake Union Control Project was initiated to reduce untreated discharges from approximately 50 per year on average, to one untreated event per year on average (see more details in Section 1.2.1 below).

Denny Way Cap monitoring program data indicated surface sediments in the center of the cap were gradually becoming recontaminated with phthalate compounds. The highest concentrations were detected at the monitoring station closest to the old Denny Way Regulator Station CSO outfall (Striplin Environmental Associates (SEA) 1997). Elevated sediment chemical concentrations surrounding the cap were also detected (SEA 1998). Chemicals of concern included polychlorinated biphenyls (PCBs), phthalate compounds, and mercury.

Five areas of concern requiring remediation were identified in the vicinity of the previous Denny Way Regulator Station CSO outfall (SEA 1999; King County 1999). Two areas were located inshore of the sediment cap, while three were located offshore of the cap (Figure 2). Dredging and disposal of contaminated sediment following outfall construction was identified as the preferred remedial alternative for the inshore areas of concern. Monitored

[4] The Denny Way outfall was acquired from City of Seattle in 1962 by Metro.

natural recovery was identified as the preferred alternative for the offshore areas (see more details in Section 1.2.2 below).

1.2.1 The Denny Way/Lake Union CSO Control Project

Construction of the new outfalls was completed in March 2002. The longer, deeper Elliott West WWTS outfall is designed to discharge treated CSO effluent during periods of moderate to large rainfall when normal system capacity is exceeded. This outfall is covered by a concrete "blanket" to prevent damage from excessive wave action or navigational mishaps. Habitat enhancement following construction included placement of "habitat mix" (sand, gravel, cobble) in the disturbed areas surrounding the construction zone, along with armoring cobbles and boulders and large woody debris. The original Denny Way Regulator Station CSO outfall was deconstructed in August 2002. When this happened the discharge of untreated CSO effluent moved offshore to the new Denny Way Regulator Station CSO outfall. This shorter, shallow outfall was designed to discharge untreated CSO effluent during large storm events an average of once-per-year. However, the discharge frequency was greater than once-per-year until the Elliott West WWTS came online in mid-2005. Now online, the new facility falls under King County's National Pollutant Discharge Elimination System (NPDES) permit WA0029181 for its West Point Treatment Plant and associated CSO treatment satellite facilities.

King County has monitored sediment quality at this site to meet the BO monitoring requirements. Monitoring events occurred in: 2001, prior to outfall construction; in 2003/2004, following completion of all construction activities; and annually from 2006 through 2010, and again in 2015, since Elliott West WWTS became operational. Additional monitoring is scheduled for 2020 and 2025.

1.2.2 Sediment Remediation at the Denny Way Site

In 1997, King County characterized the nature and extent of surface and subsurface sediment contamination in the area of the previous Denny Way Regulator Station outfall, as well as areas both inshore and offshore of the existing Denny Way sediment cap (SEA 1997). Follow-up sediment sampling conducted in 2005 demonstrated that chemical concentrations in the offshore areas declined over time due to a combination of natural processes, including biodegradation, accumulation and mixing with clean sediment, and reduction of contaminant sources (King County 2005). Thus, monitored natural recovery was the prospective cleanup remedy for the offshore areas (Areas C, D, and E). These areas continue to be monitored by Ecology and King County to determine if a more active cleanup remedy may be required. Areas C, D, and E are shown in Figure 2.

Unlike the offshore areas, the rate of natural recovery in the inshore sediment areas appeared to be progressing relatively slowly. To accelerate cleanup of the site and minimize risk of future recontamination to other areas of the site due to resuspension of inshore sediments, including the offshore cap, an interim sediment cleanup action plan for the site was developed by King County and Ecology in 2007. The cleanup plan included dredging to the extent practicable to remove sediments exceeding the SMS, and backfilling

to restore the grade to close to pre-project conditions (Ecology 2007). This interim action remediated contaminated sediment present in the two nearshore areas in the immediate vicinity of the former Denny Way Regulator Station CSO outfall (referred to as Areas A and B). A combination of dredging, backfilling, placement of clean sand around the perimeter of dredge area and armoring was employed to remediate the nearshore areas. The dredging boundary for the Areas A and B cleanup is shown in Figure 2.

Between November 2007 and February 2008, approximately 14,376 cubic yards (cy) of contaminated sediments were dredged from approximately -5 feet MLLW to approximately -35 feet MLLW within the 1.2-acre interim action area. The material within the dredge footprint was mechanically dredged using a clamshell bucket deployed from a derrick barge. The dredged area was backfilled and armored with an average thickness of more than 10 feet of material. Approximately 11,886 cy of well-graded clean sand was armored with approximately 4,821 cy of sandy-gravel habitat mix, as well as large cobbles and boulders. An additional 1,540 cy of well-graded clean sand was placed in an approximately 6-in thin layer around the perimeter of the dredge prism to address any residuals that may have resulted from the dredging.

Prior to commencement of construction activities, sediment grab samples were collected adjacent to, and beyond the dredge boundary, to document baseline pre-dredge sediment quality conditions near the project area. Sediment monitoring continued following construction including annual monitoring from 2008 through 2012 in Areas A and B to identify any recontamination, as well as Areas C, D and E to evaluate progress of natural recovery of these areas. The annual monitoring stations are the same as those required for the BO monitoring (Figure 2). Evaluation of these data, with regard to recontamination and natural recovery, will be presented in a subsequent King County report.

1.3 Biological Opinion Monitoring Objectives

The primary goal of the Denny Way Monitoring Program is to produce scientific data of known quality that can be used to determine whether implementation of the Denny Way/ Lake Union CSO Control Project has reduced risk to human health and biological communities in the marine environment surrounding the CSO (NMFS 2000). If the operation of the outfalls causes sediment contamination in the surrounding area at levels above established criteria, this monitoring program will lead to a site assessment, which will determine if a cleanup is needed. The monitoring will identify such contamination and help King County and the other interested parties develop a response plan (NMFS 2000).

1.3.1 Original Sediment Monitoring Scope of Work

The two monitoring objectives outlined in the BO necessary to meet the program goal include the following:

1. Determine the extent of chemicals of concern in the vicinity of Denny Way CSO
    - Collection of sediment chemistry samples at 16 stations

2. Determine the condition of the benthic and epibenthic communities in the area surrounding the Denny Way CSO through the use of:
   - Sediment Profile Imaging (SPI)
   - Video transects
   - Benthic community analysis

The monitoring events included pre-and post-construction, and post-operation of the Elliott West WWTS in Years 1–5, 10, 15 and 20. Collection of chemistry and SPI data would occur during all years, video transects for initial years (stopped by Year 4), and benthic community analysis for pre- and post-construction years. Chemistry analysis was to include metals, volatile and semi-volatile organic compounds, PCBs and pesticides.[5] An adaptive management strategy was also included in the monitoring plan to provide flexibility to re-evaluate the monitoring program.

Reporting includes tabulated data, a comparison of chemistry data to state marine sediment standards (as discussed in Section 1.3.3), and a summary of field activities, field methods, and data quality. An analysis and discussion of the benthic invertebrate community data are also included.

1.3.2 Amended Sediment Monitoring Scope of Work

The monitoring program outlined in the BO was amended in 2008 per the adaptive management strategy. The changes were based on initial results from the pre- and post-construction monitoring and after starting operation of the Elliott West WWTS. The amended scope of work encompasses the modifications listed below (King County 2008a):

- Permanent discontinuation of SPI and video surveys.
- Discontinuation of the following chemical parameters: antimony, nickel, ethylbenzene, tetrachloroethene, trichloroethene, total xylenes, 1,3-dichlorobenzene, hexachloroethane, total volatile solids, and chlorinated pesticides (with the exception of 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT).
- Decrease the number of benthic community stations from 16 to 8. King County chose to continue benthic community sampling beyond the required two 16-station sampling events (pre- and post-construction) at the following stations: DWMP-01, DWMP-03, DWMP-05, DWMP-08, DWMP-09, DWMP-10, DWMP-14, and DWMP-15[6].
- Change the sample depth stratum from 0-2 cm to 0-10 cm at 11 of the 16 stations to appropriately compare results to the SMS.

[5] The specific chemical compounds were those included in SMS numeric marine standards and Puget Sound Dredged Disposal Analysis analyte lists in 2000.
[6] Details on station locations are in Section 2.

Collection of samples from 16 stations (Stations DWMP-01 through DWMP-16) for chemical analysis was also continued. The reporting requirements were not amended (those summarized in Section 1.3.1 still apply).

Sampling events from 2008 through 2010 included sample collection at five stations proximal to the Elliott West WWTS outfall (DWMP-06, -07, -09, -11, and -12) with sediment chemistry samples collected from the top 2 cm. In addition, the station nearest to the Elliott West WWTS outfall (DWMP-08) had two chemistry samples collected; one each from the 0- to 2-cm and 0- to 10-cm depth strata. The 0-2 cm sample was targeted to fulfill the requirements of the NPDES permit at the time. However, the current NPDES permit, which includes this outfall, now requires sediment chemistry sample collection from the top 10 cm to determine SMS compliance. Therefore, to be consistent with new NPDES requirement and sample depths at other stations, all sediment chemistry samples collected in 2015, were taken from the top 10 cm.

1.3.3 Evaluation of Monitoring Results

Per the BO (NMFS 2000), the monitoring results will be compared to the SMS Washington State marine sediment standards (WAC 173-204-300) and sediment quality guidelines in effect at the time of sample collection. The following steps will be taken if results are above SMS:

- Identify the contaminant that exceeds the standard or guideline
- Identify the geographic extent of the exceedance
- Develop a sampling plan to collect additional data to confirm the exceedance and the geographic extent of it
- Develop a methodology to compare data from the Denny CSO area to control areas
- Use the original and additional data to determine the likelihood that the exceedance is being caused by the Denny Way/ Lake Union CSO Control Project outfalls
- If the source of contamination is not identifiable, additional sampling and analysis of sediment will be conducted and the results will be correlated to the contaminants in the discharges to determine the source
- As appropriate, in conjunction with other agencies with jurisdiction, develop a remediation plan to address the identified area of contamination

Although the long-term monitoring period is not complete, this data report provides an evaluation of the current status of the Denny Way site. This report addresses most of the steps above. Additional reporting will occur following the final monitoring event. To address objectives in the 3rd and 7th bullet above, King County is also preparing a cleanup action plan for the Denny Way site per its Sediment Management Plan (King County 1999; see Section 6). Cleanup action plans need to identify sources and determine adequate controls prior to initiating action.

1.4 Report Organization

Section 2 summarizes the sampling and analytical methods associated with the Denny Way sediment monitoring effort. Section 3 presents chemistry results and highlights quality assurance/ quality control (QA/QC) issues that could affect data evaluation, and Section 4 presents results of the benthic community assessment. A discussion of the report findings are presented in Section 5 followed by summary of conclusions in Section 6. Data tables and figures are included at the end of the report following the References (Section 7). Supporting appendices are included after table and figure sections.

2.0 SAMPLING AND ANALYTICAL METHODS

This section summaries sample collection, processing, and analyses for both chemistry and benthic taxonomy samples. Details these methods can be found in the project sampling and analysis plans (SAP) (King County 2006; 2007; 2008b; 2009; 2010; 2015). In addition, Appendix A presents the King County Environmental Laboratory (KCEL) Quality Assurance reports (QA 1 Reports) for each year's sampling event; these reports include additional detail on sample collection effort and analysis methods. All samples were collected by KCEL Field Sciences Unit (FSU) staff and Allan Fukuyama (contract benthic taxonomist) assisted with benthic taxonomy sample collection and associated field processing.

2.1 Sample Locations and Sampling Events

Sixteen sediment stations have been established for the Denny Way monitoring program and are located around the two new outfalls in a grid pattern consisting of transect lines running perpendicular to the shoreline. The two outer transect lines consist of four stations each (n=8), while the two inner transect lines include three stations each (n=6). The final two stations are located near the terminus of the 490-foot outfall for the Elliott West WWTS. Fourteen of the 16 sampling sites are located at stations previously sampled as part of the Denny Way Sediment Characterization (SEA 1998).

Per the monitoring plan, sediment chemistry was analyzed at all 16 stations. In 2006 and 2007, benthic community samples for taxonomy were collected from all 16 stations. Following 2007, benthic taxonomy samples were collected from eight of the 16 stations. Figure 2 shows station locations and which eight stations were analyzed for benthic taxonomy after 2007. The same locations were sampled during each monitoring event and all sampling occurred in the spring. This report does not summarize video surveys or SPI data because this information was not collected in 2006 or 2007 per the original monitoring plan. Benthic taxonomy samples were collected from all 16 stations to characterize the benthic community instead.

Table 1 presents the station names, sample coordinates, approximate station depths, sediment depth strata, and collection period. Samples were collected from all 16 stations in 2006, 2007, 2009, 2010, and 2015. In 2008, samples were not collected from stations DWMP-05, DWMP-10, and DWMP-13 due to lack of suitable material. Substrate at the three locations was composed of rock and gravel. DWMP-08 was the only station where two samples (at two different sediment depth strata) were collected from the same station in a given year.

2.2 Field Sampling Procedures

All sampling was performed per project SAPs, which follows guidelines recommended by the Puget Sound Estuary Program's (PSEP) Puget Sound Protocols (PSEP 1987, 1997, 1998). Sediment grab samples were collected from the King County research vessel, *Liberty*, which was equipped with a differential global positioning system (DGPS). Field coordinates were recorded using DGPS for each deployment of the tandem grab samplers as they contacted the sediment. Sediment samples were collected using dual, tandem 0.1 m^2 modified, stainless steel van Veen grab samplers deployed via hydrowire and hydraulic winch from the *Liberty*. For each acceptable deployment, between 5–17 cm of sediment was recovered, allowing sub-sampling from the top 2 or 10 cm. Multiple sampler deployments were needed to collect sufficient sample volume to perform all chemistry and benthic taxonomy analyses.

2.2.1 Chemistry Samples

The top 2-cm or 10-cm (depending on target depth strata identified in the project SAP for that year's monitoring event) was collected from each van Veen sampler cast. Prior to any homogenization, an aliquot of sediment was collected directly from the van Veen for total sulfide analysis. The remaining top 2-cm or 10-cm of sediment was transferred to, and homogenized in, a station dedicated pre-cleaned stainless steel mixing bowl with a pre-cleaned stainless steel spoon. This precluded the need for equipment decontamination in the field. At each station, sediment from three Van Veen grabs was homogenized for chemistry analysis and then transferred to appropriate laboratory containers for specified analytical methods (see Section 2.3). The Van Veen grab sampler was decontaminated between stations by scrubbing with a brush and ambient seawater, followed by a thorough in-situ rinsing.

All samples were stored in ice-filled coolers from the time of collection until delivery to the KCEL. They were delivered under chain-of-custody (COC) and maintained as such throughout the analytical process. Samples were stored frozen (-18 °C) at the KCEL until analysis, with the exception of samples for particle size distribution (PSD), volatile organic analysis, ammonia and total sulfide analysis which were stored at approximately 4 °C. Copies of COC forms, field notes, and additional discussion of sampling procedures and handling are found in the QA1 reports in Appendix A. Ninety-six sediment chemistry samples were collected from 2006 through 2015. Sample ID information is presented in the Table Section and Appendix B.

2.2.2 Benthic Taxonomy Samples

Three replicate benthic taxonomy samples were collected at each station and consisted of the entire contents of the Van Veen grab. Sediment from acceptable grabs was flushed with ambient seawater through a 1.0-millimeter sieve to remove all fine material. The remaining sediment was then transferred into an appropriate sized bottle (e.g., 1-liter plastic container) depending on sample volume, using a minimum amount of seawater.

Samples were preserved in the field with 10% buffered formalin. Labels were placed on both the inside and outside of sample containers, recorded on COC forms, and placed in coolers for at least 24 hours, but not exceeding 96 hours, prior to rescreening by contract laboratory personnel. Benthic samples were rescreened at the contract laboratory where formalin solution was replaced with 70% ethanol solution as recommended by PSEP protocols (PSEP 1987). Ninety-four benthic taxonomy samples (including replicates) were collected from 2006 to 2015.

2.3 Analytical Laboratory Analyses

All analytical laboratory analyses were performed by KCEL per project SAPs. A summary of methods and major analytical method modifications over the monitoring period are summarized below.

2.3.1 Conventional Parameters

Sediment chemistry samples were analyzed for the following conventional parameters: total solids, total volatile solids, total organic carbon (TOC), PSD, ammonia, and sulfide. Total volatile solids were analyzed in 2006, 2007, and 2008 to provide a different type of estimate of sediment organic content[7]. However, total volatile solids, which was not required by the BO for the Denny Way monitoring plan, was removed from the analyte list after 2008.

Total solids and total volatile solids were both analyzed using the Standard Method (SM) 2540-G, which is a gravimetric determination. TOC analysis was performed on all samples. These data were used to normalize sediment concentrations of select organic parameters to the organic carbon content, which can reduce the bioavailability of hydrophobic organic contaminants in sediment. TOC analysis was performed according to EPA Method 9060/SW-846, high-temperature combustion with infrared spectroscopy.

PSD analysis was performed according to ASTM Method D422, which is a combination of sieve and hydrometer analyses. Results are presented for phi sizes and the four broad classifications consisting of clay, silt, sand, and gravel, as well as fines (combination of clay and silt fractions).

Ammonia and sulfide, which are indicators of potential sediment toxicity, were analyzed by SM 4500-NH3-G and SM 4500-S2-D (EPA 9030B), respectively. Ammonia analysis by SM 4500-NH3-G includes a potassium chloride extraction followed by spectrophotometric analysis of the extract. The total sulfide method includes distillation following acidification and colorimetric analysis of the distillate. In 2013, KCEL changed the ammonia analysis to Kerouel & Aminot 1997. This method includes a potassium chloride extraction followed by a fluorometric analysis of the extract. KCEL did a comparative analysis between the two

[7] Total volatile solids can provide similar measure of sediment carbon content to total organic carbon, as long as mineral salts are not present.

methods (King County 2012), and found the results to be comparable. Therefore, the ammonia results using both methods are compared across the monitoring period.

2.3.2 Metals and Mercury

Sediment chemistry analysis included the following metals: arsenic, cadmium, chromium, copper, lead, mercury, silver, and zinc. From 2006-2008, nickel and antimony were also analyzed but discontinued in 2009 per the amended monitoring scope (Section 1.3.2). Mercury was analyzed by cold vapor atomic absorption spectroscopy (CVAA) using EPA Method 7471A in 2006 and 2007, and EPA Method 7471B from 2008 through 2015. The remaining metals were analyzed by inductively coupled plasma optical emission spectroscopy (ICP-OES) with a strong acid digestion using EPA Method 3050A/6010B in 2006, EPA Method 3050B/6010B in 2007, and EPA Method 3050B/6010C from 2008 through 2015. These method changes are not expected to affect comparability of metal sample results over the monitoring period.

2.3.3 Organic Compounds

Sediment chemistry for organic compounds included volatile organic compounds, semi-volatile organic compounds, chlorinated pesticides, and PCBs (specific analytes are listed in Appendix B). As noted in Section 1.3.2, the analyte list for organic compounds was reduced following the 2008 monitoring event.

The volatile organic compounds (ethylbenzene, tetrachloroethene, trichloroethene, and total xylenes) were analyzed by EPA SW-846 Method 8260B, which employs a methanol extraction diluted in reagent water and introduced via purge and trap to analysis by gas chromatography/mass spectroscopy (GC/MS). These compounds were analyzed from 2006 through 2008.

The semi-volatile organic compounds analysis includes base/neutral/acid extractable (BNAs), such as phenolic compounds, polycyclic aromatic hydrocarbons (PAHs), phthalates, and chlorinated benzenes. This analysis was performed according to EPA SW-846, methods 3550B/8270B, from 2006 through 2009 and methods 3550B/8270C from 2010 through 2015. These methods employ solvent extraction (50-50 methylene chloride/acetone) with sonication and analysis by GC/MS. The same extraction method and solvent were used for all monitoring years. The difference between methods 8270 B and C was largely associated with instrument and calibration QC requirements and not expected to affect data comparability over the monitoring period.

Chlorinated pesticide/ PCB Aroclor analysis was performed according to EPA SW-846 Method 8081A/8082 from 2006 through 2008. The chlorinated pesticide analyte list was reduced to 4,4’-DDD, 4,4’-DDE, and 4,4’-DDT starting in 2009 and the analytical method was changed to EPA SW-846 Method 3550B/8082B for these compounds. At the same time, the PCB Aroclor method was changed to EPA SW-846 Method 3550B/8082A. These methods employ solvent extraction with sonication and analysis by gas chromatography with electron capture detector (GC/ECD) and dual column confirmation.

In 2011 sample, KCEL modified the PCB extraction methods for Method 8081B/8082A to reduce chemical interference and improve accuracy of quantification. The extraction solvents were changed from methylene chloride and acetone, to hexane and acetone. In addition, starting in 2012, the chromatogram peaks selected for quantitation were changed to eliminate the potential for double-counting Aroclors that have overlapping peaks (e.g. Aroclor 1254 and 1260) and improve accuracy. An automated software program was also introduced in 2012 to improve quantitation consistency. To evaluate impacts associated with the revised extraction method, KCEL conducted independent analyses of sample and laboratory standard reference material (SRM) using different extraction solvents. The results indicated that the shift to hexane/ acetone may result in slightly higher (~5%) total Aroclor concentrations (Grothkopp 2017).

2.4 Benthic Taxonomy Identification and Biomass Measurements Methods

Contract laboratory staff used standard techniques to sort all organisms from sediments (PSEP 1987). Small fractions of sample material were placed in a petri dish under a 10x dissecting microscope. The petri dish was scanned systematically and all animals and associated fragments were removed using forceps and separated according to one of the following major taxonomic groups: Annelida, Crustacea, Mollusca, and miscellaneous taxa (Echinodermata, Nemertea, Sipuncula, etc.). All samples were then placed in 70% ethanol for preservation.

All organisms were counted and identified to the lowest practical taxonomic level, which was usually species. If animal fragments were present, only anterior portions were counted. Identifications were performed by regional taxonomic experts using stereo dissecting and high-power compound microscopes. Biomass measurements were also performed in accordance with standard PSEP procedures. All benthic taxonomy identifications were conducted by or overseen by Allan Fukuyama.

2.5 Deviations from SAP

In 2008, stations DWMP-05, -10, and -13 did not have chemistry samples collected due to lack of suitable sediment material. Material at these locations consisted of rock and gravel. However, a benthic taxonomy sample was collected from station DWMP-05 in 2008.

In 2015, the field crew was unable to achieve 11 cm sediment depth penetration for the Van Veen grabs at three stations due to a rocky bottom. The sediment depth in the grab samples ranged between 5 and 8 cm for samples L62484-5, -10, and -13 (from stations DWMP-05, -10, and -13, respectively).

3.0 SEDIMENT CHEMISTRY RESULTS

This section presents sediment chemistry data summaries for years 2006–2012 and 2015, discussions of data quality and comparisons to Washington State SMS marine standards. The SMS apply to the biological active zone (typically top 10 cm in Puget Sound marine sediments) (WAC 173-204); however, they were compared to both 0- 2 cm and 0-10 cm sediment samples in this report as a means to evaluate sediment quality per the BO. For parameters without state marine standards, the numeric guidelines from Washington's Dredge Material Management Program (DMMP) User's Manual are used to evaluate sediment quality. The DMMP numeric guidelines are used when evaluating disposal options for dredged sediment within Washington state marine areas.

Comparisons to SMS for marine sediments use SQS and Cleanup Screening Level (CSL) numeric values (WAC 173-204). Chemical concentrations less than or equal to the SQS are defined as levels at which no acute or chronic adverse effects on biological resources are expected (WAC 173-204-300). Chemical concentrations between the SQS and CSL are defined as having the potential for minor adverse effects, and chemical concentrations greater than the CSL are defined as levels above which minor adverse effects are expected. The SQS and CSL for a number of organic compounds are based on organic carbon (OC) normalized values. For these compounds, the sediment chemistry data are OC normalized when the sediment sample's TOC is 0.5 to 3.5%. However, when the sediment sample's TOC content is less than 0.5% or greater than 3.5%, the dry weight (dw) chemical concentration is compared to the corresponding SQS or CSL Apparent Effects Threshold (AET) value (Ecology 2015).[8] Sample TOC results were within the OC normalization range except for four stations (DWMP-01, -10, -12 and -13) over multiple years.[9]

The DMMP numeric guidelines, which were used for antimony, nickel, select organochlorine pesticides and VOCs, include a screening level (SL) and maximum level (ML). The SL is similar to the SQS and is defined as the chemical concentration at or below which there is no reason to believe that dredged material disposal at a Puget Sound disposal site would result in unacceptable adverse effects (ACOE 2013). The ML is equal to the highest AET, a chemical concentration at which all biological indicators with AETs show significant effects (ACOE 2013). The ML values serve to provide dredge project proponents an estimate on the likely outcome of bioassays.

Chemistry results are summarized by chemical parameter groups. SMS rules were followed in the calculation of total PCBs and low and high molecular weight PAH sums. The complete

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[8] The SMS numerical marine chemical criteria are based on AETs developed for four marine benthic endpoints. An AET is the highest "no effect" chemical-specific sediment concentration above which a significant adverse biological effect always occurred among the several hundred samples used in its derivation. In general, the lowest of the four AETs for each chemical was identified as the SQS; the second lowest AET was identified as the CSL.

[9] Results were OC-normalized by dividing dry weight concentration (µg/kg dw) by the kg TOC / kg dw and dividing by 1,000 to get the OC-normalized concentration (mg/kg OC).

analytical results (including parameters with no SMS or DMMP values) are presented in Appendix B. Laboratory QA/QC details are presented in each year's QA 1 Report (Appendix A) and any relevant findings are highlighted below. Referenced figures and tables are presented at the end of this report.

In addition to laboratory data qualifiers, method blank results were also reviewed to determine how sample data results would be qualified based on the associated method blank batch results. Method blank results from each QC batch report were compared to the analytical results for each sample in the same analytical workgroup. When a compound was detected in the method blank, any sample results within five times the method blank concentration was qualified with a "U" flag and considered non-detect. For these "U" flagged data, if the sample result was less than the RDL, the RDL value was considered the level of detection, and when the sample result was greater than the RDL, the sample result value was considered the level of detection. In addition, "U" and "J" data quality flags were added to samples with "<MDL" or "<RDL" laboratory qualifiers, respectively. The "U" qualifier indicates a non-detect value, while a "J" qualifier indicates an estimated value. Results of this data review are presented in Appendix C and a summary of data impacted by method blank contamination is presented below in Sections 3.3.3 and 3.3.4 below.

3.1 Conventional Parameters

Conventional parameters summarized here include TOC, ammonia, sulfide, and PSD. These parameters can influence sediment toxicity and contaminant bioavailability, as well as benthic community structure (see Section 4.0). Data quality for each conventional parameter is summarized below, followed by a general summary of results. Details on data quality can be found in each monitoring year's QA 1 Report (Appendix A). Results for TOC, ammonia, sulfide and PSD presented by year collected are included in Tables 2c-7c.

3.1.1 TOC

QA/QC results for all TOC samples were within acceptable lab limits. Across all stations and years, average TOC was 1.93 % [dw] and ranged from less than MDL (0.049 % [dw]) to 6.59 % [dw]. The lowest TOC levels tended to occur at stations DWMP-10 and DWMP-13, while the highest levels generally occurred at DWMP-01 and DWMP-12. The greatest variability in TOC over the years monitored was observed at Station DWMP-10 due to the remedial action taken in 2008.

3.1.2 Ammonia

QA/QC results for all ammonia samples were within acceptable lab limits. Ammonia concentrations ranged from 0.438 to 7.33 mg/kg dw, with average of 2.76 mg/kg dw, across all stations for all years monitored. For most of the years sampled, ammonia concentrations tended to be higher in the nearshore stations (DWMP-01, -05, -10 pre-remediation, and -13) relative to the deeper stations, with the exception of DWMP-08. Average ammonia concentrations at all nearshore stations were greater than 3.0 mg/kg dw, while average levels at all the deeper stations were less than 3.0 mg/kg dw, except for DWMP-08. The highest ammonia (7.33 mg/kg) was measured in 2008 at Station DWMP-08

(in 0–2 cm depth). DWMP-08 was the only station where two depth strata samples were collected; ammonia concentrations tended to be higher in 0–2 cm than the 0–10 cm stratum.

3.1.3 Sulfide

QA/QC results for all sulfide samples were within the acceptable lab limits with the exception of the 2008 matrix spike results. The spiked sample was qualified with “JG” indicating the potential for a low bias. No other samples within the analytical batch were qualified because the spike blank for the analytical batch met QC limits.

Total sulfide concentrations ranged from less than MDL (0.53) to 1,031 mg/kg dw, with an average of 75.3 mg/kg dw, across all stations for all years monitored. Total sulfide concentrations in approximately 80% of samples were less than 100 mg/kg dw. During years 2006 through 2009 the highest overall total sulfides were detected at DWMP-08. In 2010, total sulfides were highest at DWMP-06 and in 2015 concentrations were highest at DWMP-01. Over all years, DWMP-08 had highest average sulfides followed by DWMP-01.

3.1.4 PSD

QA/QC results for most PSD samples were within the acceptable laboratory ranges. Gravel fraction results in 2006, 2008, and 2015 were qualified as estimated values (“J” flagged) based on laboratory triplicate relative standard deviations greater than the QC limit. The 2010 sample results for sand and gravel fractions were also qualified as estimated values with a potential low bias based on laboratory error in measuring sieve weights. A review conducted in 2015 of the 2010 data records identified analytical errors related to the initial weights collected from the #10 and #18 sieves associated with the P-1.00 and P+0.00 phi sizes, respectively. This resulted in miscalculated data being reported for the P-1.00 and P+0.00 phi sizes, as well as the associated gravel and sand categories. This caused the sum of all phi sizes for some samples to be outside the 90% to 110% acceptance laboratory limits.[10] More information is provided in the data anomaly form included in Appendix A.

The deepest stations (approximately -40 to -80 feet MLLW) were composed largely of sandy-silts and silty-sands. PSD in the nearshore stations were not as homogenous. The two shallowest stations, DWMP-05 and DWMP-13, were comprised of gravelly-sands and sandy-gravels, while Station DWMP-01 was comprised of sandy-silts and DWMP-10 shifted from largely sandy to sandy-gravels similar to the other shallow stations following the 2008 sediment remediation in this area. Post-remediation, the gravel fraction increased relative to the % sand at DWMP-10. Similar shifts in PSD were not as pronounced at other stations.

[10] Sums of all phi sizes may not total to 100% due to rounding and measurement variability.

3.2 Metals and Mercury

Arsenic, cadmium, chromium, copper, lead, mercury, silver, and zinc were analyzed in all samples over the monitoring years. Antimony and nickel were analyzed from 2006 through 2008. The metals and mercury data and comparison to SMS are presented by year in Tables 2 through 7.

QA/QC results for all metals and mercury samples were within acceptable lab limits with a few exceptions. Mercury results in 2007 were qualified as estimated values due to matrix spike results outside recovery limits. Re-analysis of mercury in these samples indicated the sample matrix was heterogeneous and the likely cause of the unacceptable matrix spike recoveries. These results were "E" qualified indicating estimated values with unknown bias. In 2007 and 2008, most mercury results were also "E" qualified due to RPDs for laboratory duplicates that exceeded the QC limit. Antimony results for most of the 2006, 2007, and 2008 samples were "G" qualified as estimated values due to low matrix spike recovery.

Overall, metals were frequently detected at all stations for all years sampled. Chromium, copper, lead, mercury, nickel, arsenic, and zinc were always detected with the exception of arsenic at one station in 2006. Cadmium and silver, while largely detected across all stations and years (90% and 89%, respectively), had the lowest frequency of detection of the metals.

Most metals had concentrations below their respective SQS/CSL or the SL/ML (only applies to antimony and nickel) throughout the monitoring period. In 2007, chromium concentration was greater than the CSL at DWMP-05 in the 0-2 cm sediment sample. In 2010, silver concentrations were greater than the CSL at DWMP-8 in the 0-2 cm sediment sample but not the 0-10 cm sediment sample. These two metals were not greater than their respective SQS or CSL at any other stations or years.

Mercury concentrations were consistently greater than both the SQS and CSL across multiple years at multiple stations. Mercury concentrations were most frequently above the SMS at DWMP-01 (always above CSL) and DWMP-03, -08, -09, and -14 (always above SQS or CSL). Other stations with one to three sample concentrations above either the SQS or CSL over the monitoring period include: Stations DWMP-7, -10, -11, -12, -15, and -16. While mercury concentrations at DWMP-10 were above the CSL in 2006 and 2007, levels were well below the SQS during every subsequent monitoring year following the 2008 sediment remediation. The greatest number of stations with mercury concentrations above SQS occurred in 2015 (9 stations) and the lowest number occurred in 2010 (5 stations); all but one of these samples were from the 0-10 cm strata.

3.3 Organic Compounds

PCBs, PAHs, phthalates, chlorobenzene compounds, phenolic compounds[11], and DDT and its derivatives were analyzed over the course of the monitoring years. Monitoring of four volatile organic compounds and the remaining chlorinated pesticides was discontinued after 2008. Additional analyte reductions occurred over the monitoring period for a few semi-volatile organic compounds because these compounds were not part of SMS numeric chemical standards or DMMP guidelines.[12] A general summary of data quality and comparisons to SMS or DMMP values by analyte group is presented below. Organic compounds are presented as either OC-normalized or dw basis depending on the SMS value. A more detailed discussion of laboratory data QA/QC results is presented in QA 1 Reports (Appendix A). The organics data results and comparison to SMS marine standards are presented by year in Tables 2a through 7a. Data with DMMP guidelines but no state marine sediment standards are presented in Tables 2b through 7b.

3.3.1 PCBs

QA/QC results for most PCB samples were within acceptable laboratory limits. Some results were qualified as estimated (JK, L, and H flagged) due to recovery limits or RPDs outside the acceptable lab limits. In 2006, one sample's Aroclor results were "L" qualified due surrogate recoveries that were outside lab acceptance limits. In 2009, the Aroclor 1260 results for one sample were "JK" qualified to indicate unknown bias due to the duplicate RPD not meeting lab QC limits. Also in 2009, four samples received "H" qualifiers because they exceeded the 40-day PCB Aroclor extract holding time by 3 days. This deviation is not expected to bias results.

Total PCBs were calculated based on the sum of detected Aroclors and at least one Aroclor was detected in all samples over the monitoring period with the exception of DWMP-10 in 2015. Aroclors 1248, 1254, and 1260 were identified and quantified in multiple samples over the monitoring period. However, Aroclors 1016, 1232, and 1242 were reported as non-detect, often with elevated MDLs or RDLs. The elevated MDL/RDLs are due to the congeners within different Aroclors that overlap on the chromatogram; this results in overlapping peaks on the chromatographs making it difficult to quantitate specific Aroclor mixtures. Specifically, the chromatographic congener peaks used to quantitate Aroclors 1232, 1242, and 1016 overlap with those associated with congeners from Aroclors 1248 and 1254. Aroclor 1248 also has some overlap with Aroclor 1254 but to a much lesser extent than the previously listed Aroclors. When chromatogram indicates PCB congeners are present that are part of Aroclor 1232, 1242 or 1016, the total PCB concentration is not expected to be underestimated because the quantification of the identified Aroclor(s) (e.g., 1248 and 1254) accounts for the presence of these other congeners. In 2015 samples, Aroclor 1242 was quantified rather than 1248. In 2011, the quantification method changed

[11] 4-methylphenol was reported in years 2006-2010 and was reported as 3-,4-methylphenol in 2015 because it was acknowledged that these two compounds cannot be distinguished on the chromatogram.
[12] The monitoring plan only required analysis of chemicals listed in SMS and DMMP guidelines.

(see Section 2.3.3); thus only affecting the 2015 data in this report. The new congener peaks used to quantitate Aroclor 1242 showed a better pattern match to Aroclor 1242 rather than 1248, but still overlapped with Aroclors 1016, 1232, and 1248. Furthermore, the new quantitation congener peaks for Aroclors 1016, 1232, 1242, and 1248 no longer included any overlapping congener peaks from Aroclor 1254.

Total PCB concentrations were above the SQS at a number of stations; however, no concentrations were greater than the CSL during the monitoring period. Concentrations at DWMP-01, -03, -08, -14, and -15 were above the SQS over all years monitored, and during four of the six monitoring years at DWMP-09. With the exception of stations DWMP-05 and-06, all stations had sporadic instances of PCB concentrations above the SQS. At these stations, a concentration above the SQS would typically be followed by a subsequent year with concentrations below the SQS. At DWMP-10, PCB concentrations following the sediment remediation were always below the SQS. Across years, 2006 experienced the highest frequency of PCB concentrations above the SQS (11), followed by 2015 (10), while 2008 had the least (5); the remaining years were similar with concentrations at 7-9 stations above the SQS each year. With the exception of 2006 and 2007 when all samples were collected from 0-2 cm, most PCB concentrations above the SQS were detected in the 0-10 cm depth strata.

3.3.2 PAHs

QA/QC results for most PAH samples were within acceptable laboratory limits. Some sample results were qualified as estimated (J and E flagged) due to recovery limits or RPDs that were outside of acceptable limits. In 2008, the laboratory duplicate RPD for pyrene was outside the acceptance limit, and “E” flagged to indicate an estimated value. In 2009, matrix spike recoveries for some samples were outside the acceptance limit for phenanthrene, pyrene, and benzo(a)pyrene. In 2010, RPDs for many PAHs exceeded the upper control limit, and “J” qualified to indicate an estimated result. In 2015, phenanthrene and fluoranthene results for one sample were “J” qualified because the lab duplicate RPD exceeded the upper control limit.

Most PAHs were regularly detected at all stations over the monitoring period. However, 2-methylnaphthalene, acenaphthene, acenaphthylene, and naphthalene were not often detected.

DWMP-01 was the only station to consistently have individual PAH compounds and total HPAHs concentrations above their respective SQS or CSL; this occurred every year except 2008. PAHs at DWMP-01 were greater than SQS or CSL in both the 0–2 cm and 0–10 cm strata. In addition, PAH compounds above SQS were dominated by HPAHs in all years, although LPAHs were occasionally above the SQS. Five other stations had at least one individual PAH compound with concentrations above the SQS, but not the CSL: DWMP-04 and -10 in 2006; DWMP-02 in 2008, DWMP-05 in 2009; DWMP-08 in 2010. Total HPAH concentrations at Stations DWMP-5, -8, and -10 were also above the SQS in the years where individual compounds were also above the SQS. Over the monitoring period, 2006 had the most PAHs above the SQS followed by 2010 and then 2009.

3.3.3 Phthalates

QA/QC results for most phthalate samples were within acceptable laboratory limits. Some sample results were qualified as estimated (B, J and E flagged) due to detections in the method blank, recovery limits or RPDs that were outside of acceptable limits. In 2008, bis(2-ethylhexyl) phthalate (BEHP) and benzyl butyl phthalate laboratory duplicate RPDs were outside the acceptance limit and “E” flagged to indicate an estimated value. In 2010 and 2015, benzyl butyl phthalate results were “J” qualified to indicate an estimated value due to laboratory duplicate RPDs outside the acceptance limit.

Results are qualified by KCEL with a “B” flag if the compound was detected in the method blank.[13] This occurred most often for three phthalates: BEHP, benzyl butyl phthalate and di-n-butyl phthalate. BEHP results in some, or all samples, in 2006, 2007, 2008, and 2009, benzyl butyl phthalate results in 2008, and di-n-butyl phthalate results in 2006, 2007, and 2008 were “B” flagged. Additional data review for these compounds, resulted in qualification of several samples results for these three phthalates as non-detects (“U” flagged) due to sample results that were within five times the associated method blank levels (see Appendix C). Specifically, nine BBP results in 2008, one BEHP result in 2009, and most results for di-n-butyl phthalate in 2006 and 2008 were “U” qualified. These QA/QC issues did not affect data interpretation because concentrations for all “U” flagged results were below their respective SQS/CSL values.

Butyl benzyl phthalate and BEHP were frequently detected at all stations over the monitoring period. Di-n-butyl phthalate was the next most frequently detected phthalate, while the remaining three phthalates were rarely or never detected.

Butyl benzyl phthalate concentrations were above the SQS, while BEHP concentrations were above either the SQS or CSL over the monitoring years. Butyl benzyl phthalate concentrations were above the SQS during all but one monitoring year (2008) at Station DWMP-01, followed by DWMP-14 and -05 where levels were above the SQS for 4 and 3 years, respectively. Concentrations at the remaining stations were occasionally above the SQS, while some were consistently below. Over the monitoring period BEHP concentrations were above the CSL at five stations one or two times, and above the SQS at nine stations one to three times. As was observed for other contaminants, concentrations of BEHP and butyl benzyl phthalate were not detected above the SQS or CSL at DWMP-10 following sediment remediation. The greatest frequency of phthalate concentrations above the SQS occurred in 2006, with all stations but three having at least one phthalate above SQS. The lowest number of stations with phthalate concentrations above the SQS occurred in 2008, with one (DWMP-14), followed by 2015, with four (DWMP-01, -03, -05 and –14). Concentrations of BEHP and BBP were above the SQS in both 0–2 cm and 0–10 cm strata.

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[13] From 2006-2008, a B flag indicated the compound was detected in the method blank and sample results were within ten times the method blank concentration; in 2009 and after, a B flag indicated the compound was detected in the method blank and the sample result was within five times the method blank concentration.

3.3.4 Other Semi-Volatile Organic Compounds

QA/QC results for most semi-volatile organic compounds samples were within acceptable laboratory limits. Some sample results were qualified as estimated (B, JG, and J flagged) due to detections in method blank, recovery limits, or RPDs that were outside of acceptable laboratory limits. In 2010, matrix spike recoveries for benzoic acid were below laboratory limits and were "JG" qualified. In addition, many of the 2010 benzoic acid results were "B" flagged by KCEL and later qualified with a "U" during method blank data review due to benzoic acid concentrations that were within five times the method blank concentration. However, these issues did not affect data interpretation for benzoic acid because concentrations were well below the SQS. Phenol and 2-methylphenol results were "J" qualified due to poor precision based on the RPD.

Most semi-volatile organic compounds (e.g., chlorobenzenes, phenolic compounds) were infrequently detected with the exception of 1,4-dichlorobenzene, dibenzofuran, benzoic acid, and phenol. Concentrations of only two semi-volatile organic compounds were above their respective SQSs: 2,4-dimethylphenol at DWMP-01 in 2015, and phenol at DWMP-02 in 2008; none were above their respective CSLs.

3.3.5 Chlorinated Pesticides

DDT and its derivatives (4,4'-DDD, 4,4'-DDE, 4,4'-DDT) were analyzed in all years sampled. As previously indicated, aldrin, dieldrin, heptachlor, alpha-chlordane, gamma-chlordane, and gamma-BHC (lindane) were analyzed from 2006 to 2008. QA/QC results for most chlorinated pesticide samples were within acceptable laboratory limits. Some results were qualified as estimated (JL, JK, L, J and E flagged) due to recovery limits or RPDs that were outside of acceptable limits.

In 2007 some chlorinated pesticide results were "L" flagged due to decachlorobiphenyl background interferences. In 2007 and 2008, continuing calibration verification standards for DDT, methoxyclor, and endrin aldehyde for some samples were unacceptable due to matrix interferences and were "E" qualified. In 2009, results for 4,4'-DDD and 4,4'-DDT in one sample "JK" qualified to indicate an unknown bias based on laboratory duplicate results. Many of the 2015 sample results for 4,4'-DDE had RPDs outside of acceptable limits on the confirmation column and were "J" qualified. Elevated MDL/RDLs for 4'4-DDT in 2015 were observed for some non-detect results. MDL/RDLs for 4'4-DDT were increased to accommodate interference of Aroclor 1254. In addition, 4'4-DDT detected results were "JL" qualified and may be biased high as a result of Aroclor 1254 interference.

Most chlorinated pesticides were never detected. Alpha chlordane was rarely detected, while 4,4'-DDD was commonly detected in all years. 4,4'-DDT and 4,4'-DDE were rarely detected in most years, except in 2015, when detection frequency increased for both compounds.

Of the pesticides analyzed, only concentrations of 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT (as sum of DDT and its derivatives) were above the DMMP SL guideline; no pesticide concentrations were above the DMMP ML guideline over the monitoring period. Pesticide concentrations above the SL were sporadic and did not demonstrate a temporal or spatial pattern. Concentrations of DDT and its derivatives at DWMP-08 were most frequently detected above SL, occurring at one or both depth strata in 2006, 2007, 2008, and 2010. Concentrations of DDT and its derivatives were most frequently above the SL at a number of stations in 2010.

The DMMP screening guidelines for 4,4'-DDD, 4,4'-DDE, 4,4'-DDT were revised over the monitoring period. Per the BO monitoring plan, analytical results were compared to the most current guideline available at the time of sampling. Prior to 2013, the DMMP guidelines for DDTs was based on the sum of 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT (SL = 6.9 µg/kg dw). In 2013, compound specific guidelines were adopted. The updated SLs are: 16 µg/kg dw for 4,4'-DDD, 9 µg/kg dw for 4,4'-DDE, and 12 µg/kg dw for 4,4'-DDT. As a result, none of the detected concentrations for these compounds were above the SLs in 2015. If the older data were compared to the updated SLs, the number of stations above the SLs would have been greatly reduced.

3.3.6 Volatile Organic Compounds

The volatile organics trichloroethene (1,1,2-Trichloroethylene), tetrachloroethene (tetrachloroethylene), ethylbenzene, and total xylenes were analyzed from 2006 to 2008. A subset of volatile organic compound sample results in 2008 were "H" qualified due to sampling handling. There were no other QA/QC issues identified. None of the compounds were detected over the monitoring period. The detection limits were always below DMMP guidelines.

4.0 BENTHIC COMMUNITY RESULTS

This section presents a summary of benthic community data for monitoring years 2006–2010 and 2015. Benthic taxonomy samples were collected from all 16 stations in 2006 and 2007 and then reduced to eight stations starting in 2008 (see Section 1.3.2; Figure 2). Benthic data are summarized using a suite of benthic community indices and are compared to Puget Sound reference conditions. The indices described below were used to analyze benthic community structure and compare results between sampling stations and to appropriate reference data.

- Total Richness represents the average number of identified taxa per 0.1 square meter (m^2)(area sampled by a standard Van Veen grab sampler) found in three replicate samples at each station and is the sum of richness values for the following four major taxonomic classifications: Annelida, Crustacea, Mollusca, and miscellaneous taxa.
- Total Abundance is the average number of individual organisms per 0.1 m^2 found in three replicate samples at each station and is the sum of abundance values for Annelida, Crustacea, Mollusca, and miscellaneous taxa.
- Total Biomass is the average combined mass (weight) of all organisms in a 0.1 m^2 sample found in three replicate samples at each station (i.e., the sum of Annelida, Crustacea, Mollusca, and miscellaneous taxa biomass values). Biomass is expressed in grams per 0.1 square meter (g/0.1 m^2).
- Diversity Indices:
    - Shannon-Wiener Diversity Index is a measure of the relationship between taxa richness and abundance. This index is based on the total number of taxa in a sample, as well as abundance of a single taxon to determine diversity. An increasing Shannon-Wiener value indicates a benthic community that is becoming more diverse.
    - Pielou's Evenness Index is expressed as the observed diversity in a sample as a proportion of the maximum possible diversity[14]. An increasing evenness value, leading to a maximum possible value of 1.0, indicates increasingly greater diversity of the benthic community.
    - Swartz's Dominance Index (SDI) is defined as the minimum number of taxa comprising 75% of the total abundance in a given sample. An increasing SDI value indicates greater diversity as well.

The indices were calculated based on averages from the three replicate samples collected at each station. All of the indices as well as PSD and TOC data are summarized in Tables 8 through 13. Tables 14 through 19 present the dominant taxa based on SDI for each station by year. Discussion of each benthic index follows as well as comparison to benthic

[14] Benthic data for Pielou's evenness and Shannon-Wiener indexes were calculated in Log base 2.

reference stations. The benthic community data are presented in Appendix D. Discussions regarding statistical trends in benthic community data are included in Section 5.2.

As a point of reference for benthic community analysis, Stations DWMP-08 and -09 are closest to the Elliott West WWTS outfall and are the deepest stations (~-80 to -95 ft. MLLW), Stations DWMP-03, -14 and -15 are mid-water depth (~-40 to -70 ft. MLLW), and Stations DWMP-01, -05 and -10 are in the nearshore (~-10 to -35 ft. MLLW); DWMP-05 and -10 are closest to Denny Way Regulator Station Overflow outfall. Sediments were remediated (dredged and backfilled with clean material) in winter of 2007-2008 in an area that includes station DWMP-10 (Figure 2). Benthic taxonomy data were collected at these eight stations over entire monitoring period.

4.1 Richness

Total taxa richness ranged from 44 at DWMP-05 in 2008 to 105 at station DWMP-02 in 2007. Average total taxa richness over the monitoring period at all locations was 72 (10^{th} and 90^{th} percentiles of 58 and 90, respectively). In general, total richness was highest at more stations in 2007 and 2010 and lowest in 2008. When comparing richness across stations, the highest average total richness (98) was observed at DWMP-02 and DWMP-11 during the two years these locations were sampled, while the lowest richness (56) was observed at DWMP-12[15]. Taxa richness at DWMP-10 was similar between pre- and post-remediation conditions (50 in 2006 and 80 in 2007 compared to 76 in 2009, 54 in 2010, and 55 in 2015).

Across all years and stations sampled, Annelida were the major taxonomic group with the greatest percent richness[16]. Following Annelida, Crustacea tended to have the next highest percent richness at the nearshore stations (DWMP-01, DWMP-05, DWMP-10, and DWMP-13), while Mollusca tended to have the next highest percent richness at the offshore stations. These data are summarized in Figures 3 through 13.

4.2 Abundance

Total abundance ranged from ranged from 445 at DWMP-10 in 2006 to 1,951 at DWMP-05 in 2009. Average total abundance over the monitoring period at all locations was 945 (10th and 90th percentiles of 603 and 1,330, respectively). Abundance was variable across years and stations with some stations having up to three times greater abundance than other stations some years. Stations DWMP-05, -08 and -09 had the highest average abundance over the six monitoring years, while lowest average abundance was observed at DWMP-01 and -10. The lowest average total abundance across all stations (845) was observed in 2008, while the highest (1,064) was observed in 2015. In general, variability in abundance within station across years was not as great as across stations, with the exception of

[15] DWMP-02, -11 and -12 were sampled only in 2006 and 2007.

[16] Percent richness is based on the total richness for major taxonomic group (e.g., Annelida) divided by the total richness across all taxon present.

stations DWMP-05 (711 to 1,951) and -10 (445 to 1,090). At DWMP-10, average abundance was 534 for 2006/2007 (prior to remediation) and was 780 for 2009/2010/2015 (post remediation).

Major taxonomic group abundance, as a percent of total average abundance, was evaluated to facilitate comparisons between stations. Annelida had greater abundance (generally >50%) relative to other major taxa in shallower, nearshore stations (DWMP-01, -05-, -10, and -13), while Mollusca hand greater abundance (generally > 50%) at the deeper stations relative to other major taxa. The exception was at DWMP-14, which is slightly deeper (approximately -40 feet MMLW) than the nearshore stations, where the percent abundance of Annelida and Mollusca taxa were similar in all years but 2008 and 2015. In 2008, Annelida were more abundant whereas, in 2015, Mollusca were more abundant.

Over the years monitored, slight shifts in major taxa abundance were observed (Figures 4 through 28). Station DWMP-10 had more notable shifts compared to other stations. The shifts appear to be associated with remediation activities. Prior to remediation, Annelid abundance was more proportional to Mollusca abundance (48% Annelida and 30% Mollusca in 2006; 54% Annelida and 37% Mollusca in 2007). However, by 2015, the taxa abundance shifted to a greater proportion of Annelida (77%) and lower amount of Mollusca (15%). A shift from largely sandy substrate to sandy-gravel substrate following remediation may have contributed to the observed shifts in abundance, as well as benthic recolonization in the area post-remediation. Annelids are known to favor more sandy-gravelly nearshore sediments at this site.

4.3 Biomass

Total biomass ranged from 3.79 g/ 0.1 m^2 at DWMP-10 in 2006 to 37.92 g/ 0.1 m^2 at DWMP-08 in 2008. Average total biomass over the monitoring period at all locations was 13.13 g/0.1 m^2 (10th and 90th percentiles of 6.43 and 20.84 g/ 0.1 m^2, respectively). On an annual basis, the greatest biomass was observed at DWMP-08, except in 2006, where biomass at DWMP-06 was greatest. This was due to presence of sea cucumber in one DWMP-06 replicate sample. Of the major taxa, Mollusca biomass represented the majority of the total biomass across almost all stations and years. Average biomass across stations and years was relatively stable. The average yearly total biomass ranged from10.94 g/ 0.1 m^2 in 2010 to 15.57 g/0.1 m^2 in 2009.

Although always measured, total biomass is not a particularly useful comparative tool to assess benthic community assemblages, given confounding factors such as differences in shell or carapace size or the presence of one or more large individual taxa in a sample. For example the greatest biomass was observed at DWMP-06 in 2006 where the total biomass was skewed by the presence of a sea cucumber (*Molpadia intermedia*) in one of the replicate samples.

4.4 Shannon-Wiener Diversity Index

The Shannon-Wiener Diversity Index values ranged from 2.93 at DWMP-09 in 2010 to 6.17 at DWMP-15 in 2015. The average Shannon-Wiener Index across all years and stations was 4.16. The index values across stations, on average, was lowest in 2015 (3.94) and highest in 2009 (4.30).

The lowest Shannon-Wiener Diversity Index value was observed at DWMP-09 for all years monitored, except 2015, where it was lowest at DWMP-10. This diversity Index was not consistently higher at an individual station; however, the highest average Shannon-Wiener Diversity Index values were observed at DWMP-02 in 2006 and 2007, while DWMP-01 had the highest average index value when considering all 6 years monitored. The Shannon-Wiener Diversity Index values were similar at station DWMP-10 pre- and post-remediation with the exception of 2015, where one of the lowest values (2.95) for all stations and years was observed.

4.5 Pielou's Evenness Index

The Pielou's Evenness Index values across all years and stations ranged from 0.43 at DWMP-09 in 2015 to 0.83 at DWMP-05 in 2008. The average evenness index values across all years and stations monitored was 0.67. The lowest average evenness index value (0.59) was observed in 2015; in other monitoring years, the average values only ranged from 0.66 to 0.68.

Pielou's Evenness Index values were typically lowest at DWMP-09, while some of the highest values were observed at DWMP-10 and to a lesser extent DWMP-01 and -05. The evenness index values at DWMP-10 were similar between pre- and post-remediation activities, with the exception of 2015, when the lowest value for that station was observed.

4.6 Swartz's Dominance Index

Overall, the SDI was variable both across years and stations. The SDI values ranged from 3 at DWMP-09 in 2015 to 30 at DWMP-14 in 2010. The average SDI value across all years and stations monitored was 12 (with 10th and 90th percentiles of 5 and 20, respectively). Over the monitoring period, the lowest average SDI (4) was observed at DWMP-09, while this highest value was observed at DWMP-01 and DWMP-14 (18 for each). Further discussions of the dominant taxa are discussed below.

4.6.1 Dominant Taxa

Taxa in the SDI (those comprising 75% of the overall abundance) were reviewed for pollution-tolerant species. Pollution tolerance is based on an organism's sensitivity to toxicants, organic enrichment, and low oxygen conditions.

Parvilucina tenuisculpta or *Axinopsida serricata* (two Mollusca taxa) were commonly found to be two of the most abundant species across all stations over the monitoring period.

P. tenuisculpta is moderately pollution-tolerant, while *A. serricata* is slightly tolerant (Weston 1993 and Ecology 2017).[17] Both species were frequently observed in Elliott Bay by Ecology's April 2013 benthic community monitoring. Ecology (2016) found that *A. serricata* was present at 35 of 36 sites in 2013 and was the dominant species in 36% of the samples, while *P. tenuisculpta* occurred at 34 of 36 sites and was the dominant species in 25% of the samples. Ecology's June 2007 Elliott Bay sampling observed *A. serricata* at all 30 stations and it accounted for 15.3% of taxa across all stations. The next most abundant taxon observed was *P. tenuisculpta*, which was found at 26 of 30 sites, and comprised 8% of the taxa (Partridge et al. 2009).

Pollution tolerant species were frequently present (greater than 10% of the community) at DWMP-01 and DWMP-05 and typically included: *P. tenuisculpta, Mediomastus californiensis,* and *Prionospio steenstrupi.* These finding were similar to Ecology's 2007 Elliott Bay results, which showed the 10 shallow sampling stations (6 to 22 m) with sandy and silty-sand sediments were dominated by *P. tenuisculpta* and *P. steenstrupi* (Partridge et al. 2009). In addition, *Aphelochaeta glandaria complex, Lumbrineris californiensis, and Prionospio multibranchiata* were the most abundant species at DWMP-01 in 2008, 2009 and 2010, respectively.

Oligochaeta were one of the top two most abundant taxa groups at DWMP-05, -10 and -13 in 2006 and again at DWMP-05 and -13 in 2007[18]. However, in 2008 abundance of *Oligochaeta* at DWMP-05 began to decline with each subsequent sampling year such that *Oligochaeta* was no longer a part of the SDI by 2015. *Oligochaeta* are pollution-tolerant and are usually indicator of degraded habitat (Weisberg et al. 2008).

Capitella capitata complex was one of the most abundant taxa in 2006 and 2007 at DWMP-10, and in 2008 at DWMP-08. *Capitella capitata* complex was part of the SDI at DWMP-08 in all years except 2015 and it was no longer part of the SDI at DWMP-10 following site remediation in 2008. *C. capitata* is very pollution-tolerant and is used as an indicator of pollution impacts or organic enrichment in marine sediment. It is resistant to moderate hypoxia and highly tolerant to copper, hydrocarbons, and organic input (Weston 1993, Lowe and Thompson 1997, and Weisberg et al. 2007; List compiled by Diaz and Rosenberg 1995; Hiscock et al. 2005: all cited by Ecology 2017).

The SDI values at DWMP-10 prior to remediation were 12 (2006) and 18 (2007) and the SDI species composition was dominated by pollutant tolerant taxa. Following remediation, the SDI indicated a diverse community with index value of 20 in 2009. In addition, the community was not dominated by pollutant tolerant taxa. While the SDI was similar (19) in 2010, shifts in the most abundant taxa occurred; for example, *P. steenstrupi* and *P. tenuisculpta*, both pollution tolerant taxa, now represented the most abundant taxa at 15.9% and 10.3%, respectively. By 2015, this station had further changes with a SDI value declining to 5 and the most abundant taxa being pollution-tolerant species

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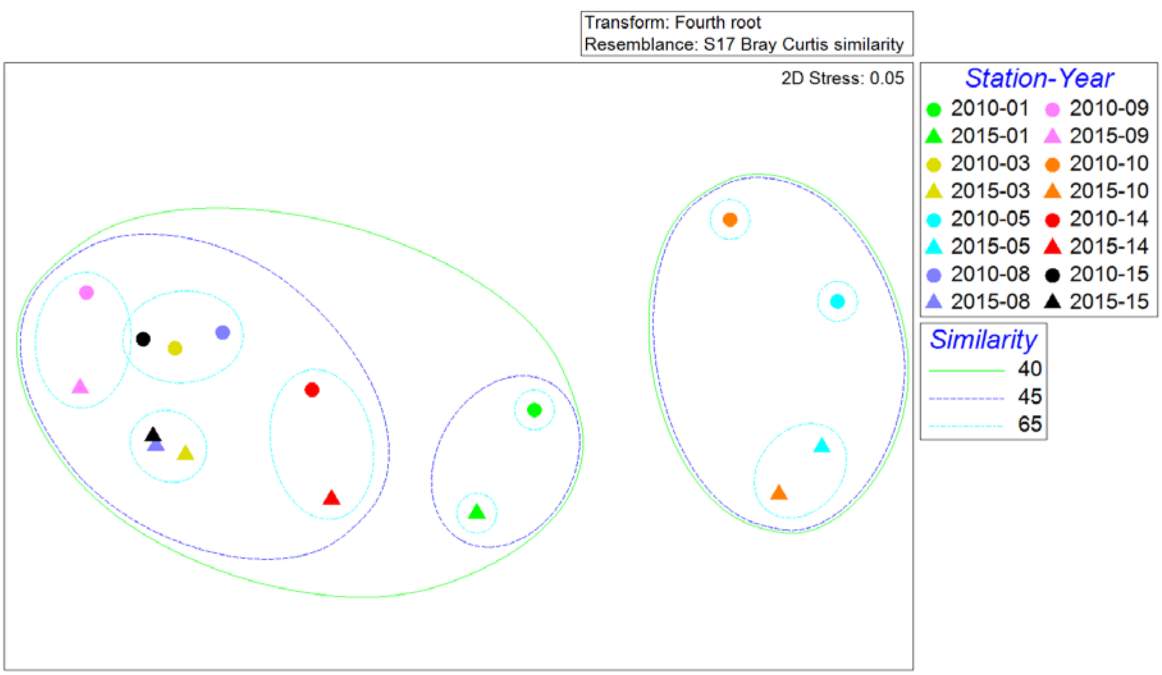
[17] Information on pollution-tolerant species from PSEMP's database (Ecology 2017).
[18] Benthic community sampling was discontinued at DWMP-13 after 2007.

(e.g., *P. steenstrupi* comprising the most at 54.3% of the abundance). The available chemistry data do not suggest a toxicant is the cause at this location and thus a different stressor(s) is believed to be the cause of the large decrease in the SDI value.

4.6.2 Taxon changes between 2010 and 2015

Non-metric multidimensional scaling (MDS) analysis was conducted on the 2010 and 2015 benthic community data to evaluate similarities among sites using PRIMER v6software. This analysis provides additional species composition analysis to evaluate if observed benthic community changes between 2010 and 2015 were related to conditions at a specific station (or set of stations) or interannual variability.

The MDS analysis distributes sites based on their rank-ordered similarity scores, and indicates that the stations are grouping together largely by depth (Plot 1). Depth is one of a number of physical factors that can influence benthic community composition. The MDS results show stations DWMP-03, -08 and -15 grouped together with the most similarity (65%). Stations DWMP-08 and DWMP-09 are also grouped closely with stations DWMP-03, DWMP-14, and DWMP-15 (45%), which are further away from potential outfall discharge influences, but similar in depth and grain size. The nearshore stations, DWMP-05 and -10, are grouped together, while depth at DWMP-01 is intermediate relative to the deeper and nearshore stations.



Plot 1. MDS plots by site averages (Circles are 2010 data, triangles are 2015 data).

The analysis demonstrates a similar shift in community structure at all stations between 2010 and 2015, indicating that the community as a whole was likely changing due to natural interannual differences and common environmental factors, rather than a site specific factor. Further review of taxonomy data was done to evaluate which species were

contributing the most to variability between 2010 and 2015. The species listed below had the greatest contribution to differences between stations, and therefore the greatest influence on station placement on the MDS plot:

- *Parvilucina tenuisculpta*
- *Axinopsida serricata*
- *Rochefortia tumida*
- *Mediomastus californiensis*
- *Scoletoma luti*
- *Prionospio steenstrupi*
- *Euphilomedes carcharodonta*
- *Macoma carlottensis*
- *Levinsenia gracilis*
- *Alvania compact*

The Puget Sound Ecosystem Monitoring Program Marine Waters Workgroup noted that 2015, like 2014, experienced notable departures from average conditions. A major feature was much warmer than average water temperatures; other conditions of note included salinity changes and dissolved oxygen deficits throughout Puget Sound (PSEMP Marine Waters Workgroup 2016). These conditions may have influenced benthic community species composition changes between 2010 and 2015. Benthic community data from the next monitoring event in 2020 will help ascertain whether these changes are an anomaly caused by unusual marine conditions or part of a longer term trend.

4.7 Benthic Reference Comparisons

Comparison of benthic community data to reference locations provides an additional level of analysis. Sediment sites sampled for benthic community taxonomy analysis under Ecology's Puget Sound Ambient Monitoring Program were reviewed to identify possible reference sites for the Denny Way monitoring program. Sites needed to have similar physical characteristics (i.e., water depth, PSD, and TOC), similar years of data collection, available sediment quality data, and benthic sample replicate samples.[19] A comparable reference station(s) for the Denny Way dataset was not identified. Because of this, Ecology's Puget Sound Reference Value Ranges (RVRs)[20] (Ecology 2003), which serve as programmatic reference data, were selected to further assess the benthic community health at Denny Way area. Programmatic references are a reasonable substitution for site-specific reference comparisons when no site-specific reference station can be identified (SEA 1996). Comparison to RVRs also complete one of the data evaluation methods covered in Section 1.3.3 (i.e., develop a methodology to compare data from the Denny CSO area to control areas).

[19] Replicate samples provide a measure of variability in the benthic community at a location. Denny Way project collects three replicates per station. The Puget Sound Ambient Monitoring Program collects one sample per station.
[20] The benthic community data for which RVRs are based only include sample data prior to 1999.

4.7.1 Reference Comparison Methods

The RVRs provide reference thresholds (10th and 90th percentiles) for different benthic community indices that serve as characteristics for Puget Sound reference area benthic community data. The lower reference threshold (based on 10th percentile) represents the value below which test station community indices are likely to be statistically and significantly lower than reference area, and the upper reference threshold (90th percentile) is that value above which test station community indices are statistically higher than reference area (Ecology 2003). Benthic community values below the lower reference threshold are considered likely to be significantly lower than reference area, and therefore an impacted site. There is no consensus that values greater than the upper threshold represents a potential impact, with the exception of Polychaeta abundance (Ecology 2003). This is because high Polychaeta abundance can be associated with pollutant tolerant species.

The benthic community indices from the RVRs correspond to habitat categorized by % fines and apply to areas less than 150 feet water depth (Table 20). The habitat categories for which the Denny Way samples correspond to are shown in Table 21; the % fines of Denny Way samples are presented in Tables 8 through 13. Indices results from 8 stations sampled for all monitoring years were compared to the RVRs. Comparison of Denny Way benthic data to RVRs for all stations sampled, including the additional stations sampled in 2006/2007, are presented in Tables 8 through 13.

Polychaeta were not reported separately from Annelida in Denny Way dataset by the taxonomist. Therefore, Polychaeta abundance and richness were calculated by subtracting the *Oligochaeta* data from rest of the Annelida data.[21] The calculated Polychaeta abundance and richness values (Tables 8 through 13) were compared to corresponding Ecology's Polychaeta RVRs. The Amphipoda RVRs were not be used for this comparison because the Denny Way benthic data were reported under the Crustacea group, and not Amphipoda. All other Denny Way benthic community indices could be compared to RVRs.

Shannon-Wiener Diversity index values from Ecology's RVRs are calculated in log base 10 (Striplin Pers. Comm. 2017); therefore, King County's results were converted to log base 10 to allow for comparison[22] (see Tables 8 through 13).

The Polychaeta abundance and the SDI RVRs were the primary means for determining potential Denny Way area benthic community impacts as compared to reference areas. All the other indices were used in combination to evaluate impacts. Results of the RVR evaluation are summarized below.

[21] Discussions with project's taxonomist indicated this method would result in appropriate estimation of Polychaeta abundance and richness (A. Fukuyama Pers. Comm. 2017).
[22] The Shannon-Wiener Diversity index for Denny Way dataset was originally calculated in log base 2.

4.7.2 Reference Comparison Findings

Polychaeta abundance in the Denny Way dataset was greater than the corresponding RVR 90th percentile for at least one year at six of the eight stations as summarized below:

- DWMP-01 greater from 2007 to 2010
- DWMP-05 greater for all years sampled except 2008
- DWMP-08 greater in 2015
- DWMP-09 greater in 2010
- DWMP-10 greater in 2009 and 2015
- DWMP-14 greater for 2007 through 2009

The instances when Polychaeta abundance was greater than RVR 90th percentile indicates the benthic community at these locations may be adversely impacted when compared to reference areas.

The opposite interpretation occurs for the SDI; when stations are below the 10th percentile SDI RVR, it indicates the site data are below reference area conditions. DWMP-01 and DWMP-05 were consistently above the SDI RVR 10th percentile for all years sampled indicating similar conditions to reference areas. DWMP-03 was below the 10th percentile in 2006, but its SDI increased with each subsequent year so that it fell within SDI RVR 10th and 90th percentiles or was greater than the RVR 90th percentile thereafter. DWMP-08 was below the SDI RVR 10th percentile for years 2006 and 2007, but then fell within the RVRs in subsequent years. DWMP-09 was below the SDI RVR 10th percentile in years 2006, 2007, 2008, and 2015, but was within the RVRs in 2009 and 2010. DWMP-10 was below the SDI RVR 10th percentile in 2015 and within SDI RVRs all previous years. DWMP-14 and DWMP-15 were above the SDI RVR 10th percentile for all years sampled.

Total richness, Crustacea richness, total abundance, and Mollusca abundance values at all locations were greater than the respective RVR 10th percentile values. For these indices, values often fell within the RVR 10th and 90th percentiles, which indicate that benthic community condition are not measurably different from the reference areas. Indices at some locations were greater than the RVR 90th percentiles indicating that those benthic conditions were statistically greater than reference areas. Mollusca abundance was greater than the RVR 90th percentile for most years at all stations except for DWMP-01 and -10, which were within the RVRs most years. Results for total richness, Crustacea richness, and total abundance had a mix of being within RVR 10th and 90th percentiles and being above the 90th percentile over the monitoring years.

Mollusca richness values were only below the RVR 10th percentile at DWMP-05 in 2008. Polychaeta richness values were only below the RVR 10th percentile at DWMP-10 in 2006.

Crustacea abundance values all stations were above the RVR 10th percentile except DWMP-10 in 2009, which is one year post-remediation of this location. The benthic community underwent a recolonization period post dredging and backfilling. Crustacea abundance

increased to levels within RVR 10th and 90th percentiles in subsequent sampling years (2010 and 2015).

Pielou's Evenness index values at DWMP-01, DWMP-14, and DWMP-15 were within the RVRs for all years sampled. Evenness values were below the RVR 10th percentile at DWMP-03 in 2006, 2008, and 2009 but were above the 10th percentile at DWMP-05 for all years sampled except for 2015. Evenness values were below the 10th percentile at DWMP-08 in 2009 and 2015, at DWMP-09 in all years sampled, and at DWMP-10 in 2015.

Shannon-Wiener Diversity index values for DWMP-01, DWMP-03, DWMP-14, and DWMP-15 over the monitoring period were within RVR 10th and 90th percentiles. These index values were also within these RVRs at DWMP-05 and DWMP-10 for all years except for 2015, when the index values were just below the RVR 10th percentile. The diversity index value at DWMP-08 was within the RVRs for all years except for 2015, when it was below the 10th percentile. Finally, the diversity index value at DWMP-09 was below the 10th percentile for all years sampled except for 2015, when it was within the RVRs.

Overall, the benthic community data indicated that no station consistently over the years was impacted when compared to Ecology's RVRs for multiple indices. However, there are some years and locations for which data do suggest an impact to the benthic community as compared to reference areas, most notably at DWMP-01, -05, and -09. In addition, 2015 data tended to have more different index values adversely compare to the RVRs (suggesting benthic community conditions are lower than reference areas). However, the RVRs do not include recent benthic data (data are prior to 1999), to know if the differences observed in Denny Way dataset and Ecology's RVRs are due to stressors such as increased temperature recorded in 2014 and 2015 in Puget Sound (PSEMP Marine Waters Workgroup 2016).

5.0 DISCUSSION

This section summarizes comparisons of sediment chemistry to SMS, as well as temporal trend analyses of both chemistry and benthic community indices. This discussion pertains to the objectives of the BO discussed in Section 1.3.3. Statistical analyses to evaluate potential temporal trends were conducted using R statistical program[23]. Results of these analyses are presented below.

5.1 Chemistry

Chemicals of potential concern and their spatial extent for the Denny Way site are identified in this section; these are two of the BO monitoring objectives. Key contaminants identified based on SMS comparisons are examined for changes over time with a focus on changes associated with the two outfalls. The time trends are used to address the likelihood that changes in sediment chemistry concentrations are related to the outfall discharges resulting from the CSO control project.

5.1.1 SMS Summary

Chemicals of potential concern are identified based on comparisons of sediment chemistry to SMS numeric marine criteria. Over the monitoring period, concentrations of total PCBs, mercury, BEHP and BBP were most frequently above their respective marine sediment standard (i.e., SQS). Concentrations of these contaminants over both sample depth strata at multiple stations were above the SQS. In some instances, mercury and BEHP concentrations were also above the CSL. Concentrations of total HPAHs and a number of individual PAHs were frequently above the SQS (and often CSL) at DWMP-01 over the monitoring period (includes both sample depth strata). Three to 8 individual PAHs were above their respective SQS once during the monitoring period at the following stations: DWMP -02, -04, -05, -08 and -10. Concentrations of chromium at DWMP-05 in 2007 and silver at DWMP-08 in 2010 (in the top 2 cm but not the top 10 cm) were above their respective CSL. Concentrations of phenol at DWMP-02 in 2008 and 2,4-dimethylphenol at DWMP-01 in 2015 were also above their respective SQS values. Concentrations of DDT and its derivatives (4,4'-DDD, 4,4'-DDE) were greater than DMMP SL guidelines at some stations in some years; there are no SMS numeric criteria for these compounds.

Overall, the data show that the 0-2 cm and 0-10 cm samples have similar SMS comparison outcomes but 0-10 cm samples typically have more sample concentrations greater than SQS. In addition, annual variability or spatial heterogeneity across stations shows more variation in SMS comparison outcomes than the two sample depth strata comparisons.

[23] The "lme4" (Bates et al. 2015) and "lmerTest" packages were used to run linear mixed models with fixed effects for time, and in some cases proximity of stations relative to WWTS outfall or Regulator Station outfall. Stations were random effects. P-values were calculated by the "lmerTest" package using Satterthwaite approximation for degrees of freedom.

Spatial extent of mercury, total PCBs, BEHP, and BBP concentrations above SQS or CSL are shown in Figures 29 through 32. These figures also give a visual depiction of the relative concentrations over the monitoring period for each of these key contaminants. With the exception of four stations (DWMP-04, 05, -06, and -13), mercury concentrations above the SQS or CSL were observed throughout the monitoring area; this occurred most often at Stations DWMP-01, -03, -08, -09 and -14. PCB concentrations above the SQS were observed throughout the monitoring area except at DWMP-05 and -06. Stations most often with PCB concentrations above the SQS show a similar pattern to mercury (Stations DWMP-01, -03, -08, -09, -14, and -15). However, unlike mercury, PCB concentrations were never greater than CSL. BEHP and BBP concentrations were variable both spatially and temporally. BEHP concentrations were never above the SQS or CSL at Stations DWMP-02, -04, -07, and -11; while BBP concentrations were never above the SQS or CSL at DWMP-06, -09, -13 and -16.

A review of sediment chemistry data prior to construction of the new outfalls and the Elliott West WWTS becoming operational indicates concentrations of mercury, total PCBs, BEHP and BBP at a number of stations, as well as PAHs at DWMP-01 being above the SQS and sometimes the CSL (King County 2005). The percent of samples with concentrations above SQS prior to and after operation of the WWTS outfall and Denny Way Regulator Station new outfall were also reviewed as a measure of change (Table 22). The comparison included combining data from all 16 stations with different depth strata.[24]

The percent of sample concentrations above the SQS for mercury (~50%) and PCBs (~60%) were reasonably consistent during the monitoring period although there was some annual fluctuations. The percent of BEHP and BBP concentrations above the SQS declined over the monitoring period. The percent of total HPAH concentrations above the SQS was low and somewhat variable over the monitoring period. Total HPAH concentrations were above the SQS at DWMP-01 before and after use of the new outfalls. Concentrations of a few individual HPAH (benzo(a)anthracene and pyrene)and LPAH (anthracene and phenanthrene) compounds were sometimes above the SQS post-operation of outfalls but not pre-operation.

Overall, the data indicate there were sediment contamination concerns prior to construction and operation of the outfalls and operation of Elliott West WWTS with limited change with respect to SMS since operations began for some but not all chemicals of concern. The sediment contamination appears to be related to historic contamination rather than inputs from the new outfall with treated effluent or new CSO outfall. Further analysis of changes in sediment chemistry over time is explored in the next section.

[24] Samples prior to operation (2001 and 2003) and just after (2006 and 2007) were only collected from 0-2 cm depth strata while monitoring years 2008-2010 contained a mix of 0-2 cm and 0-10 cm depth strata and 2015 were all 0-10 cm samples.

5.1.2 Time Trend Analysis

Sediment chemistry data from the Denny Way monitoring program, as well as additional sediment data from 2001, 2003, and 2004[25] were further evaluated to assist in identifying significant changes overtime pre- and post-construction and operation of the outfalls. Trend analysis was conducted using linear mixed models with the R Statistical Program. The analysis focused on key contaminants: mercury, total PCBs, BEHP and BBP. To allow for comparability between pre- and post-operation of the outfalls, only chemistry results from the top 2 cm were included in the time trends analysis[26]. Sampling stations were grouped based on geographic scales (distance and orientation from the outfalls, and bathymetry) as described in more detail below. Plots were generated using the "car" package in R, with a regression line automatically generated by the "scatterplot" function from the results for each station grouping.

Results of these analyses, as described in the four subsections below, do not indicate increasing contaminant concentrations from the period prior to and following operation of both outfalls. As such, they suggest that outfall discharges are not causing sediment conditions to degrade further since their operation began.

5.1.2.1 Stations near Elliott West WWTS Outfall by Distance

The six stations closest to the Elliott West WWTS outfall were categorized into two groups based on distance from the outfall, either "Close" or "Far."

- Close – Stations DWMP-06, -08 and -11 are closest to the WWTS outfall at mean distance of 188 feet
- Far – Stations DWMP--07, -09, and -12 are furthest from WWTS outfall with mean distance of 352 feet

King County (2011) concluded that deposition from CSO discharges only contributed measurable sediment chemical concentrations within 100m (approximately 328 feet) of CSO outfalls. These "Close" and "Far" designations allowed an evaluation of whether the WWTS outfall discharges could be causing an increase in contaminant concentrations relative to other monitoring stations at the site.

Sediment chemistry data collected from the top 0–2 cm at these stations in 2001, 2003, 2004, and from 2006 through 2010 were used in the time trend analysis. The 2015 data were not included because samples were collected from the 0–10 cm depth stratum and thus may not be comparable or would add a confounding factor.

Chart 1 summaries the linear mixed model results for the key contaminants and conventional parameters (% fines, % sand, and TOC). The conventional parameters were evaluated

[25] 2001, 2003, and 2004 data are documented in the Pre-Construction Sediment Characterization Study (King County 2001) and Denny Way Post-Construction Sediment Characterization Study (King County 2005).
[26] Samples were not collected from the top 10 cm until later in the monitoring program.

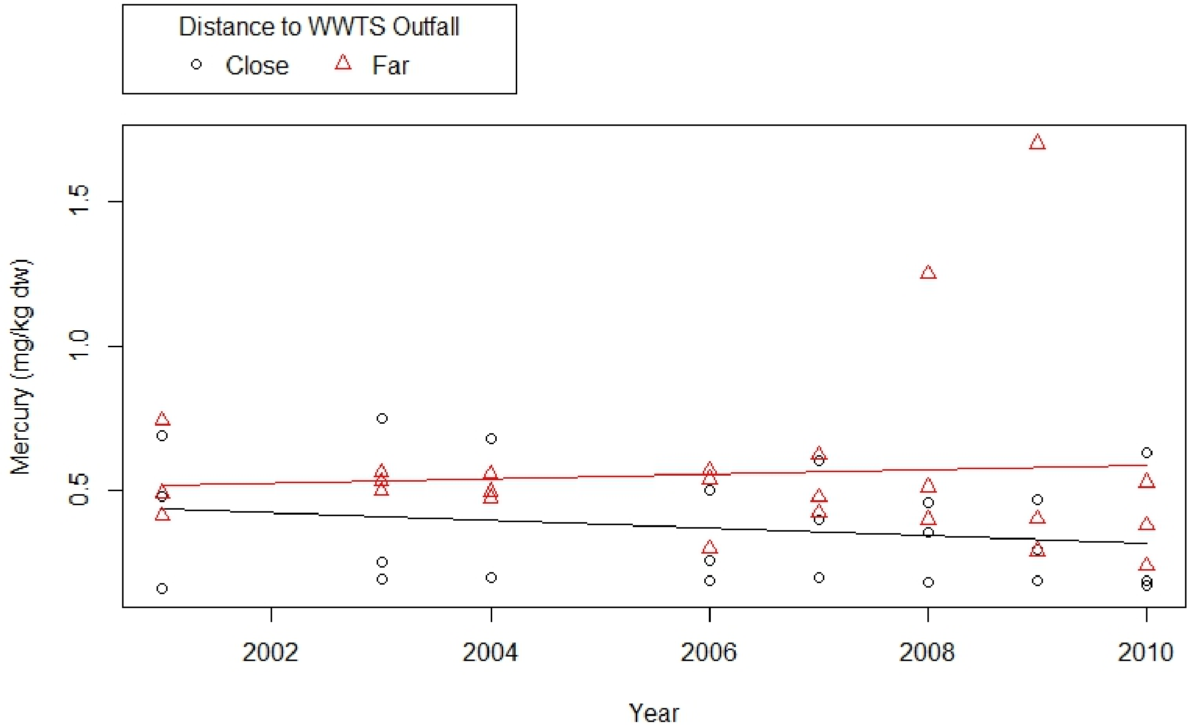
because sediment contaminant concentrations can be influenced by the amount of TOC, sand, or fines present. For each parameter, the summary below notes if there was a significant change over time and if that change was an increase or decrease. In addition, the analysis indicates if there was a significant difference in the rate that concentrations were changing over time between the "Close" and "Far" station groups. Data were evaluated in two ways: all six stations in aggregate and interactions between the Close and Far groups.

Chart 1. Results of linear mixed models for key contaminants based on station distance to WWTS outfall.

Analyte	Change over time (6 aggregate stations)	Significant Difference in Rate of Change between Groups[1]	Significant Change at WWTS Outfall Stations	
			Close	Far
Mercury	No	No	No	No
PCBs	Yes*** - Decrease	No	Yes**- Decrease	Yes***- Decrease
BBP	No	No	No	No
BEHP	No	No	No	No
% Fines	No	No	No	No
TOC	No	No	No	No
% Sand	No	No	No	No

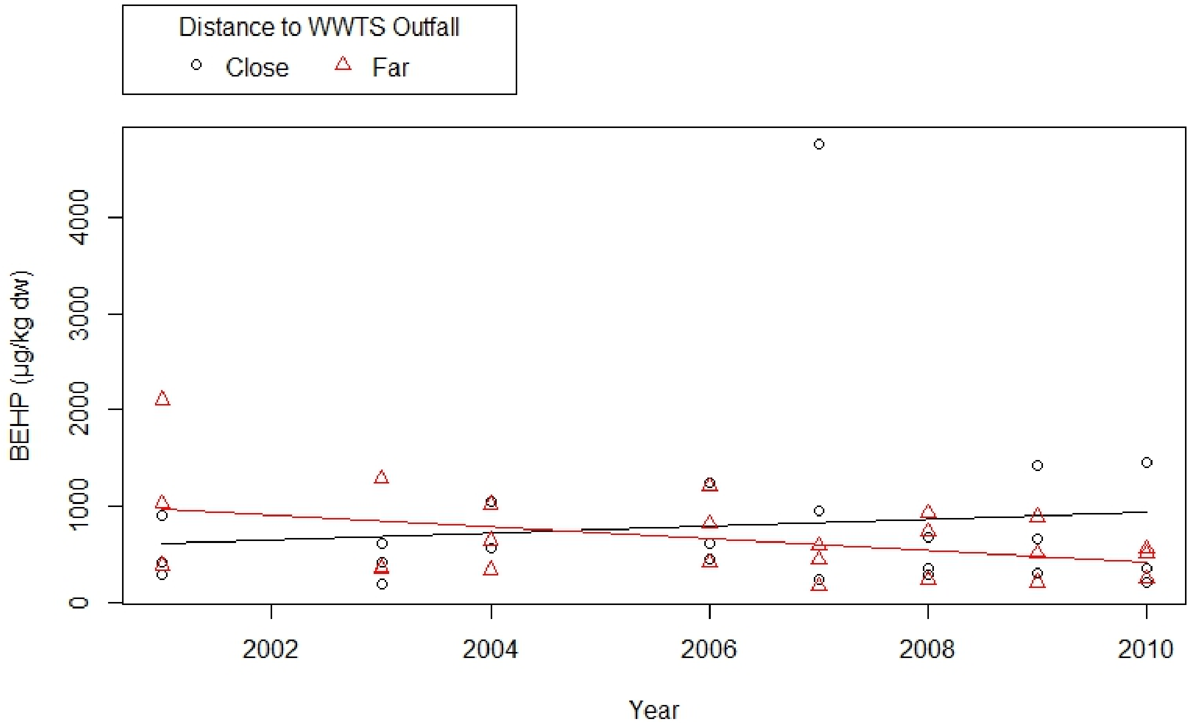
* = Significance at p< 0.05
** = Significance at p<0.01
*** = Significance at p<0.001
1 = "Close" group includes DWMP-06, -08 and -11, "Far" group includes DWMP-07, -09, and -12.

Mercury concentrations (based on the 6 aggregate stations) did not significantly change over time and the rate of change between the two station groupings (Far and Close) was not significantly different (Plot 2). The stations near the outfall were not significantly changing over time.



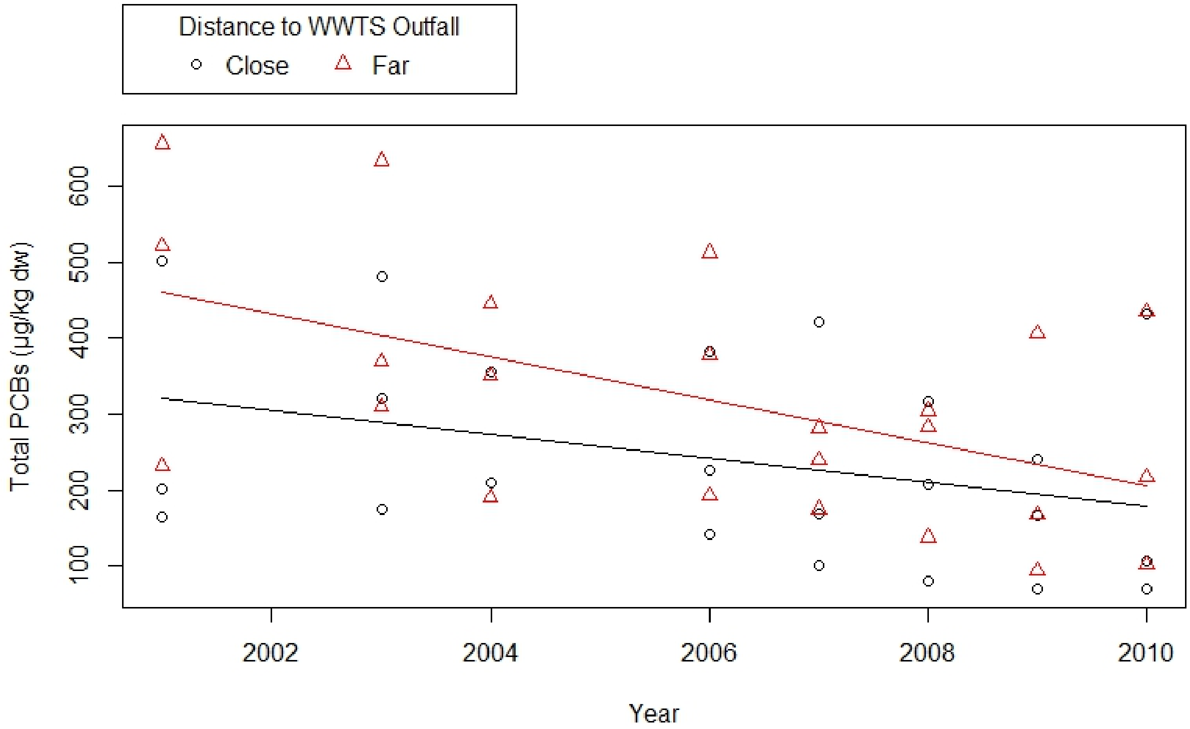
Plot 2. Mercury concentrations (mg/kg dw; 0 – 2 cm) over time based on proximity to the WWTS outfall.

No statistical trends in BEHP or BBP concentrations (both OC-normalized and dry weight) over time were observed (Plot 3 illustrates BEHP data). The range of BEHP and BBP concentrations over time was similar at stations close to the WWTS outfall and those further away.



Plot 3. BEHP concentrations (µg/kg dw; 0 – 2 cm) over time based on proximity to the WWTS outfall.

Dry weight PCB concentrations across all sediment stations evaluated in aggregate decreased significantly over time (slope: -21.7; p<0.001). Concentrations at stations further from the outfall demonstrated a steeper decline (slope: -28.3, p<0.001) than the Close stations (slope: -15.0, p<0.01) (Plot 4). The same analysis using OC-normalized PCB concentration resulted in a similar trend.

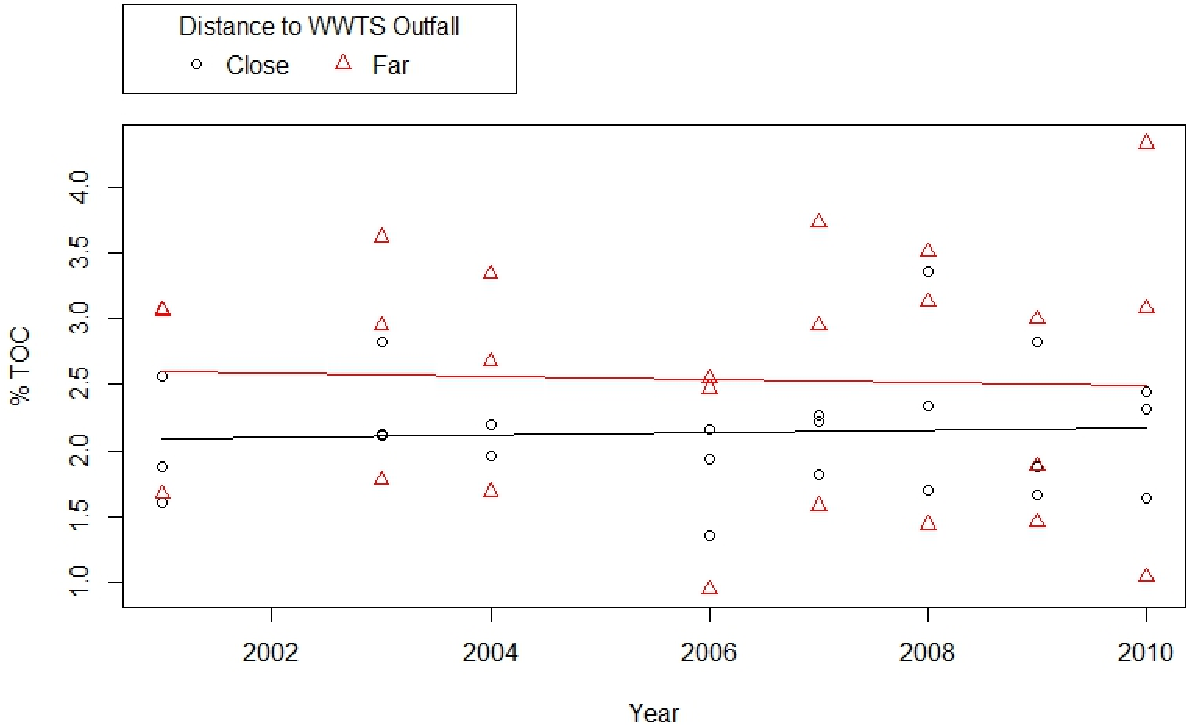


Plot 4. PCB concentrations (µg/kg dw; 0 – 2 cm) over time based on proximity to the WWTS outfall.

Results of the trends analysis for TOC, % sand, and % fines for all stations in aggregate, as well as rate of change between station groups (Close and Far), indicated there was no significant difference over time or between station groups. Therefore, physical parameters for stations near the outfall were not significantly changing over time (Plot 5 illustrates TOC data).

Mercury, PCB, BBP, and BEHP concentrations were also compared to TOC (except mercury), % fines and % sand to identify any significant relationships between chemical concentrations and these parameters. PCB concentrations across the six stations evaluated had significant positive relationship with % fines and TOC; however, BEHP and BBP concentrations were not significantly associated with these conventional parameters. PCB concentrations had a significant negative relationship with sand. While statistically significant, all of these associations were weak with R^2 values ranging from 0.24 to 0.36. Mercury also demonstrated a significant positive relationship with % fines ($R^2 = 0.21$) and significant negative relationship with % sand ($R^2 = 0.25$); although both were weak.

The analyses of TOC, particle size, and contaminant interactions indicate the decrease in PCB concentrations is largely related to reductions in sediment chemistry and are not attributed solely to changing TOC, % fines, or % sand. These factors did not change significantly ($p > 0.05$), while a significant decrease in dry weight PCB concentrations at all stations in aggregate was observed.



Plot 5. **Percent TOC (0 – 2 cm) over time based on proximity to the WWTS outfall.**

5.1.2.2 Stations near Elliot West WWTS Outfall by North-South Orientation

The six stations closest to the Elliott West WWTS outfall were categorized into three groups based on orientation from the outfall, either directly "Offshore," "North" or "South." These groupings allow another assessment of whether discharges from outfall maybe causing an increase in contaminant concentrations compared to other stations at the site. The station designations for each group were:

- Offshore – Stations DWMP-08 and -09, just offshore and closest to the WWTS outfall (mean distance of 224 feet)
- North – Stations DWMP-11 and -12, just north of the WWTS outfall (mean distance of 317 feet)
- South – Stations DWMP-06 and -07, just south of the WWTS outfall (mean distance of 270 feet)

As previously noted, data for samples collected from 0–2 cm depth stratum in 2001, 2003, 2004, and 2006 through 2010 were used for this analysis.

Chart 2 summarizes results of the linear mixed model analysis for the key contaminants and conventional parameters (% fines, % sand, and TOC) and indicates if the change was a significant increase or decrease over time. In addition, the analysis indicates if there was a

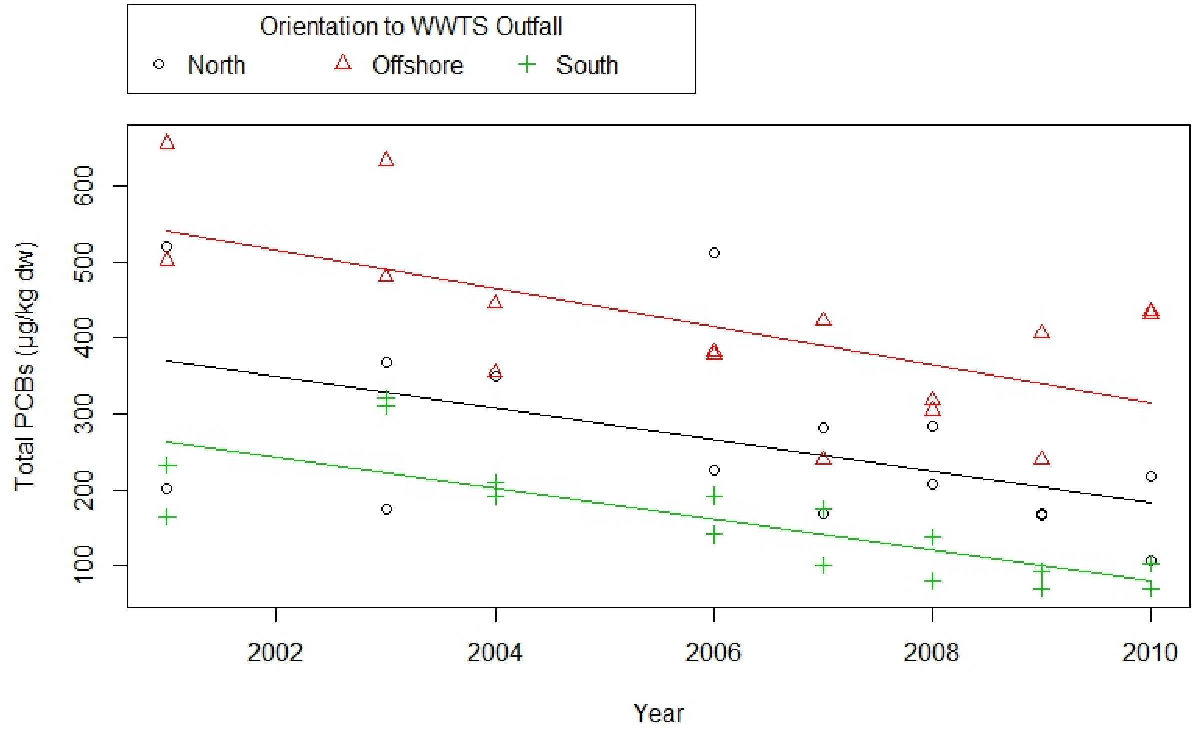
significant difference in the rate of concentration change over time between the Offshore, North, and South station groups. Similar to the previous analysis, data were evaluated in two ways: all six stations in aggregate and through interactions between the three station groups (Offshore, North, and South).

Chart 2. Results of linear mixed models for key contaminants based on station orientation to WWTS outfall.

Analyte	Change over time (6 aggregate stations)	Significant Difference in Rate of Change between Groups[1]	Significant Change at WWTS Outfall Stations		
			Offshore	North	South
Mercury	No	No	No	No	No
PCBs	Yes***-Decrease	No	Yes***-Decrease	Yes**-Decrease	Yes**-Decrease
BBP	No	No	No	No	No
BEHP	No	No	No	No	No
% Fines	No	Yes**	No	No	Yes**-Decrease
TOC	No	No	No	No	No
% Sand	No	Yes**	Yes* - Increase	Yes* - Decrease	No

* = Significance at p< 0.05
** = Significance at p<0.01
*** = Significance at p<0.001
1 = "Offshore" group includes DWMP-08 and -09, "South" group includes DWMP-06, -07; "North" group includes DWMP-11 and -12.

Significant trends in mercury, BBP, and BEHP concentrations were not observed over the time period evaluated. Dry weight PCB concentrations significantly decreased (slope: -21.7; p<0.001) across all stations evaluated in aggregate (Plot 6), at each station group, and the rate of decrease between station groupings was similar. Significant decreases in OC-normalized PCB concentrations across each station grouping as well as all stations in aggregate was also observed.

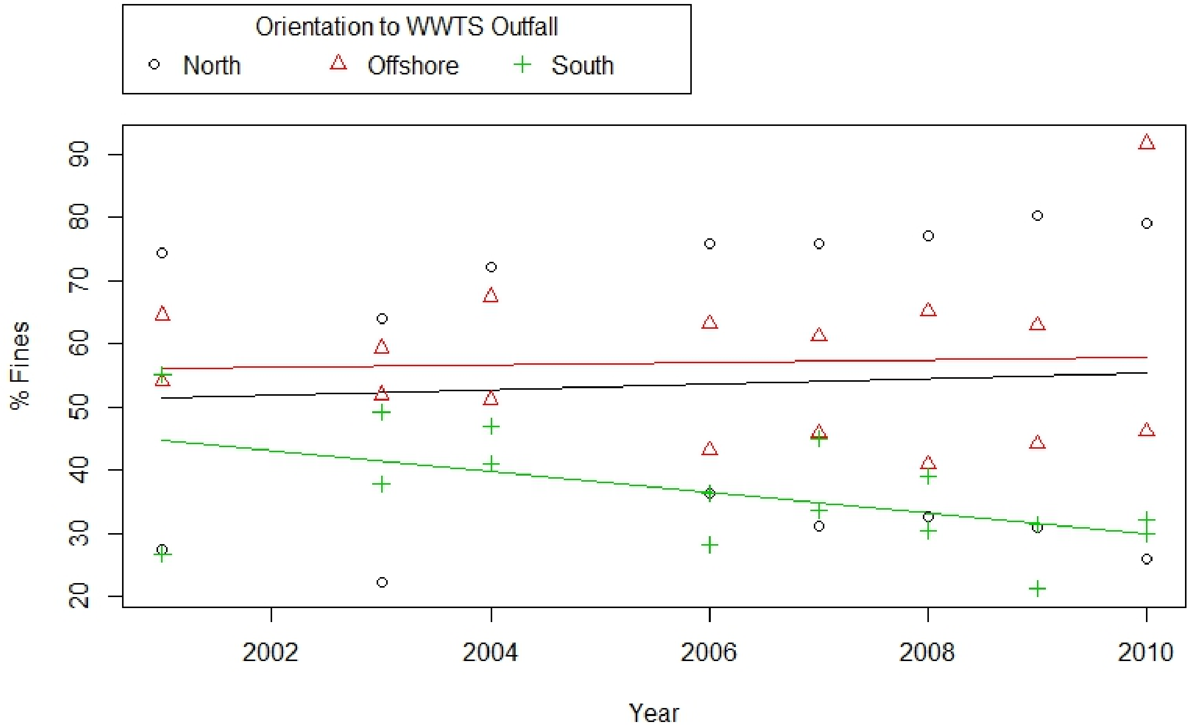


Plot 6. PCB concentrations (µg/kg dw; 0 – 2 cm) over time based on orientation to the WWTS outfall.

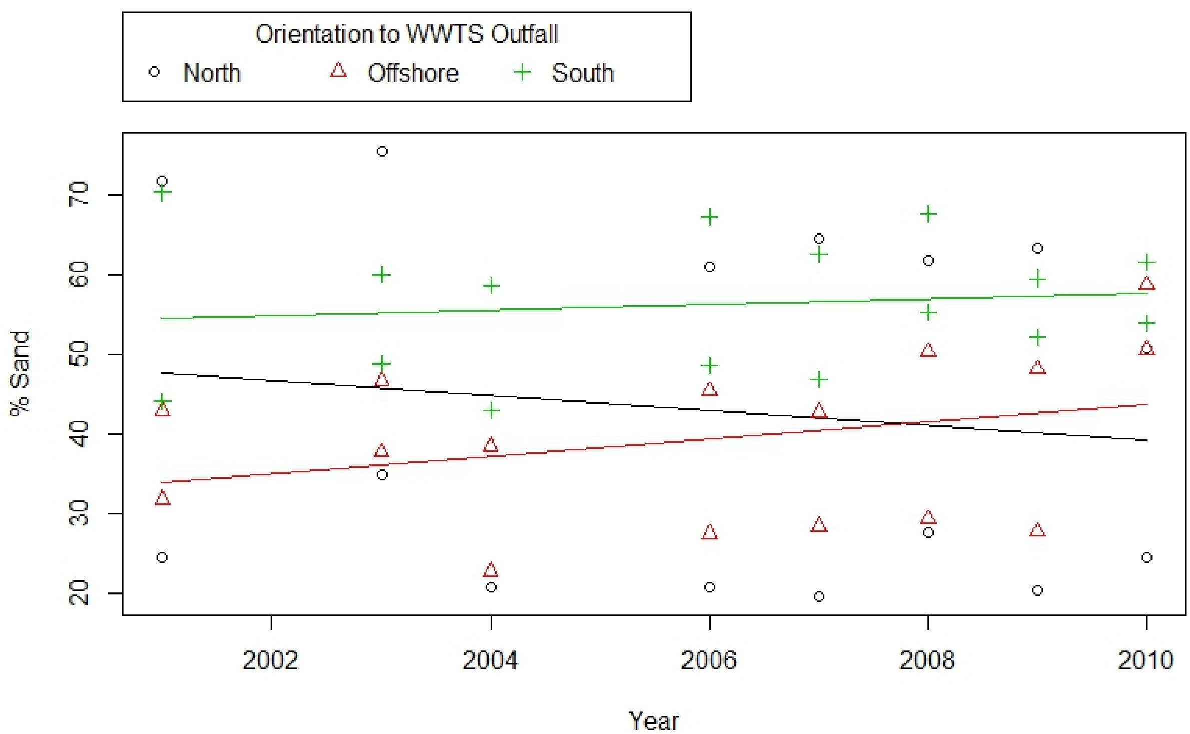
No significant changes in TOC over time were observed. Percent fines significantly decreased (slope: -1.64; p<0.01) over the time period evaluated at the South stations, but not the North and Offshore station groups (Plot 7). Considering the TOC and % fines trend results, the decrease in PCB concentrations at these stations may have been influenced by the change in % fines. However, the association between PCBs and % fines at the south stations was weak ($R^2 = 0.40$) indicating any change in % fines would only partially influence PCB concentrations.

The observed changes in % sand differed by station group. The north stations experienced a significant decrease in % sand (slope: -1.27; p<0.05), while the offshore stations demonstrated a significant increase (slope: 1.07, p<0.05) (Plot 8). The change in % sand is not expected to influence contaminant concentrations due to the weak ($R^2 = 0.27$) association between PCBs and % sand at these stations.

As previously discussed, of the chemical parameters evaluated, only PCBs showed significant relationships with TOC, % fines and % sand, although the associations were weak (R^2 of 0.24 - 0.36). Therefore, observed decreases in PCB concentrations at the different station groupings would only partially be explained by changes in TOC, % fines, or % sand.



Plot 7. Percent Fines (0 – 2 cm) over time based on orientation to the WWTS outfall.



Plot 8. Percent Sand (0 – 2 cm) over time based on orientation to the WWTS outfall.

5.1.2.3 Stations near Denny Way Regulator Station Outfall

Time trend analysis was also performed on station groupings that allow analysis of stations near and north and south of the Denny Way Regulator Station outfall; this analysis included data from 10 stations. Only data collected in 2001, 2003, 2006, and 2007 from the top 0-2 cm were used in this analysis so that the data collected prior to and after operation of the new Denny Way Regulator Station outfall were comparable. This is the period for which all 10 stations had the same sampling depth stratum data available. Stations were classified into three categories based on orientation to the shoreline and the Denny Way Regulator Station outfall:

- Nearshore – Stations DWMP-01, -05, -10 and -13 located along the shoreline and closest to the Regulator Station outfall (mean distance of 376 feet)
- North – Stations DWMP-14, -15, and -16 located north of the Regulator Station outfall (mean distance of 689 feet)
- South – Stations DWMP-02, -03 and -04 located south of the Regulator Station outfall (mean distance of 586 feet).

DWMP-10 was included in the time trends analysis because the time period only includes data collected prior to the remediation in 2008 that includes the area with Station DWMP-10.

Chart 3 provides a summary of the linear mixed model results for the key contaminants and conventional parameters (% fines, % sand, and TOC) and indicates significant changes over time as well as differences in the rate of change between the Nearshore, North, and South station groups. Data were evaluated in two ways: the aggregate of all 10 stations, as well as interactions between the three station groups: Nearshore, North, and South.

Chart 3. Results of linear mixed models for key contaminants based on orientation to Denny Way Regulator Station outfall

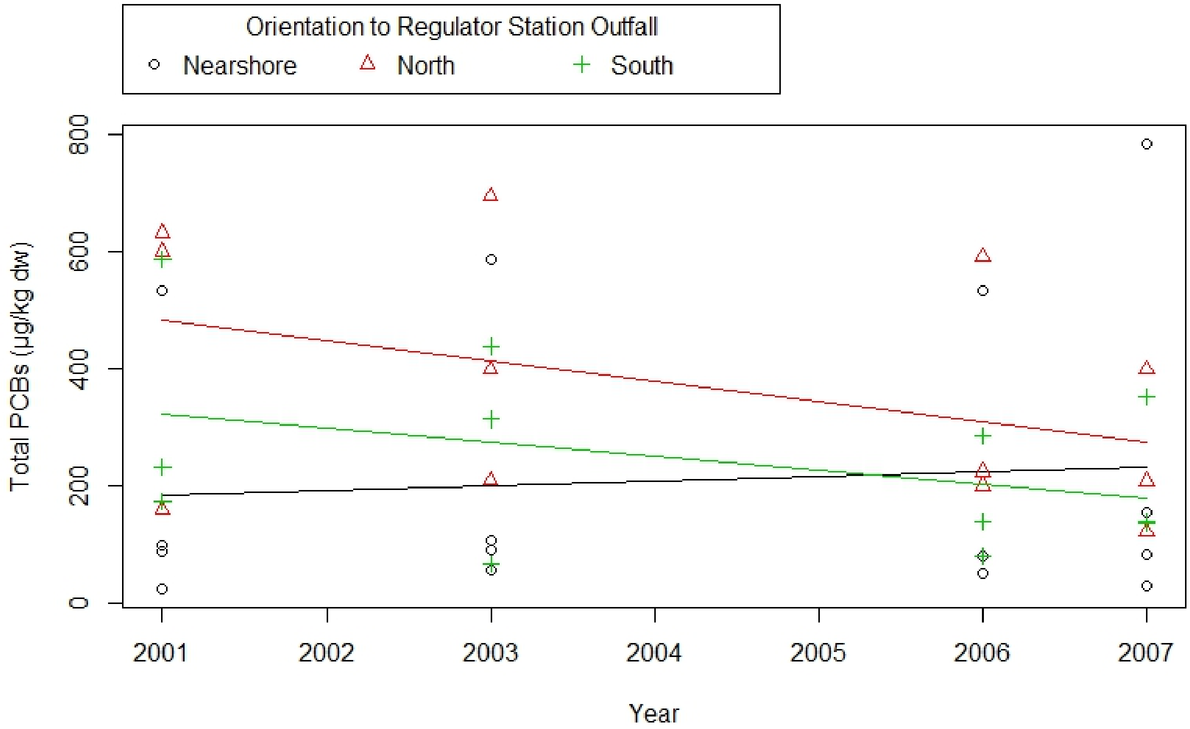
Analyte	Change over time (10 aggregate stations)	Significant Difference in Rate of Change between Groups[1]	Significant Change at Denny Way Regulator Outfall Stations		
			Nearshore	North	South
Mercury	No	No	Yes* - Increase	No	No
PCBs (dw)	Yes* - Decrease	Yes*	No	Yes** - Decrease	Yes* - Decrease
PCBs (OC-normalized)	No	No	No	Yes* - Decrease	No
BBP	No	No	No	No	No
BEHP	No	No	No	No	No

Analyte	Change over time (10 aggregate stations)	Significant Difference in Rate of Change between Groups[1]	Significant Change at Denny Way Regulator Outfall Stations		
			Nearshore	North	South
% Fines	No	No	No	No	No
TOC	Yes* - Decrease	Yes*	No	Yes** - Decrease	No
% Sand	Yes* - Decrease	Yes*	No	Yes** - Decrease	No

RS = Regulator Station
* = Significance at p< 0.05
** = Significance at p<0.01
*** = Significance at p<0.001
1 = "Nearshore" includes DWMP-01, -05, -10, and -13; "North" includes DWMP-14, -15, and -16; and "South" group includes DWMP-02, -03, and -04

When all stations were evaluated in aggregate, no significant trends in mercury concentrations were observed. While a significant increase in mercury concentrations was observed at the Nearshore stations (slope: 0.081, $p<0.05$), removal of data for station DWMP-10 resulted in a lack of statistical significance. These results indicate the increase was likely driven by mercury concentrations at DWMP-10.

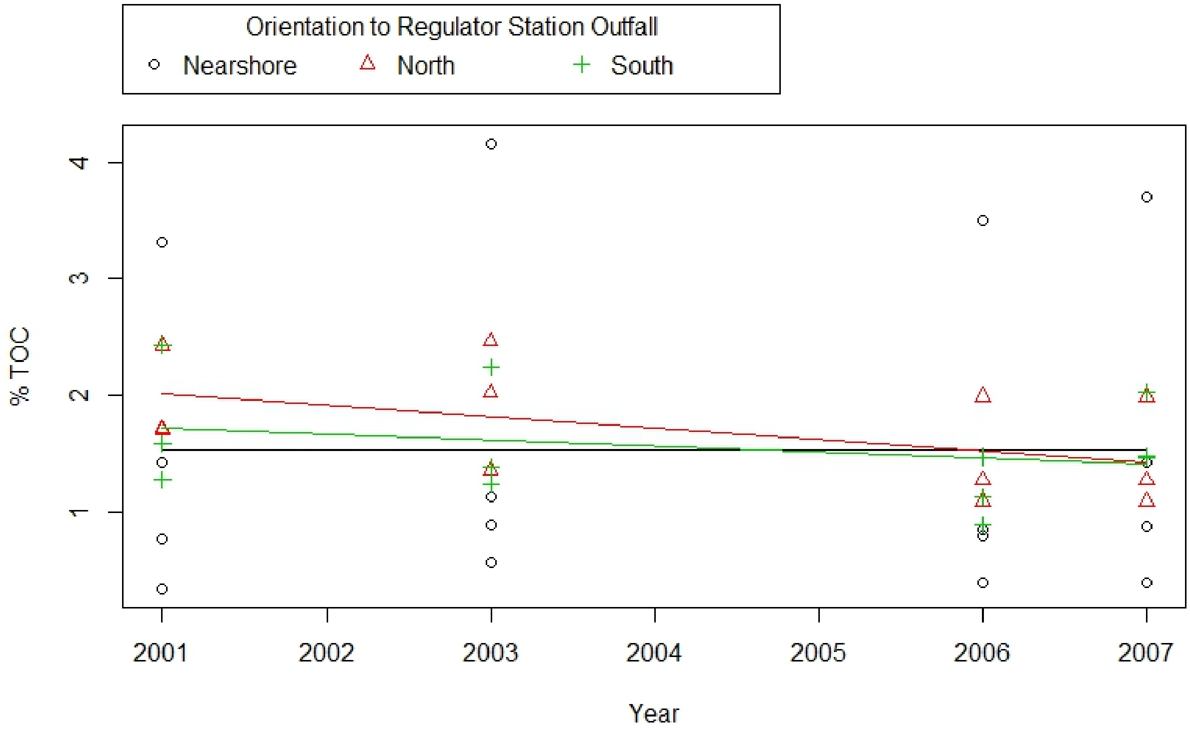
A significant decrease in dry weight PCB concentrations was observed across all stations analyzed (slope: -14.4, $p<0.05$). However, a similar trend was not observed when PCB concentrations were OC-normalized. Dry weight based PCB concentrations at both North (slope: -34.7, $p<0.01$) and South (slope: -24.1, $p<0.05$) station groupings significantly decreased over the time period evaluated (Plot 9). A significant decrease in OC-normalized PCB concentrations at the North stations was also observed (slope: -1.15, $p<0.05$).



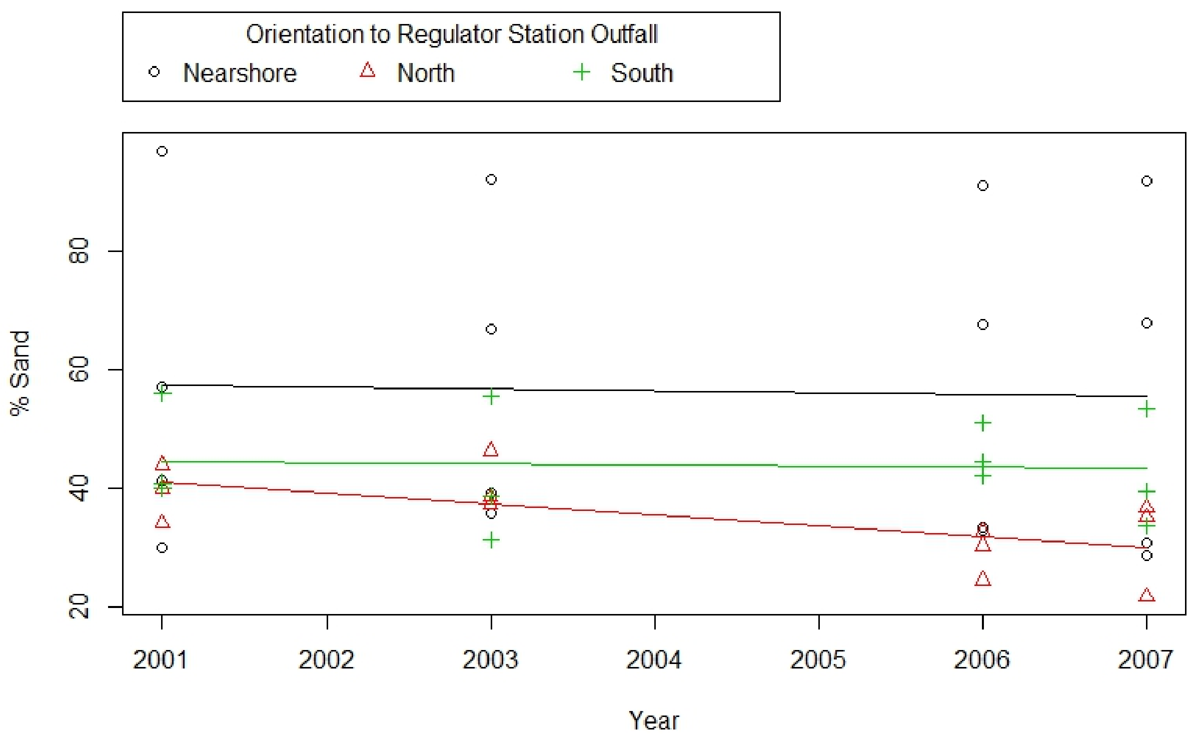
Plot 9. PCB concentrations (µg/kg dw; 0 – 2 cm) over time based on orientation to the Regulator Station outfall.

No significant trends in BEHP or BBP concentrations or % fines were observed over the time period evaluated. Both TOC (slope -0.052; $p < 0.05$) and % sand (slope -0.734; $p < 0.05$) significantly decreased across all stations when evaluated in aggregate (Plots 10 and 11). These results were primarily influenced by conditions at the north stations, where a small, but significant decrease in TOC (slope: -0.09824; $p < 0.01$) and % sand (slope: -1.84; $p < 0.01$) were observed.

Significant positive relationships were detected between PCB concentrations and TOC (R^2 = 0.69) as well as % fines (R^2 = 0.47), while a significant negative relationship was observed between PCBs and % sand (R^2 = 0.15). However, no significant changes in % fines were observed across all stations in aggregate, or for any station groups. Significant decreases in % sand and TOC were observed for all stations in aggregate, as well as at the North stations. The decrease in PCB concentrations at these 10 stations was likely influenced by the change in TOC.



Plot 10. Percent TOC (0 – 2 cm) over time based on orientation to the Regulator Station outfall.



Plot 11. Percent Sand (0 – 2 cm) over time based on orientation to the Regulator Station outfall.

5.1.2.4 Stations by Depth

Time trends for all 16 stations were evaluated for the same four key contaminants by grouping station data by depth. Only data collected from the top 0-2 cm and years 2001, 2003, 2004[27], 2006, and 2007 were used for this analysis so that data collected prior to and after operation of the WWTS and Denny Way Regulator Station outfalls were comparable. This is the period for which all 16 stations had the same sampling depth stratum data available. Data were evaluated to examine change over time by depth using linear mixed models with fixed effects for time and depth. Stations were classified into four categories based on depth:

- Deep – Stations DWMP-04, -07, -08, -09, -12, and -16 (-80 feet MLLW or deeper)
- Intermediate – Stations DWMP-03, -06, -11, and -15 (between -50 and -80 feet MLLW)
- Shallow – Stations DWMP-02 and -14 (between -40 and -50 feet MLLW)
- Shallowest – Stations DWMP-01, -05, -10, and -13 (less than -40 feet MLLW)

For this analysis, data were evaluated in two ways: all 16 stations in aggregate, as well as interactions between the four station groups (Deep, Intermediate, Shallow, and Shallowest). Chart 4 provides a summary of the linear mixed model results by depth. The shallowest station group includes station DWMP-10, which is included in the area remediated in 2008. This is noted because higher concentrations of some key contaminants were observed at this station prior to remediation and thus trend analyses were sometimes evaluated with and without data for this station to evaluate its influence on the trend analysis.

Chart 4. Results of linear mixed models for key contaminants based on stations grouped by depth.

Analyte	Change over time (aggregate of 16 stations)[1]	Significant Difference in Rate of Change between Groups[2]	Significant Change at stations			
			Deep	Intermediate	Shallow	Shallowest
Mercury	No	Yes*	No	No	No	Yes** - Increase
PCBs (dw)	Yes* - Decrease	Yes*	Yes** - Decrease	Yes*** - Decrease	Yes* - Decrease	No
PCBs (OC-normalized)	Yes* - Decrease	Yes*	No	Yes** - Decrease	No	No
BBP	No	No	No	No	No	No

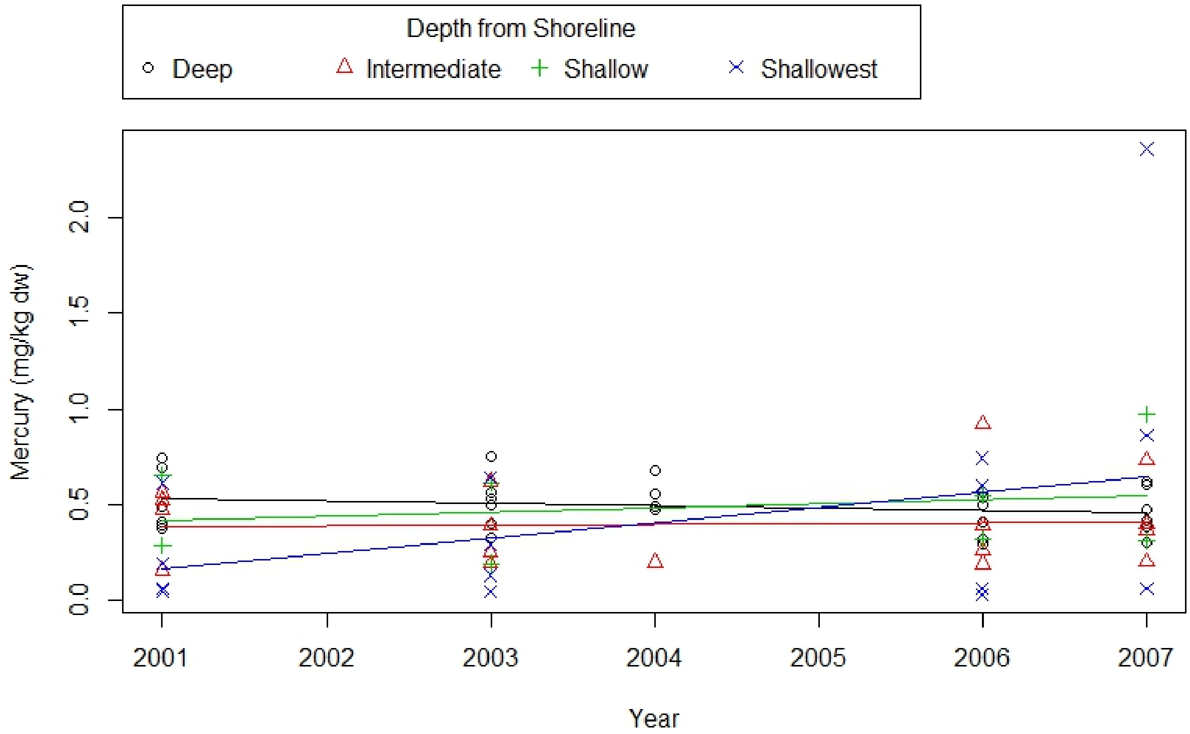
[27] 2004 data available for six stations: DWMP-06, -07, -08, -09, -11, and -12

BEHP	No	No	No	No	No	No
% Fines	No	No	No	No	No	No
TOC	Yes** - Decrease	No	Yes* - Decrease	No	No	No
% Sand	Yes** - Decrease	No	No	Yes* - Decrease	No	No

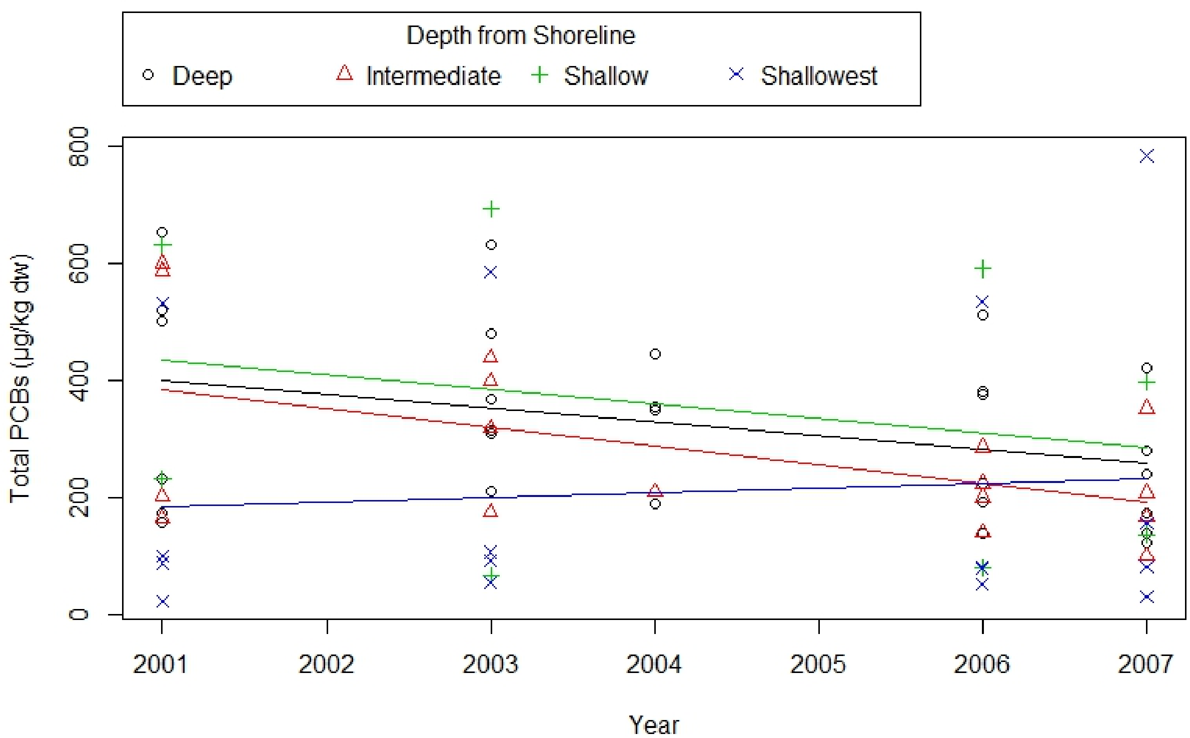
Both PCB dry weight and OC-normalized results are summarized because of the significant relationship between the two parameters for the 16 stations (R^2 of 0.57).
* = Significance at p< 0.05
** = Significance at p<0.01
*** = Significance at p<0.001
1 = Data for years 2001, 2003, 2004, 2006 and 2007 used; in 2004, only a subset of station data available.
2 = “Deep” includes DWMP-04, DWMP-07, DWMP-08, DWMP-09, DWMP-12, and DWMP-16; “Intermediate” includes DWMP-03, DWMP-06, DWMP-11, and DWMP-15; “Shallow” includes DWMP-02 and DWMP-14, and “Shallowest” includes DWMP-01, DWMP-05, DWMP-10, and DWMP-13.

When all locations were evaluated in aggregate, no significant changes in mercury concentrations were observed; however, over the time period evaluated, a small but significant increase mercury concentrations at the Shallowest stations was observed (slope: 0.0807, p<0.01) (Plot 12). However, when data for station DWMP-10 was removed from the analysis, the rate of change was no longer significant at the Shallowest stations. Since the area around station DWMP-10 was remediated in 2008, it is expected that mercury concentrations at the Shallowest stations will no longer have an increasing trend.

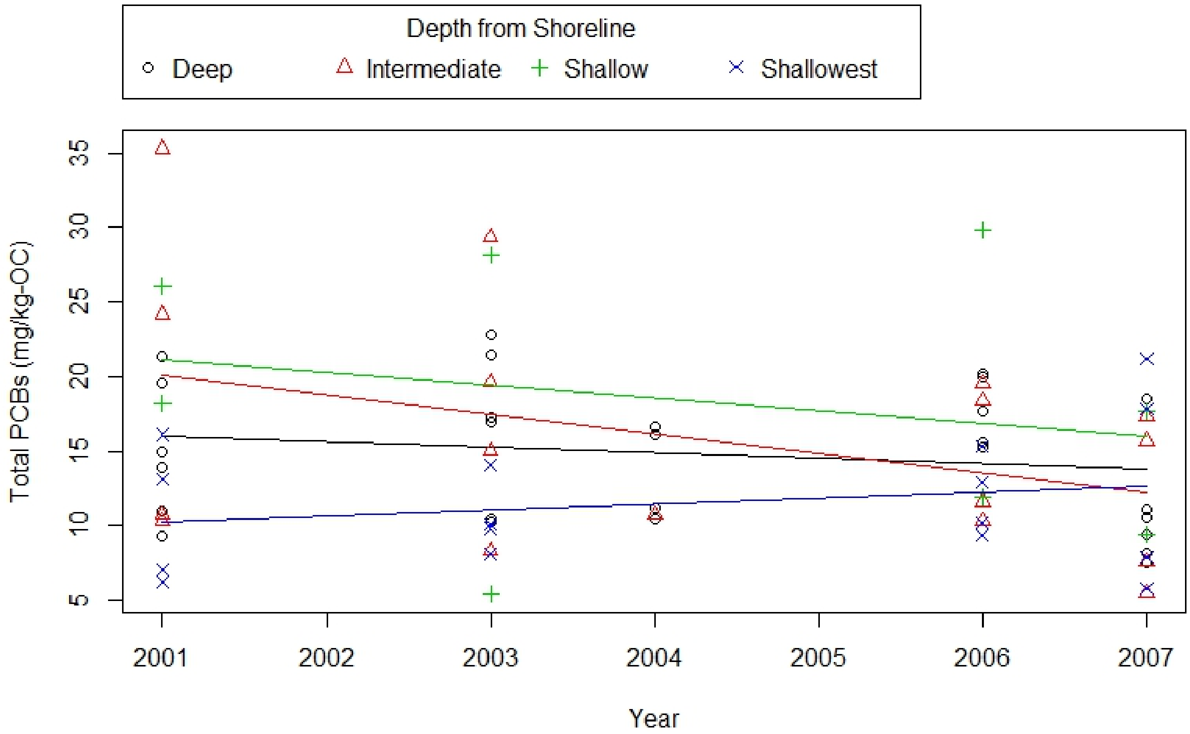
Across all 16 stations analyzed in aggregate, both OC-normalized (slope: -0.469) and dry weight PCB concentrations (slope: -17.8) decreased significantly (both p<0.05) over time. However, when evaluated by station group, PCB concentrations (both OC-normalized and dry weight) in the Shallowest stations exhibited an increase (but not significant) over the time period evaluated (Plots 13 and 14). However, dry weight PCB concentrations significantly decreased at the Deep (slope: -23.0; p<0.01), Intermediate (slope: -32.4; p<0.001), and Shallow (slope: -24.6; p<0.05) station groups. Analysis of the OC-normalized PCB concentrations indicated a significant decrease (slope: -1.32, p<0.01) only at the Intermediate depth stations. When data for station DWMP-10 were removed from analysis of the Shallowest stations group, trend analysis results were the similar to when DWMP-10 were included.



Plot 12. **Mercury concentrations (mg/kg dw; 0 – 2 cm) over time based on station depth.**



Plot 13. **PCB concentrations (µg/kg dw; 0 – 2 cm) over time based on station depth.**

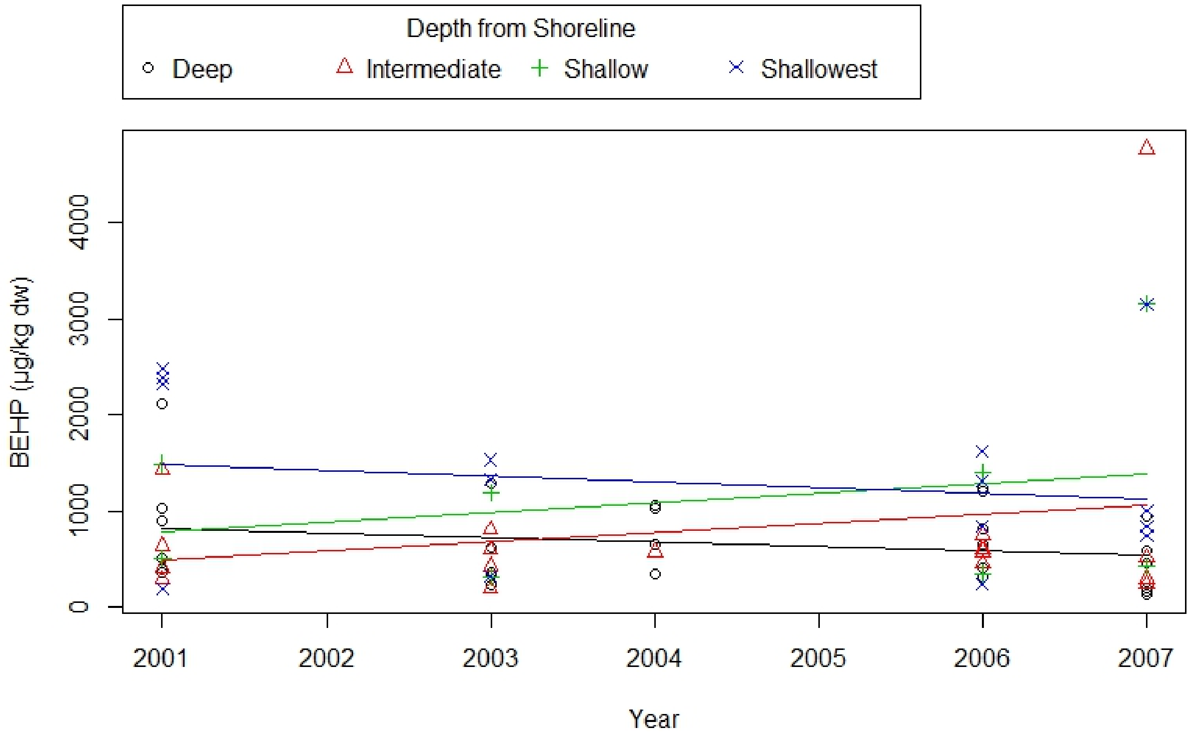


Plot 14. OC-normalized PCB concentrations (mg/kg-OC; 0 – 2 cm) over time based on station depth.

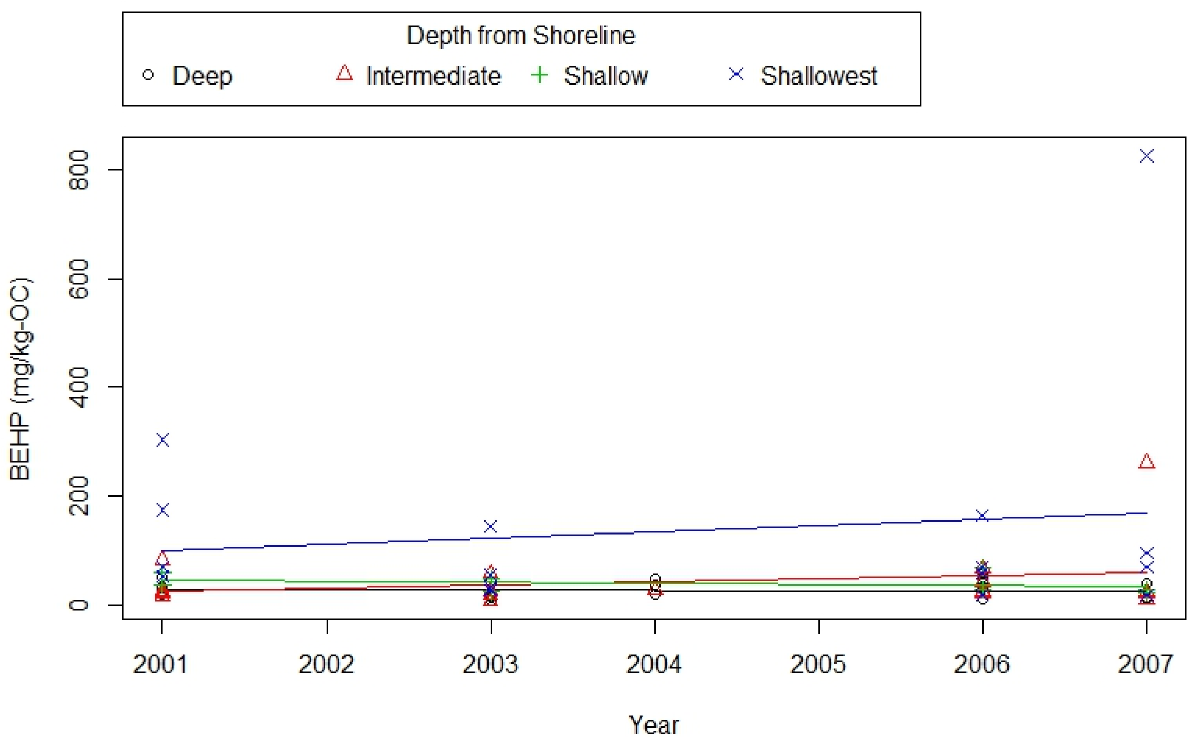
No significant increase or decrease in BEHP or BBP concentrations were observed over the time period evaluated (Plots 15 and 16). TOC demonstrates a small, but significant decrease (slope: -0.0397; $p<0.01$) across all stations evaluated in aggregate (Plot 17). This result may have been influenced by conditions at the Deep stations, where a small, but significant decrease in TOC over the time period was observed (slope: -0.0585; $p<0.05$). No significant changes in TOC were observed at the remaining station groups.

No significant changes in % fines were observed over time period evaluated. When all stations were evaluated in aggregate, % sand significantly decreased (slope: -0.733; $p<0.01$) (Plot 18). This result seems to be influenced primarily by the significant decrease (slope: -1.11; $p<0.05$) in % sand observed at the Intermediate depth stations.

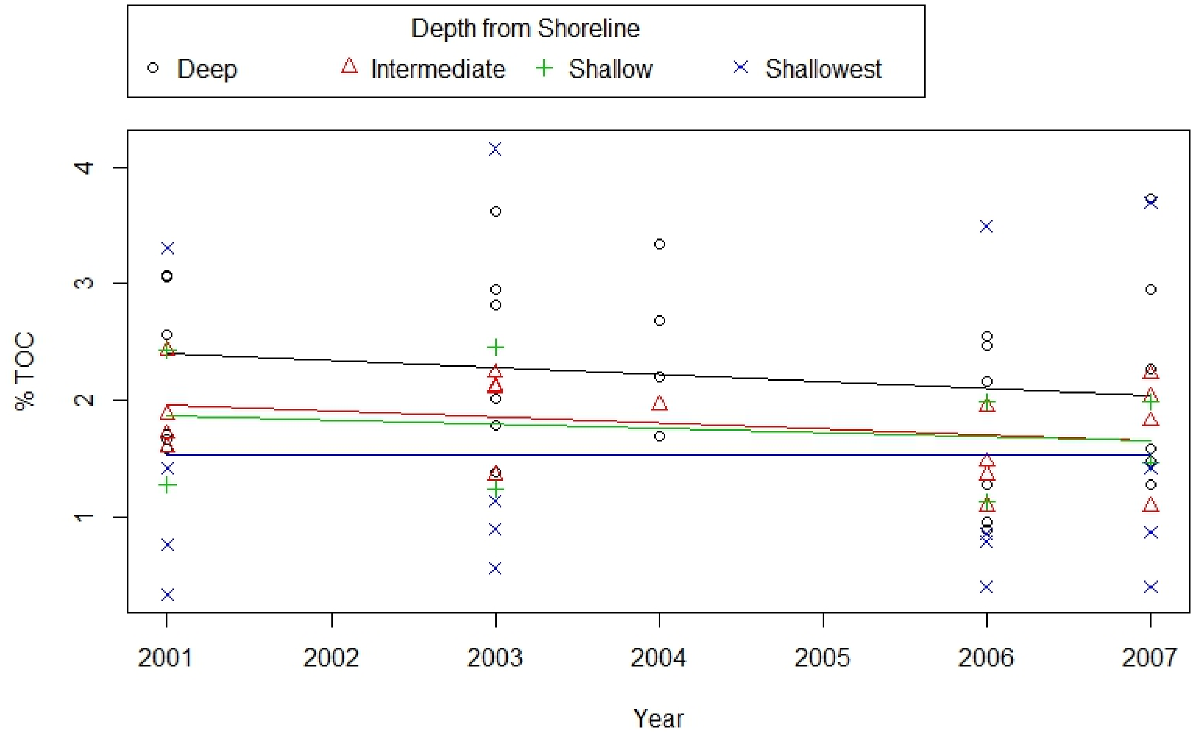
A significant positive relationship was detected between PCBs and TOC when all 16 stations were evaluated in aggregate ($R^2 = 0.57$). While changes observed in PCB concentrations are likely influenced by changes in TOC, a significant decrease in TOC only was observed when data for all stations were analyzed in aggregate and as the Deep station group. In contrast, the decrease in dry weight PCB concentrations was observed at all but the Shallowest station group. Therefore, the decrease in PCB concentrations maybe influenced by changing TOC and grain size but it is not solely attributable to these factors.



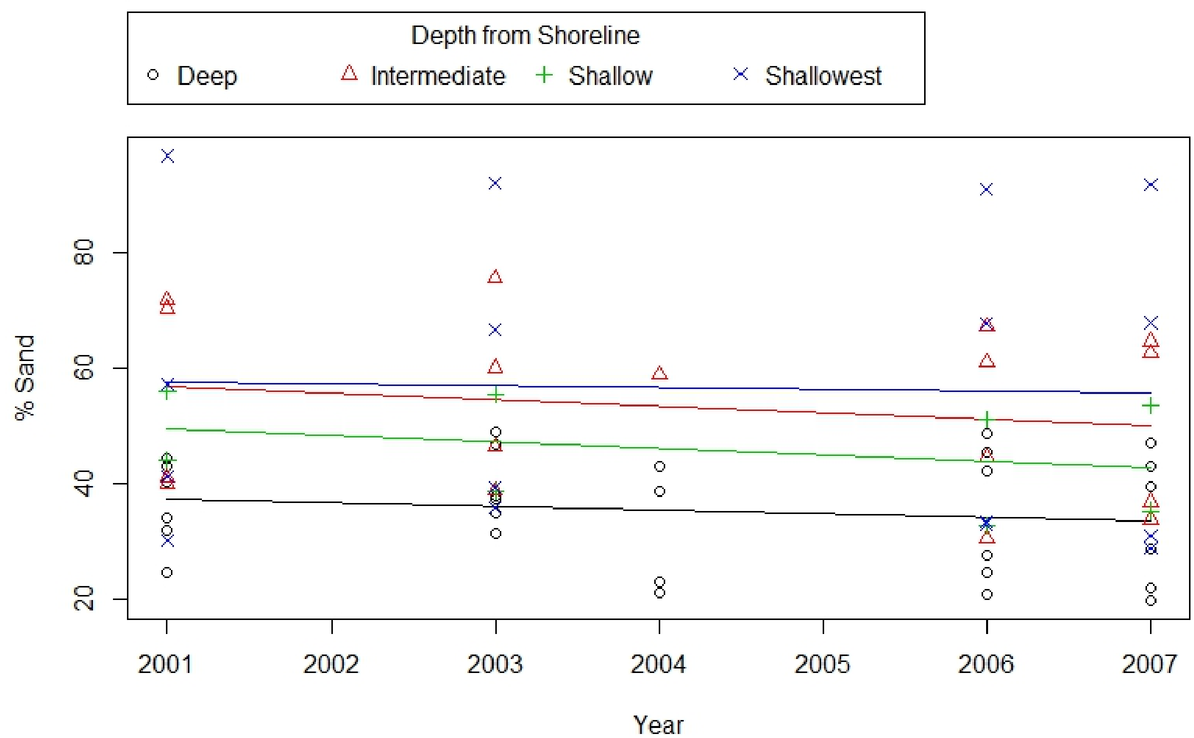
Plot 15. BEHP concentrations (µg/kg dw; 0 – 2 cm) over time based on station depth.



Plot 16. OC-normalized BEHP concentrations (mg/kg-OC; 0 – 2 cm) over time based on station depth.



Plot 17. Percent TOC (0 – 2 cm) over time based on station depth.



Plot 18. Percent Sand (0 – 2 cm) over time based on station depth.

5.1.2.5 Sediment Chemistry Time Trend Analysis Summary

Of the chemicals evaluated, only PCB concentrations demonstrated a significant decreasing trend across all stations in aggregate, as well as various other station groupings (e.g., "Shallow" station group or stations "Close" to WWTS outfall). The exception was the Nearshore stations (DWMP-01, -05, -10, -13), which did not exhibit a significant trend for PCBs. The only significant trend observed for the Nearshore stations was an increase in mercury concentrations over time. However, when data for station DWMP-10 were removed from the analysis, the mercury increase was no longer significant[28]. No significant trends were detected for either BEHP or BBP concentrations, regardless of the station groupings. Significant changes in TOC, % fines, and % sand, all factors than can influence changes in sediment chemical concentrations, were dependent on how stations were grouped. For example, TOC significantly decreases when all 16 stations were analyzed in aggregate but not always when stations were grouped by a variety of variables (e.g., proximity to WWTS outfall, depth, etc.).

5.2 Benthic Community Time Trend Analysis

The benthic community indices data provide an additional method to identify significant differences in environmental conditions before and after operation of the new outfalls. Benthic community data from the Denny Way monitoring program (2006–2010, 2015), as well as data from 2001 and 2004, were included in the time trend analysis[29]. Trend analysis was conducted using linear mixed models with the R Statistical Program.[30] Confounding factors associated with this trend analysis include benthic community effects associated with construction (2003/4) or the sediment remediation in 2008, which includes the area of Station DWMP-10. The analysis focused on taxa richness, taxa abundance, abundance of major taxa groups, and three indices: Shannon-Wiener Diversity Index, and Pielou's Evenness. As previously discussed, these index values were based on the average of three replicate samples collected at each location.

Data were grouped based on station proximity to each outfall, as well as depth. Depth was considered because the benthic community composition can be influenced by this. The following station groupings were used:

- <u>Near WWTS Outfall</u>- Stations DWMP-08 and -09, closest to the Elliott West WWTS outfall (mean distance of 224 feet) as well as the deepest stations sampled

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[28] These trends are based on data prior to sediment remediation in an area that includes station DWMP-10. Since remediation, mercury concentrations have been very low (all below the SQS) at station DWMP-10.
[29] Benthic data collected in 2003 were not included in the analysis because they were collected in late fall, whereas all other benthic data used in this analysis were collected in spring. Seasonal variation in benthic assemblages can result from changes in physical or chemical environmental variables such as temperature, light, salinity, dissolved oxygen, and habitat disturbance (PSEP 1987). As such, studies investigating interannual variation in the characteristics of benthic assemblages are more appropriately conducted using data collected during the same season each year (PSEP 1987).
[30] Benthic community indices by sampling station were evaluated using fixed effects for time and proximity to both outfalls.

- Near Regulator Station Outfall -Stations DWMP-01 and -05, closest to the new Denny Way Regulator Station outfall (referred to as RS in this section) (mean distance of 365 feet) , as well as the shallowest stations
- Intermediate-Stations DWMP-03, -14, and -15, intermediate in proximity to both the WWTS and RS outfalls as well as water depth

Data for station DWMP-10 was excluded from the analysis because this area was remediated in 2008. As a result, the benthic community has undergone recolonization following the dredging and backfill. This would result in an additional variable that could influence results of the time trends analyses for the nearshore stations.

Chart 5 summarizes results of the linear mixed model for benthic community indices evaluated and indicates if there were significant changes over time as well as difference in the rate of change between the Near WWTS Outfall, Intermediate, and Near RS Outfall station groups. The data were evaluated in two ways: all seven stations in aggregate as well as interactions between the three station groups. Only results that indicated significant changes over time, or significant differences in rates of change between station groupings, are discussed below.

Chart 5. Results of linear mixed models for benthic community indices based on station distance to WWTS outfall or Denny Way Regulator Station outfall.

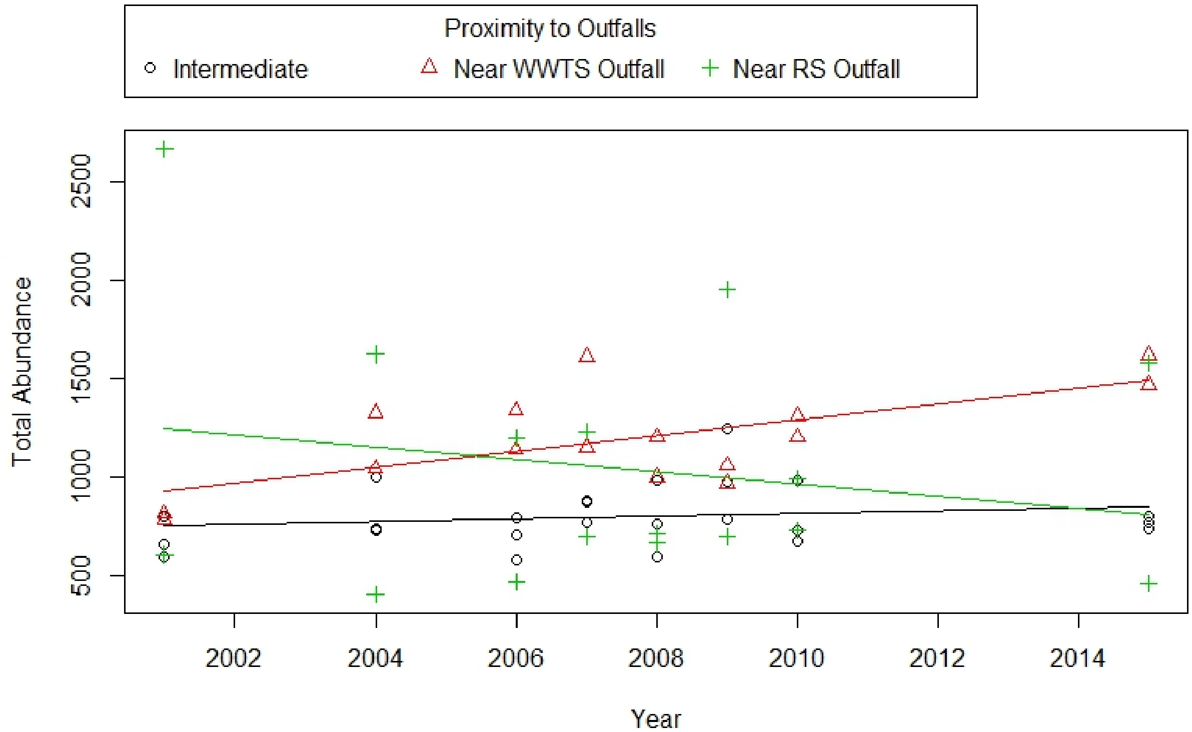
Benthic Community Indices	Change over time (7 aggregate stations	Significant Difference in Rate of Change between Groups[1]	Significant Change at Stations		
			Near RS Outfall	Intermediate	Near WWTS Outfall
Total Abundance	No	Yes**	No	No	Yes*-Increase
Total Richness	No	No	No	No	No
Annelida Abundance	No	Yes*	Yes* - Decrease	No	No
Annelida Richness	Yes *-Increase	No	No	No	No
Crustacea Abundance	No	No	No	No	No
Crustacea Richness	No	Yes**	Yes** - Decrease	No	No
Mollusca Abundance	Yes**-Increase	Yes*	No	No	Yes***-Increase

Benthic Community Indices	Change over time (7 aggregate stations	Significant Difference in Rate of Change between Groups[1]	Significant Change at Stations		
			Near RS Outfall	Intermediate	Near WWTS Outfall
Mollusca Richness	No	Yes*	No	No	Yes*- Decrease
Shannon-Wiener Diversity Index	No	No	No	No	No
Pielou's Evenness	Yes* - Decrease	No	No	No	No

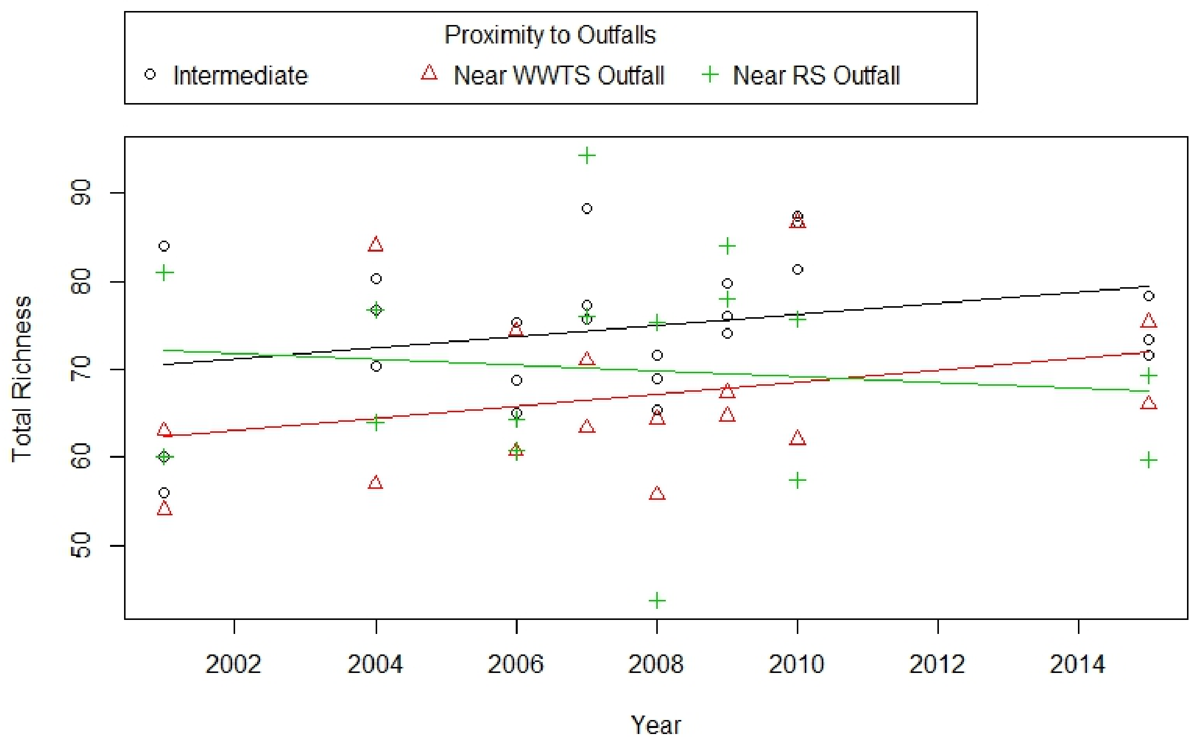
* = Significance at p< 0.05
** = Significance at p<0.01
*** = Significance at p<0.001
1 ="Near RS Outfall" includes DWMP-01 and -05; "Near WWTS Outfall" includes DWMP-08 and -09; "Intermediate" includes DWMP-03, -14, and -15,
N/A = not applicable

The Near RS Outfall stations tended to be more annelid-dominated, while the deeper stations near the WWTS outfall tended to be more mollusk-dominated. Species dominance at the Intermediate stations differed by station depth. This is emphasized further by the linear mixed model results as discussed below.

When station data were evaluated in aggregate, no significant changes in total abundance or total richness over time were observed. However, significant differences in the rate of change over time were observed between station groupings ($p<0.05$). Total abundance at stations near the WWTS outfall significantly increased (slope: 40.4, $p<0.05$) over the time period evaluated (Plot 19). While a decrease in total abundance was observed in the Near RS Outfall stations, it was not significant. Total richness did not significantly increase or decrease at any station group (Plot 20). Based on the analysis in Section 4.6.2, the time trend analysis was also performed without 2015 data. When 2015 total abundance data were removed, the increase at the Near WWTS Outfall stations was no longer significant. These results indicate the 2015 data were most likely driving the significant increase.

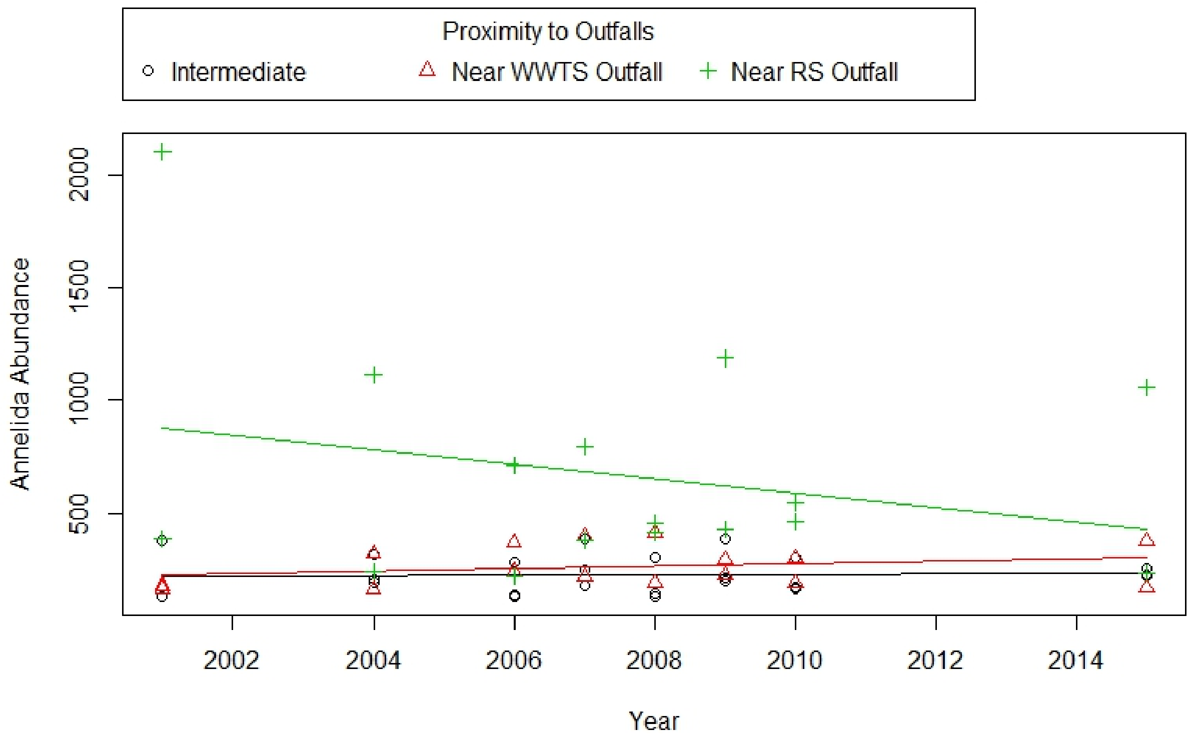


Plot 19. Total abundance based on proximity to outfalls.

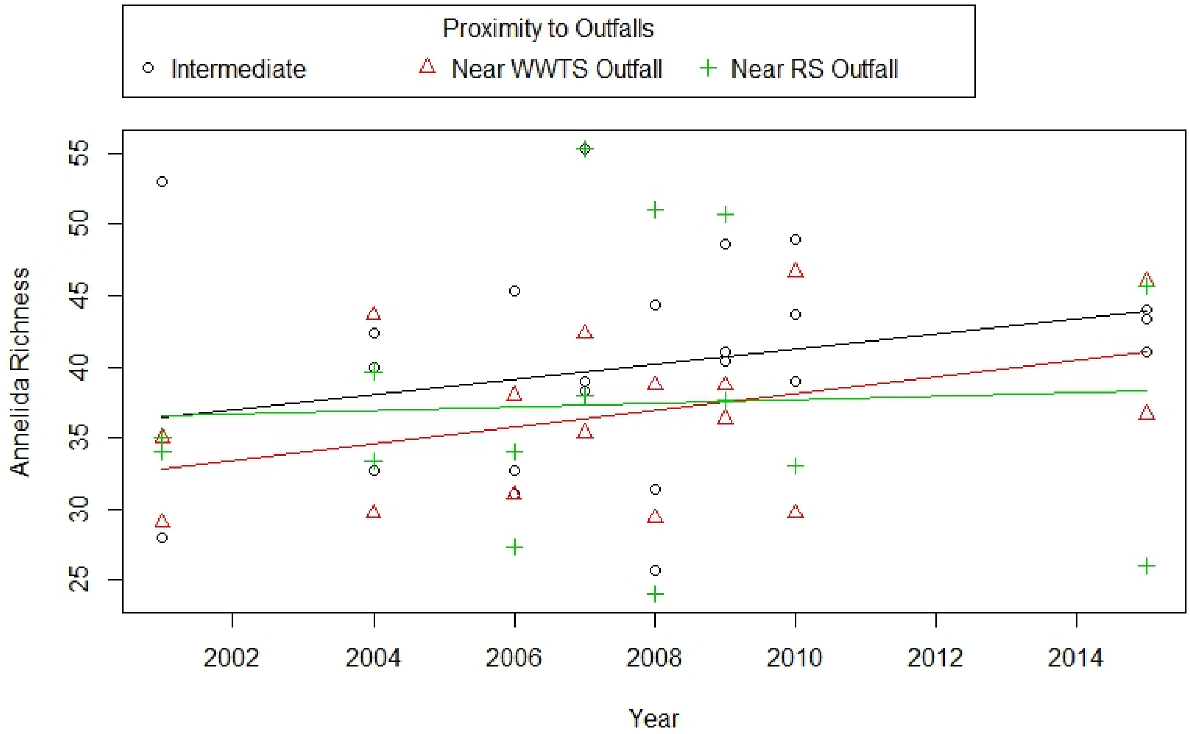


Plot 20. Total richness based on proximity to outfalls.

When all stations were evaluated in aggregate, no significant change in Annelida abundance over time was found. However, the rate of change in Annelida abundance at the Near RS Outfall stations was significantly different ($p<0.05$) relative to the Near WWTS Outfall and Intermediate station groups. Annelida abundance decreased significantly at the Near RS Outfall stations over the time period evaluated (slope: -32.2; $p <0.05$) (Plot 21). Because the 2001 data appeared much higher at Near RS Outfall group, the 2001 data were removed from the analysis to evaluate the effect on the time trends. This resulted in the decrease in Annelida abundance no longer being significant at the Near RS Outfall stations. This suggests the 2001 results were likely driving the significant decrease in Annelida abundance at the Near RS Outfall stations. Annelida richness significantly increased (slope: 0.432; $p<0.05$) over time when all stations were evaluated in aggregate. No significant difference in Annelida richness between stations groupings was detected (Plot 22).

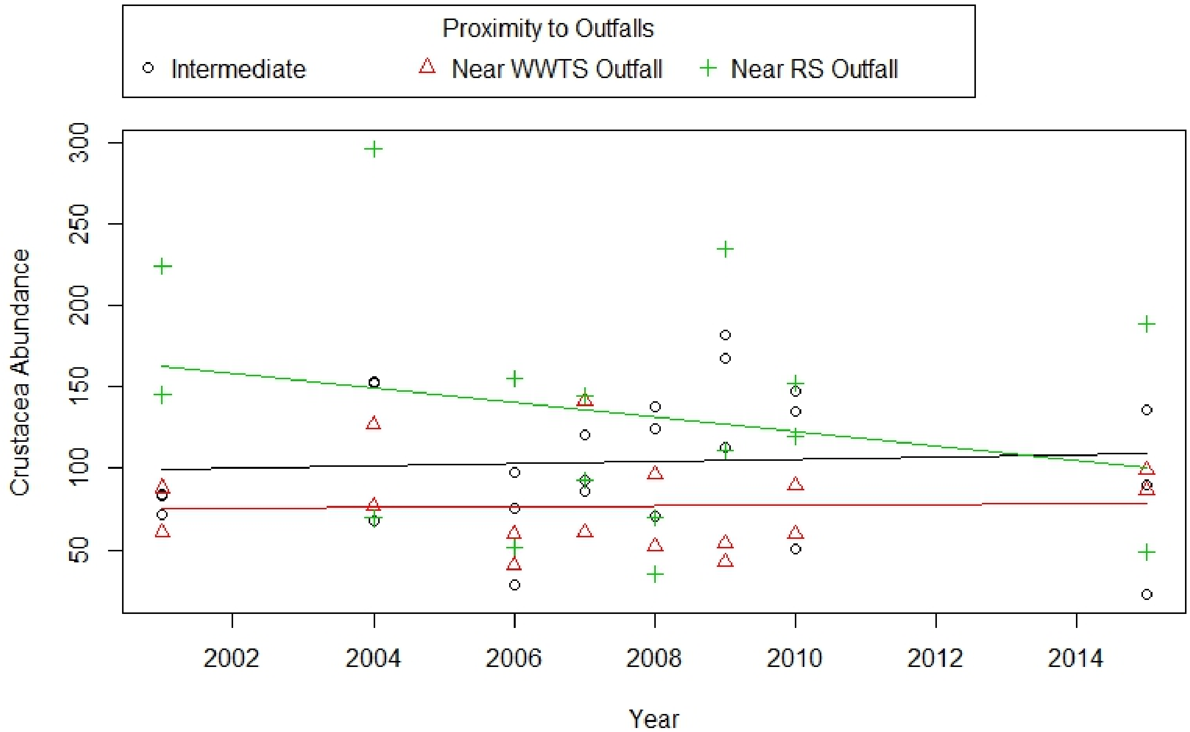


Plot 21. **Annelida abundance based on proximity to the outfalls.**

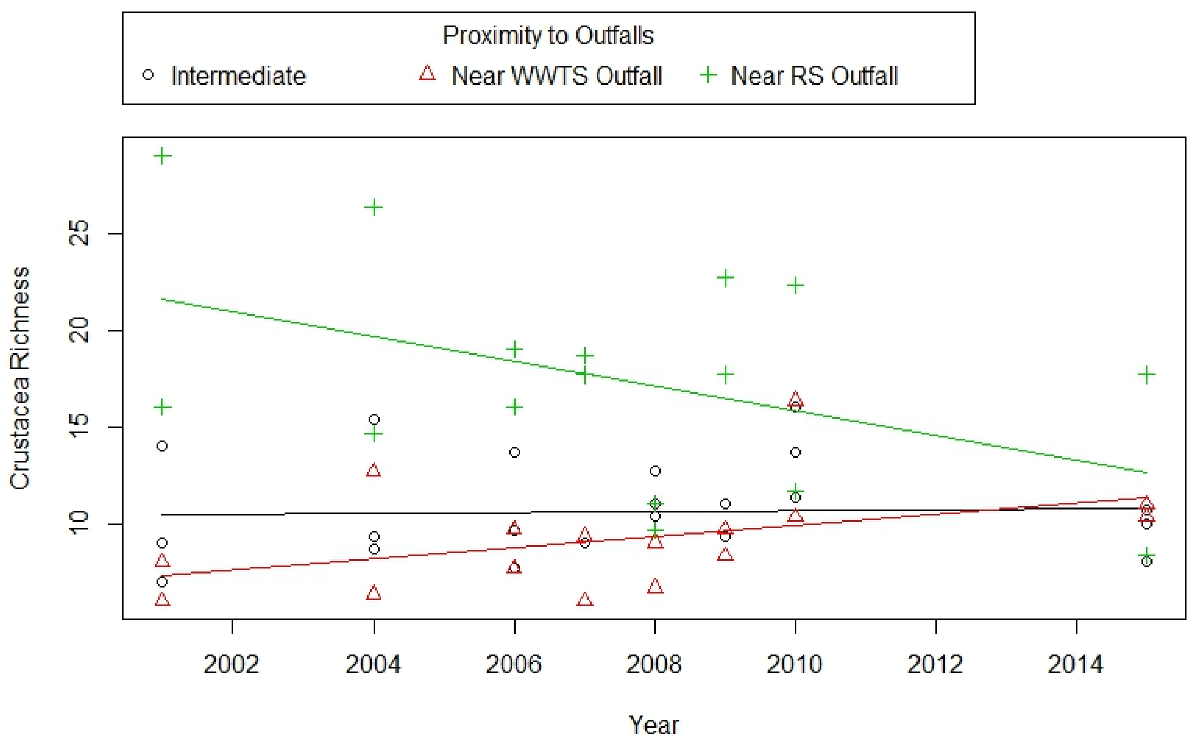


Plot 22. Annelida richness based on proximity to outfalls.

When all stations were evaluated in aggregate no significant changes in Crustacea abundance or richness over time were found (Plots 23 and 24). Crustacea richness, as well as rate of change, at the Near RS Outfall stations was significantly different ($p<0.01$) compared to richness at the Intermediate and Near WWTS Outfall stations. Further analysis indicated Crustacea richness decreased significantly (slope= -0.639, $p<0.01$) at the Near RS Outfall stations; similar results were observed when the 2001 data were removed from the analysis.



Plot 23. **Crustacea abundance based on proximity to the outfalls.**



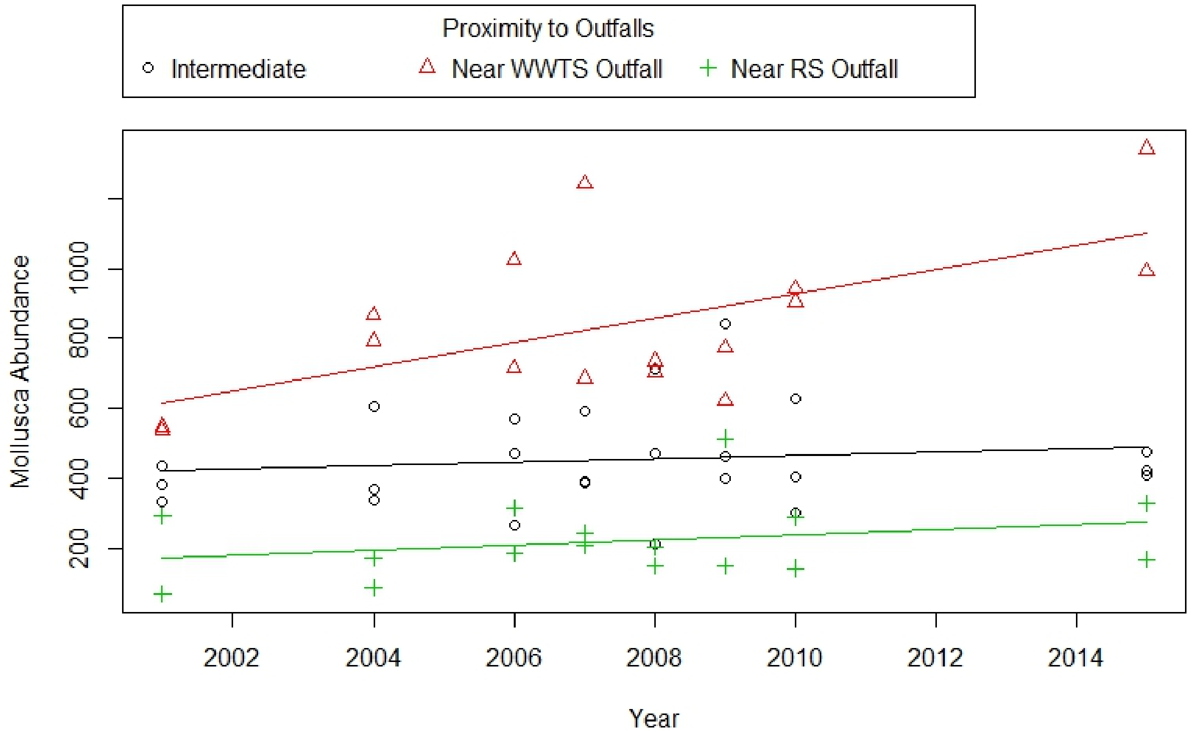
Plot 24. **Crustacea richness based on proximity to the outfalls.**

A significant increase in Mollusca abundance over time was observed when all stations were evaluated in aggregate (slope: 14.0; $p<0.01$). A significant difference in the rate at which Mollusca abundance changed over time between station groups ($p<0.05$) was also observed and likely influenced by abundance at stations near the WWTS outfall. The rate of change in Mollusca abundance at the Near WWTS Outfall stations was significantly different compared to the Intermediate and Near RS Outfall stations ($p<0.01$ and $p<0.05$, respectively). When just the Near WWTS Outfall stations were evaluated, Mollusca abundance significantly increased over time (slope: 34.9; $p<0.001$) (Plot 25). In addition, the Near WWTS Outfall stations experienced the highest Mollusca abundance across all years, while the lowest abundance was observed at the Near RS Outfall stations. This pattern was observed prior to and following the operation of the WWTS outfall and the RS outfall.

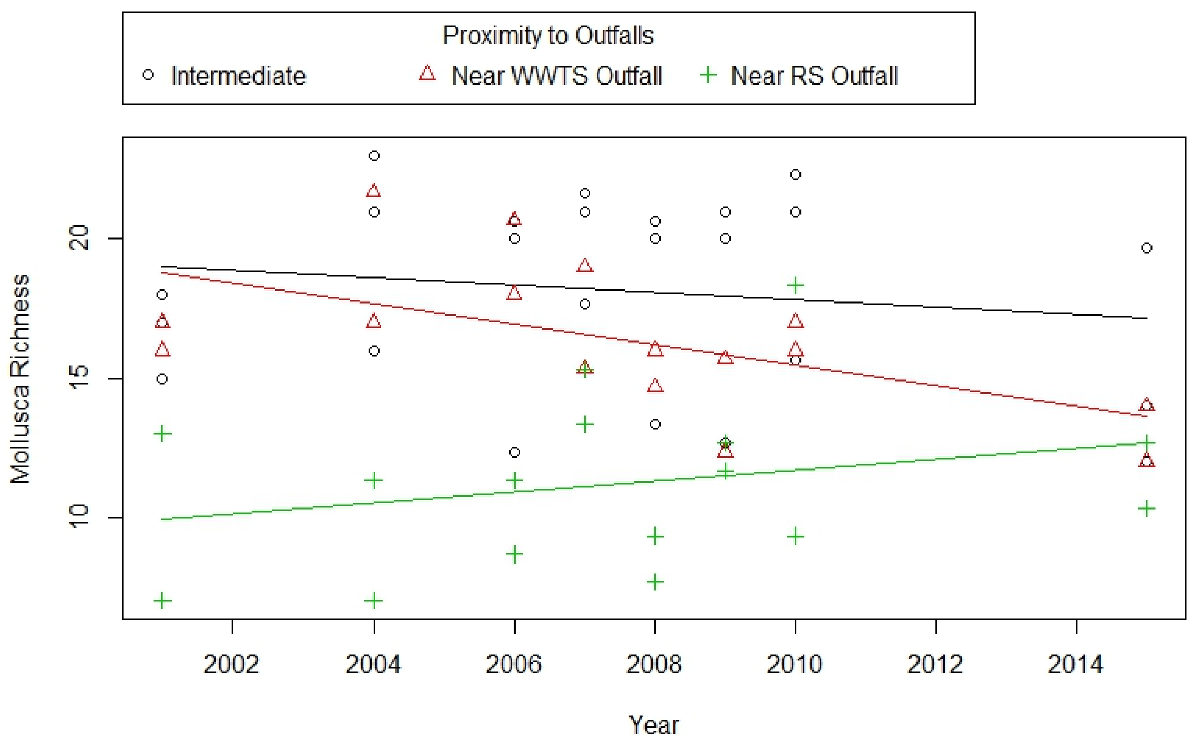
Mollusca richness did not change significantly over time when all stations were evaluated in aggregate. The rate of change for Mollusca richness between the Near WWTS Outfall and RS Outfall stations was significantly different ($p<0.05$); a significant decrease in Mollusca richness was observed at the Near WWTS Outfall stations (slope: -0.370, $p<0.05$) (Plot 26).

The data indicate both an increasing Mollusca abundance and decreasing Mollusca richness near the WWTS outfall which suggests a community shift that includes more individuals but fewer species. *Parvilucina tenuisculpta* and *Axinopsida serricata* are the most dominant taxa consistently observed at station DWMP-09. *P. tenuisculpta* was the dominant taxa over the monitoring period at station DWMP-08 as well; *A. serricata* is always one of the taxa in the SDI, but is not always one of the top two dominant taxa[31]. These species represented the top two dominant taxa in 2001 and 2004 at DWMP-08 and -09 and together comprised over 50% of individuals at these stations. Therefore, the dominant species were similar before and after operation of the WWTS outfall. These data suggest the discharges from the outfall have not significantly shifted benthic community composition.

[31] Annelida taxa sometimes represent the second most abundant taxa at DWMP-08.

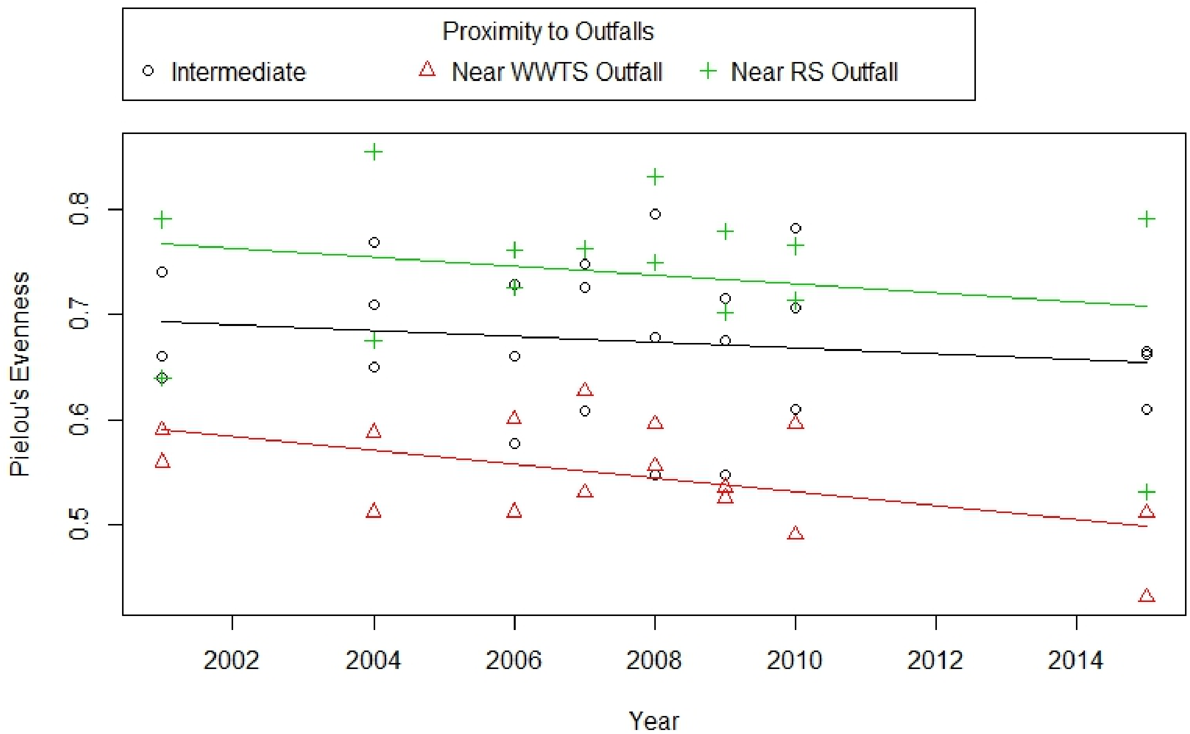


Plot 25. **Mollusca abundance based on proximity to the outfalls.**



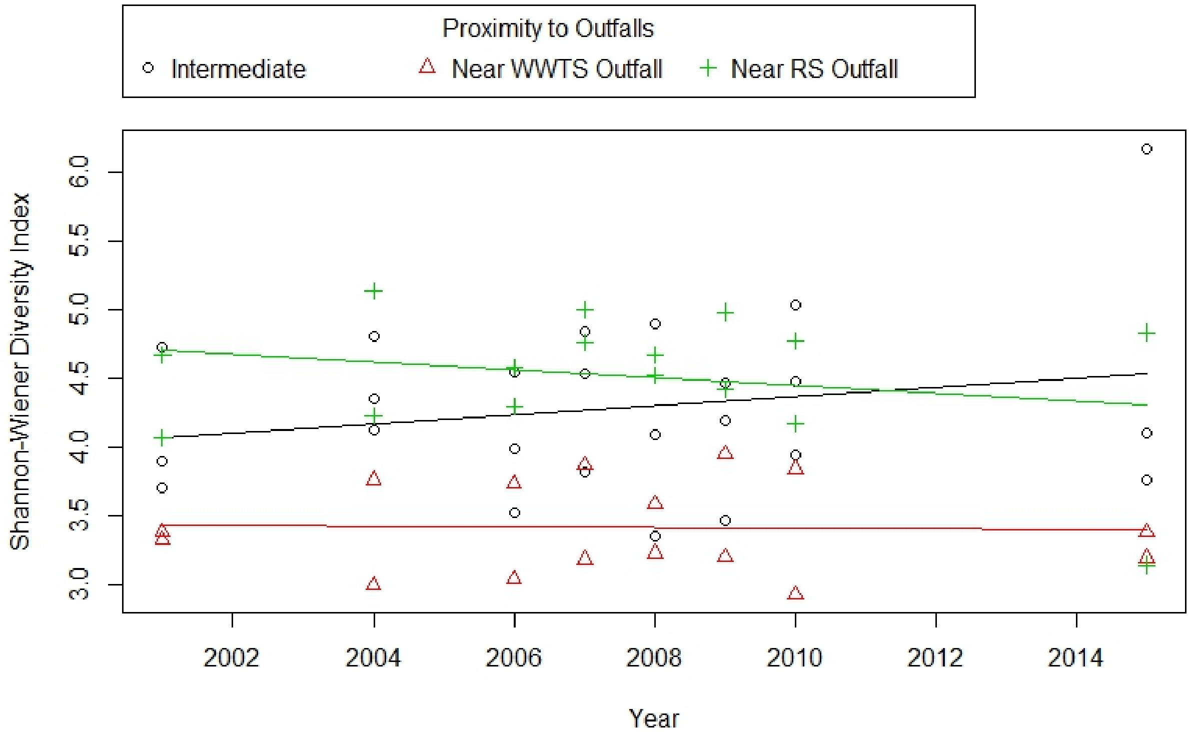
Plot 26. **Mollusca richness based on proximity to the outfalls.**

A significant decrease in Pielou's evenness (slope: -0.00424; $p<0.05$) was observed when all stations were evaluated in aggregate. This decrease appears to be driven by the stations near the WWTS outfall; although evenness values are not significantly changing at these stations (slope: -0.00659, $p=0.051$) (Plot 27). The rate of change in Pielou's evenness is small, and is evident in the small changes in evenness values (DWMP-08 ranged from 0.63 to 0.51 and DWMP-09 from 0.56 to 0.43 over the period). However, this trend was not observed for the Shannon Wiener Diversity Index, where no significant change over time for either as station groups or all stations in aggregate was observed (Plot 28). When 2015 data were removed from the Pielou's evenness time trends analysis, the decrease was no longer significant for all stations in aggregate (Plot 29). This additional analysis indicates the decrease in Pielou's evenness' was highly influenced by the 2015 data.[32] As discussed in Section 4.6.2, benthic community shifts were observed across all stations in 2015.

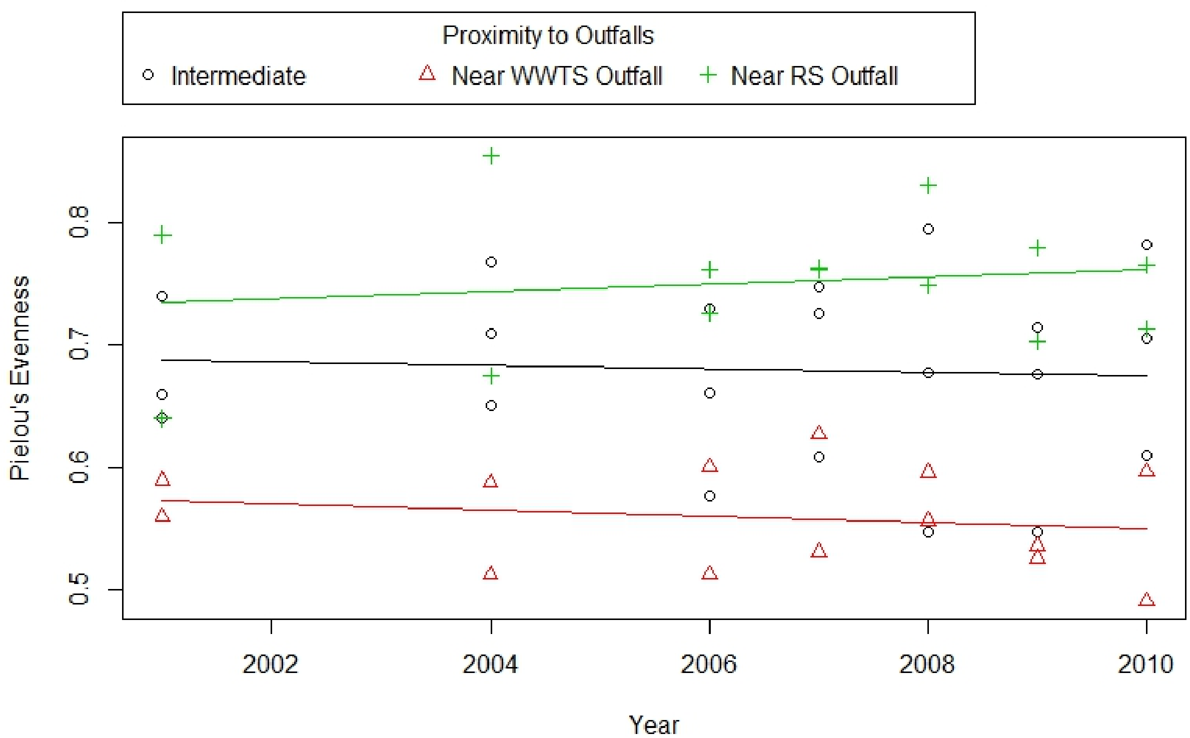


Plot 27. Pielou's Evenness over time based on proximity to the outfalls.

[32] All other benthic community indices time trend analyses were also assessed without 2015 results; however, the results were unchanged from original analyses.



Plot 28. Shannon Wiener Diversity Index over time based on proximity to the outfalls.



Plot 29. Pielou's Evenness over time, excluding 2015 results, based on proximity to the outfalls.

6.0 CONCLUSIONS

King County is conducting a long-term sediment monitoring program for the Denny Way/Lake Union CSO Control Project to fulfill requirements of the BO issued by the National Marine Fisheries Service. The sediment chemistry and benthic community monitoring data for program years 1–5 (2006–2010) and Year 10 (2015) are presented in this report. The primary goal of the Denny Way Monitoring Program is to produce scientific data of known quality that can be used to determine if implementation of the Denny Way/ Lake Union CSO Control Project has led to a reduction in the risk to human health and to the biological communities in the marine environment surrounding the CSO (NMFS 2000). Although the monitoring period is ongoing (Years 15 and 20 still to be completed), this report evaluates the current status of the Denny Way site with respect to the BO monitoring objectives. The following summarizes the findings of the monitoring data to date.

6.1 Chemicals of Concern and the Geographic Extent

The Washington State marine sediment standards were developed from sediment triad data sets typically collected at 0-10 cm and apply to the biological active zone (typically top 10 cm in Puget Sound marine sediments) (WAC 173-204). However, these standards were compared to samples collected from both 0–2 cm and 0–10 cm to evaluate sediment quality per the BO. The chemicals of concern at the Denny Way site include mercury, total PCBs, BEHP, BBP, and total HPAHs, as well as some individual PAH compounds. Concentrations of these chemicals above the SQS have been detected more than once and at various stations over the monitoring period (in both 0-2 cm and 0–10 cm samples). All 16 stations at one point during the monitoring period had at least one contaminant above the SQS. Chemical concentrations above the SQS were most frequently detected at stations DWMP-01, -08, and -14. All chemical concentrations above the SQS at station DWMP-10 occurred prior to remediation actions in 2008; all subsequent chemical concentrations have been below their respective SQS.

6.2 Benthic Community Condition

General observations from the benthic community results include the following:

- Average total taxa richness was 72 for all years and stations with the Annelida group having the greatest percent richness.
- Total abundance averaged 945 individuals for all years and stations. Abundance was variable across years and stations; some locations had up to three times more individuals than others in some years. Annelid taxa had greater total abundance (generally >50%) relative to other major taxa groups at shallower, nearshore stations, while Mollusca had greater abundance (generally > 50%) at deeper stations.

- The average Shannon-Wiener Index value across all years and stations was 4.16. The lowest value was observed at station DWMP-09 for all years monitored, with the exception of 2015 when the lowest value was observed at station DWMP-10.
- The average Pielou's evenness value was 0.67 across all years and stations monitored. The lowest evenness values were observed at station DWMP-09 during five of the six years sampled, while some of the highest evenness values were measured at station DWMP-10 followed by DWMP-01 and -05.
- The average SDI value was 12 across all years and stations monitored. The lowest average SDI value was observed at station DWMP-09 (4) across the years measured, while the highest SDI value was measured at stations DWMP-01 and DWMP-14 (18 for each). *Parvilucina tenuisculpta* or *Axinopsida serricata,* two Mollusca taxa, were commonly observed as one of the two most abundant species at all stations in all years sampled. These species are moderately to slightly pollution tolerant.

Overall, the benthic community data indicated that no station consistently over the years was impacted when compared to Ecology's RVRs for multiple indices.[33] However, comparison of RVRs to Denny Way data for some years and locations did suggest a periodic impact to the benthic community, most notably at Stations DWMP-01, -05, and -09. In addition, more benthic community indices in 2015 indicated a potential impact when compared to RVRs than other years. However, since the RVRs are not based on data from 2015, it is possible the observed differences may have been related to other stressors; such as increased temperature and depressed oxygen levels that were recorded in 2014 and 2015 in many areas of Puget Sound (PSEMP Marine Waters Workgroup 2016).

When compared to the RVRs, the benthic community diversity indices (Pielou's Evenness, Shannon Wiener Diversity and SDI) indicate impacts were greatest at Station DWMP-09. The chemicals of concern, mercury and total PCBs, and low benthic diversity have been characteristic of this station since monitoring began in 2001, prior to construction and operation of the WWTS outfall (King County 2005). Besides chemical contamination, factors such as ammonia and sulfide concentrations or % fines, may have contributed to the poor benthic diversity at Station DWMP-09.

The area that includes Station DWMP-10 was remediated by dredging and back-fill in winter of 2007-2008. With the exception of 2015, when low diversity was observed, the benthic community at this station underwent a period of recolonization and most community indices indicated improved conditions or a return to previous conditions. The 2015 condition could be attributable to stressors, such as increased water temperatures (as discussed above) or the increase (at most sites) in ammonia and sulfide concentrations from 2009 and 2010. Following remediation, all measured chemical concentrations have

[33]The RVRs were used as a method to compare Denny Way benthic community data to a reference or control area.

been below the SQS at this station. Benthic data collected during the next monitoring period will be reviewed to evaluate this further.

6.3 Additional Monitoring Data Evaluations

A key assessment of this monitoring effort was to determine the likelihood that chemical concentrations above the SQS were caused by discharge from the Denny Way/Lake Union CSO Control Project outfalls. This was accomplished through comparison of conditions prior to and following construction and operation of the outfalls.

Concentrations of the chemicals of concern were above the SQS prior to construction and operation of the WWTS outfall and the new Regulator Station Overflow outfall (King County 2005). The percent of sample concentrations above the SQS for mercury and PCBs were fairly consistent both before and after operation of the new outfalls. The percent of sample concentrations above the SQS for BEHP and BBP dropped overall, while the percent of total HPAH concentrations above SQS was low and somewhat variable before and after operation of the new outfalls.

Total PCB concentrations (top 2 cm) have decreased significantly over time at stations both near (DWMP-06, -08 and -11) and farther away (DWMP-07, -09, and -12) from the WWTS outfall; the rate of decrease, when all 16 monitoring stations were evaluated[34], was also significant. PCB concentrations were moderately associated with TOC, and in some cases TOC decreased significantly. This suggests decreases in PCB concentrations were likely influenced by decreasing TOC. Mercury concentrations (top 2 cm) significantly increased at the nearshore stations based on data from 2001, 2003, 2006, and 2007. However, when data for station DWMP-10 was removed from the analysis, the increasing trend was no longer significant, indicating that conditions at this site influenced the overall trend. BEHP and BBP concentrations did not significantly increase or decrease over the monitoring period. Other observations associated with the time trend analysis suggest that chemical concentrations in top 2 cm, as well as their rate of change over the monitoring period, appeared to be influenced by bathymetry. Rates of change in chemical concentrations differed by station groupings based on depth. Trends observed at the nearshore (DWMP-01, -05, -10, 13) were different relative to trends at stations further from shore. Although dry weight PCBs concentrations decreased overall (based on an aggregate of all 16 stations), significant decreases were not detected at the nearshore stations when grouped by depth. No significant changes in % fines based on depth were observed; however, TOC significantly decreased at the deepest stations (DWMP-04, -07, -08, -09, -12 and -16) and % sand significantly decreased at the intermediate depth stations (DWMP-03, -06, -11, and -15).

The results presented here indicate that sediment contamination is likely related to historic conditions, rather than treated effluent discharges from the WWTS outfall or once per year on average discharges from the new CSO outfall. The trend analysis indicated that sediment

[34] Pre operation included 2001, 2003, 2004 data and post operation included 2006 and 2007 data.

chemical concentrations at stations near both outfalls did not increase since the discharges started or compared to stations further away from the outfalls.

Benthic community data were also evaluated to further evaluate potential impacts from the operation of the outfalls. Trend analysis indicated the only significant decreasing benthic community indices were for (1) Mollusca richness at stations DWMP-08 and -09 (near WWTS outfall); (2) Crustacea richness at stations DWMP-01 and DWMP-05 (nearshore and south of the Regulator Station overflow outfall); (3) Pielou's Evenness at all stations when evaluated in aggregate; and (4) Annelida abundance at nearshore stations DWMP-01 and -05. Two benthic community indices, Annelida richness and Mollusca abundance, indicated a significant increasing trend across all stations. Total abundance and Mollusca abundance also significantly increased at stations DWMP-08 and -09. The lowest SDI values were observed at stations DWMP-08 and -09. However SDI values at these stations were low prior to construction of the WWTS outfall, suggesting that either historic contamination or other site conditions were the likely cause of low scores.

Overall, the chemistry and benthic results over the monitoring period showed little discernible impacts from the construction and operation of the outfalls and most observed impacts predated outfall operations. The BO includes two more monitoring events: 2020 (Year 15) and 2025 (Year 20). A final monitoring data report will be developed following these monitoring events.

The BO also includes development of a sampling plan to confirm contaminants of concern as well as the geographic extent of these concentrations. If necessary, development of a remediation plan is also included to address areas of contamination. King County is developing a cleanup action plan for the area to address these requirements. Because data collected to date suggest that concentrations above SMS or DMMP guidelines are related to historic contamination, specific sources of the chemicals of concern have not been assessed. Rather, as indicated in the BO, additional sampling and analysis of sediment conducted for the cleanup action will be evaluated against contaminant concentrations detected in the discharges to determine potential source(s). A cleanup action plan would need to identify contaminant sources and determine adequate controls prior to implementing cleanup actions.

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Figures

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Figure 1
Denny Way/Lake Union CSO Control Project Long-Term Sediment Monitoring Vicinity

Sediment Sampling Stations - 2006-2010, 2015

- Sediment Chemistry*
- Sediment Chemistry and Benthic Taxonomy
- Outfall Discharge Location
- Outfalls

- MNR Areas
- Dredge Areas
- Sand Cap - 3' Thick
- Sand Placement Dredge Residual Cover - 6" Thick

*2006-2007 - All stations analyzed for sediment chemistry and benthic taxonomy.

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April 2018

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

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Figure 2
Long-Term Sediment Monitoring Sampling Stations and Cleanup Action Areas
Denny Way/Lake Union CSO Control Project

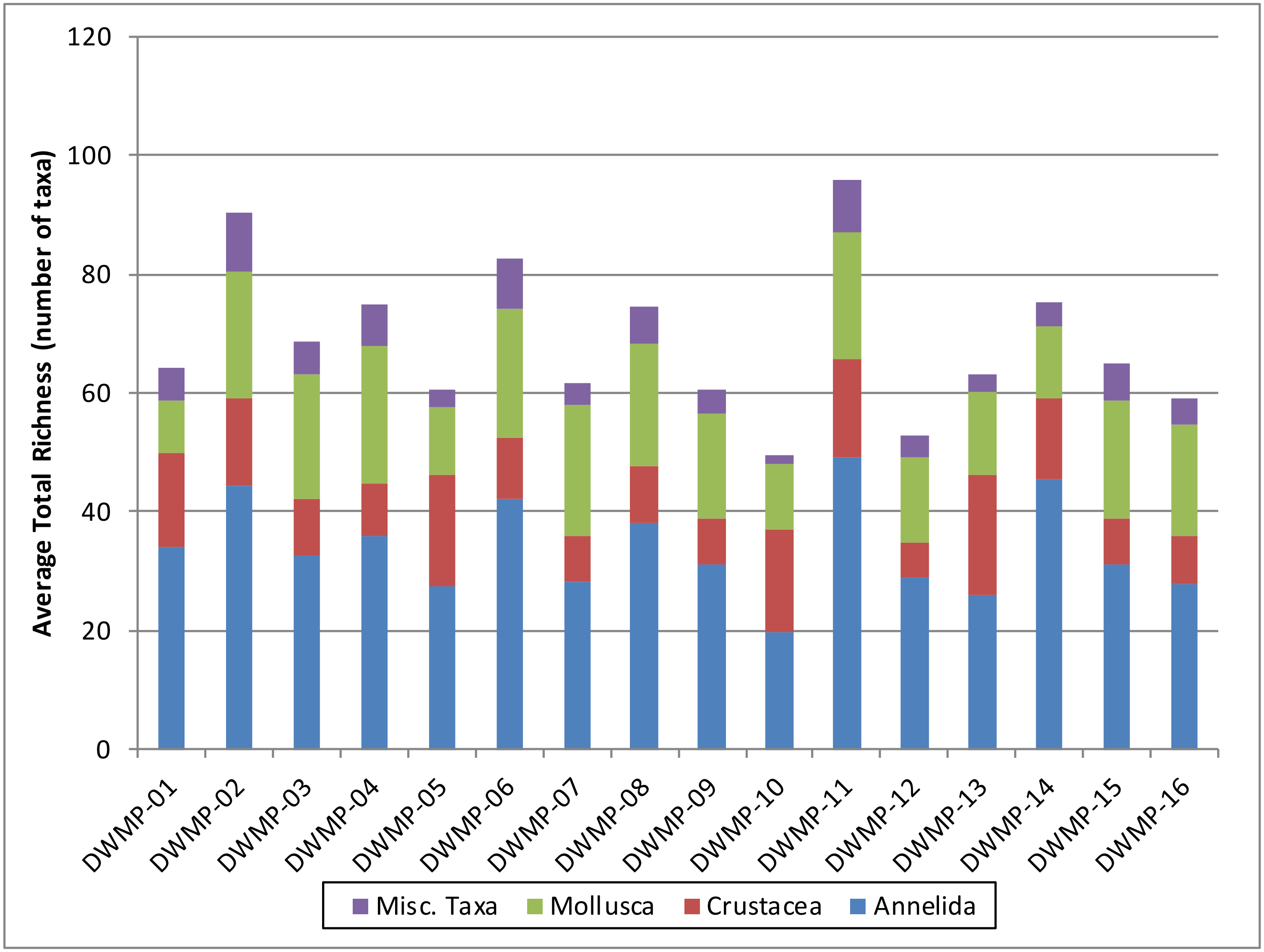


Figure 3. Benthic Community Structure Based on Average Richness - 2006

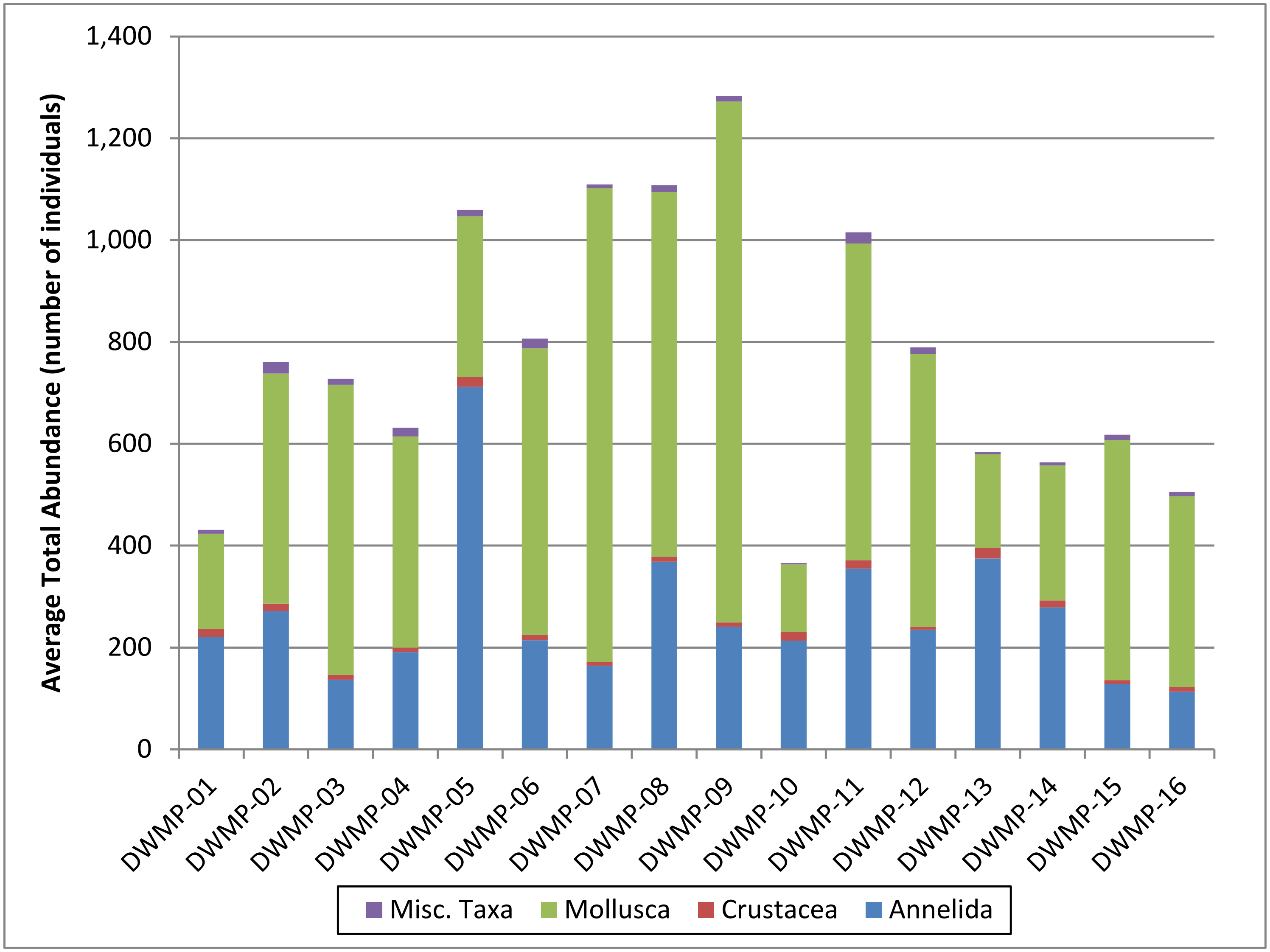


Figure 4. Benthic Community Structure Based on Average Abundance - 2006

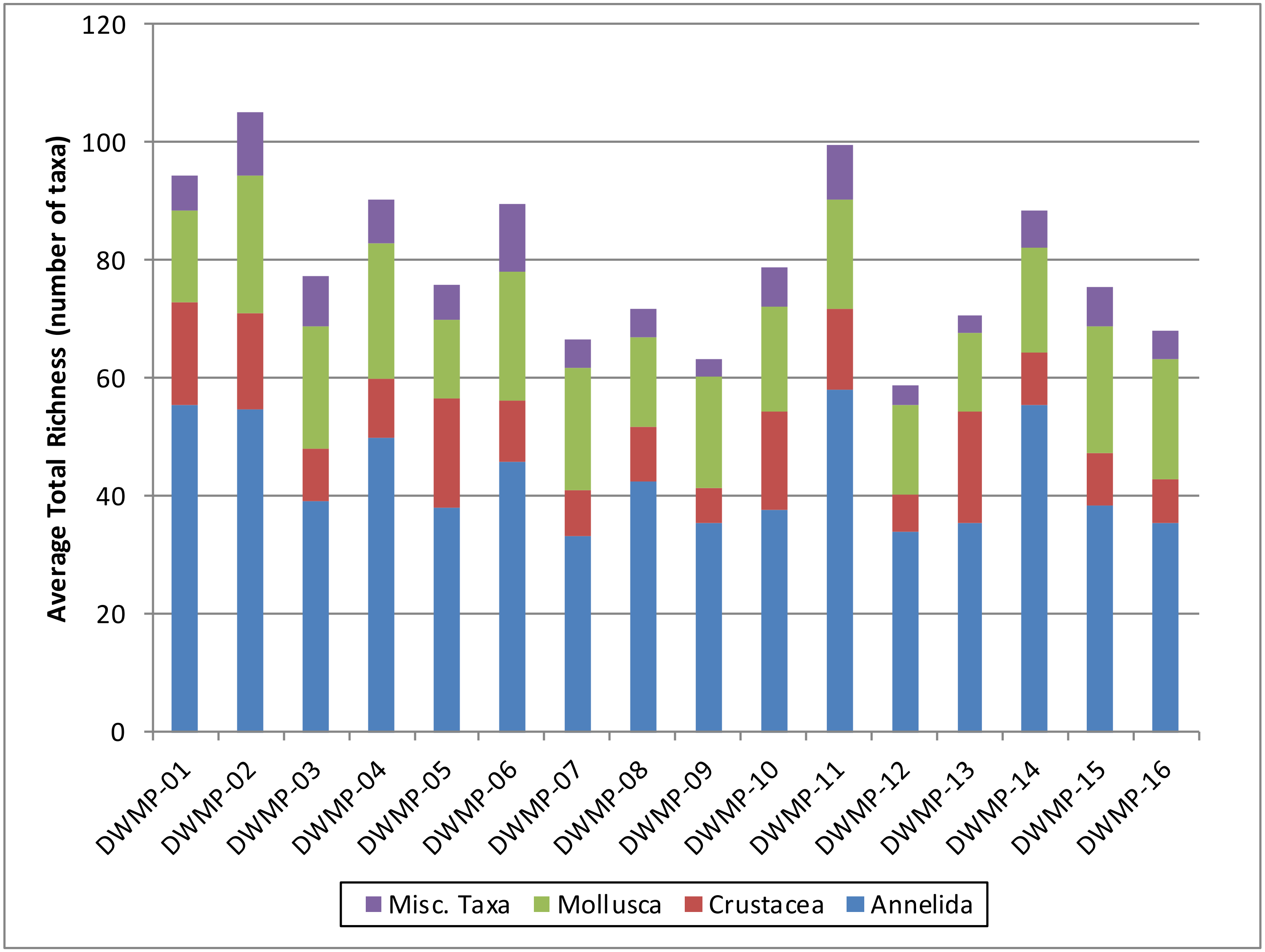


Figure 5. Benthic Community Structure Based on Average Richness – 2007

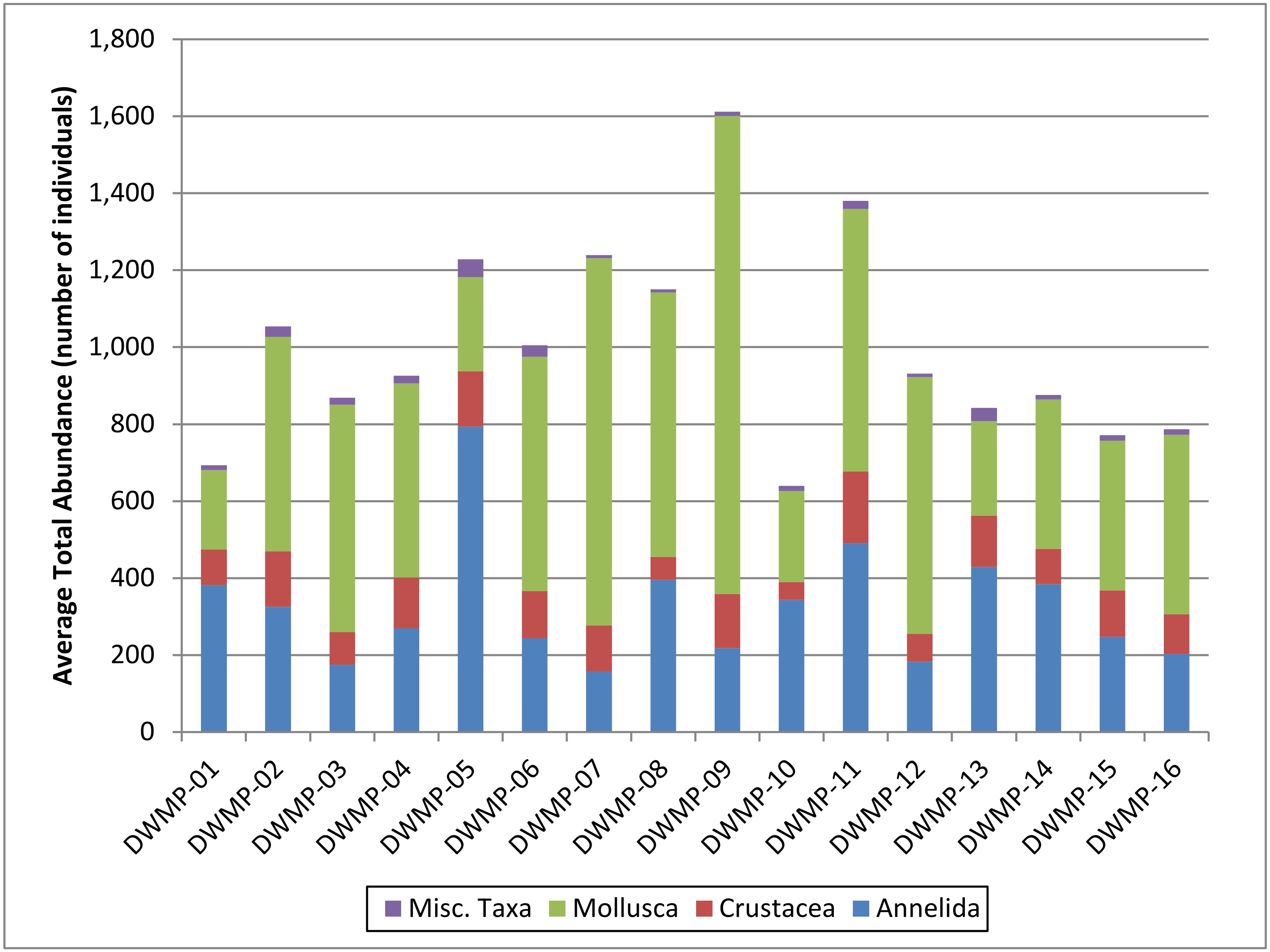


Figure 6. Benthic Community Structure Based on Average Abundance – 2007

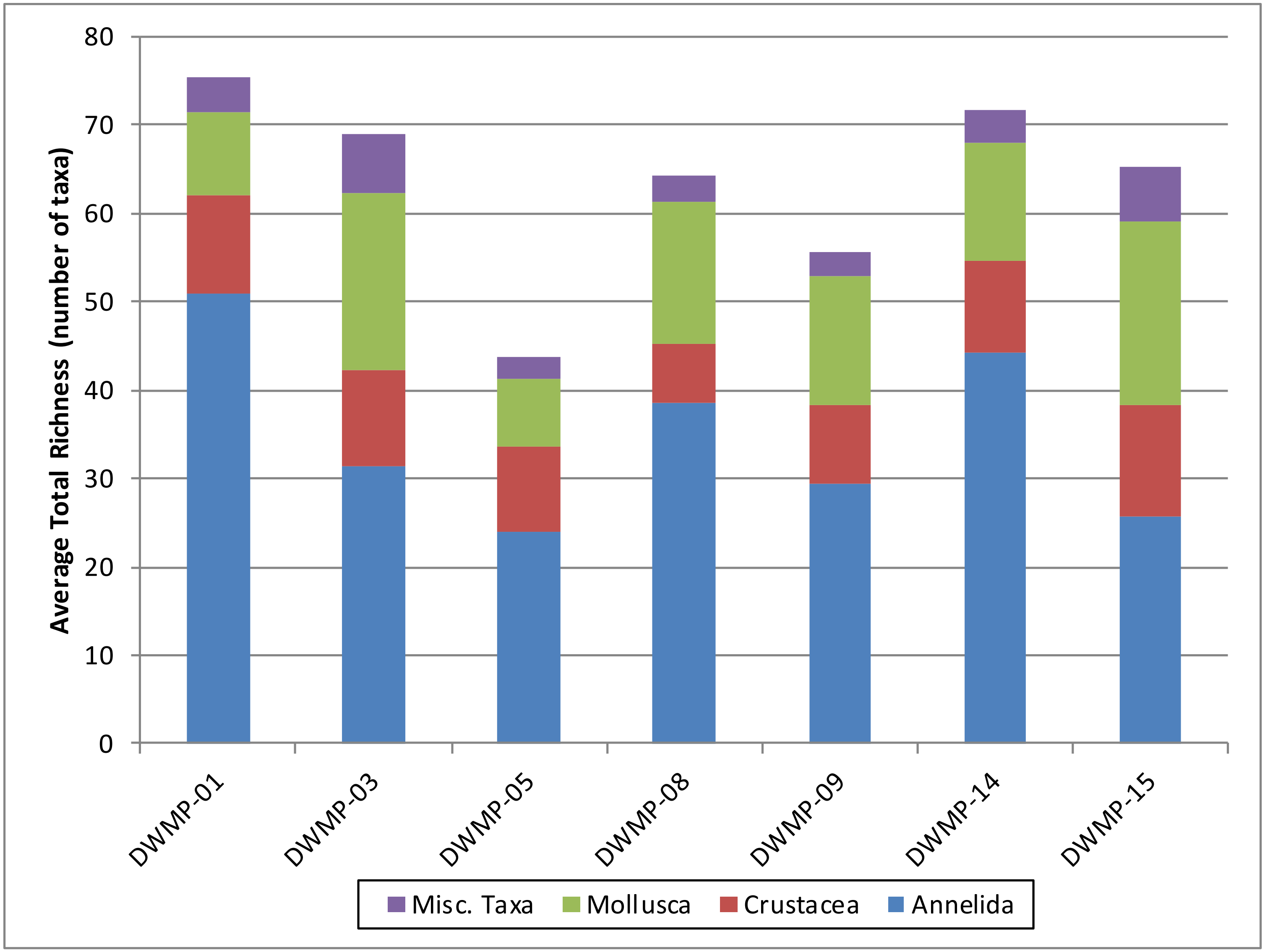


Figure 7. Benthic Community Structure Based on Average Richness - 2008

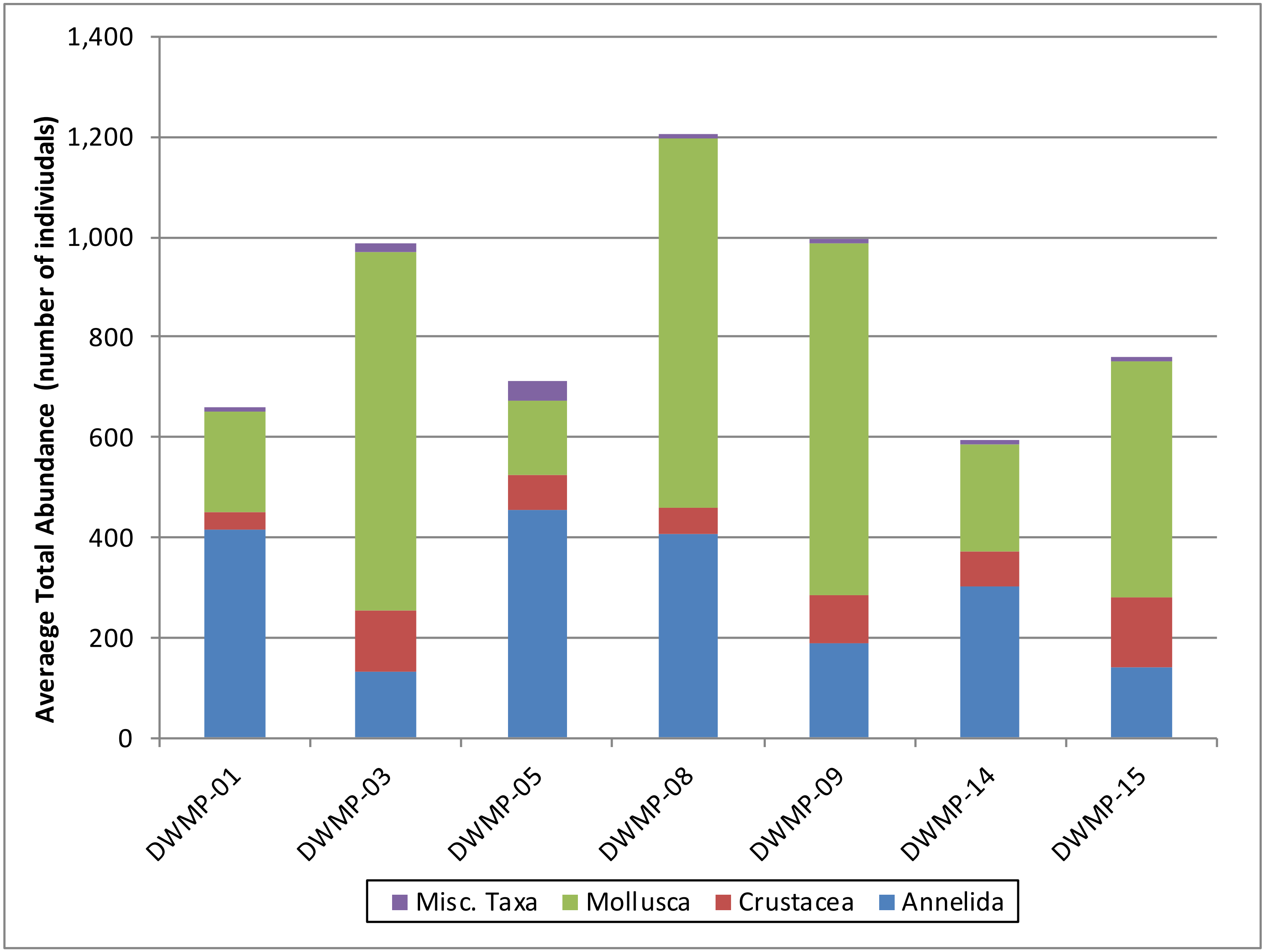


Figure 8. Benthic Community Structure Based on Average Abundance - 2008

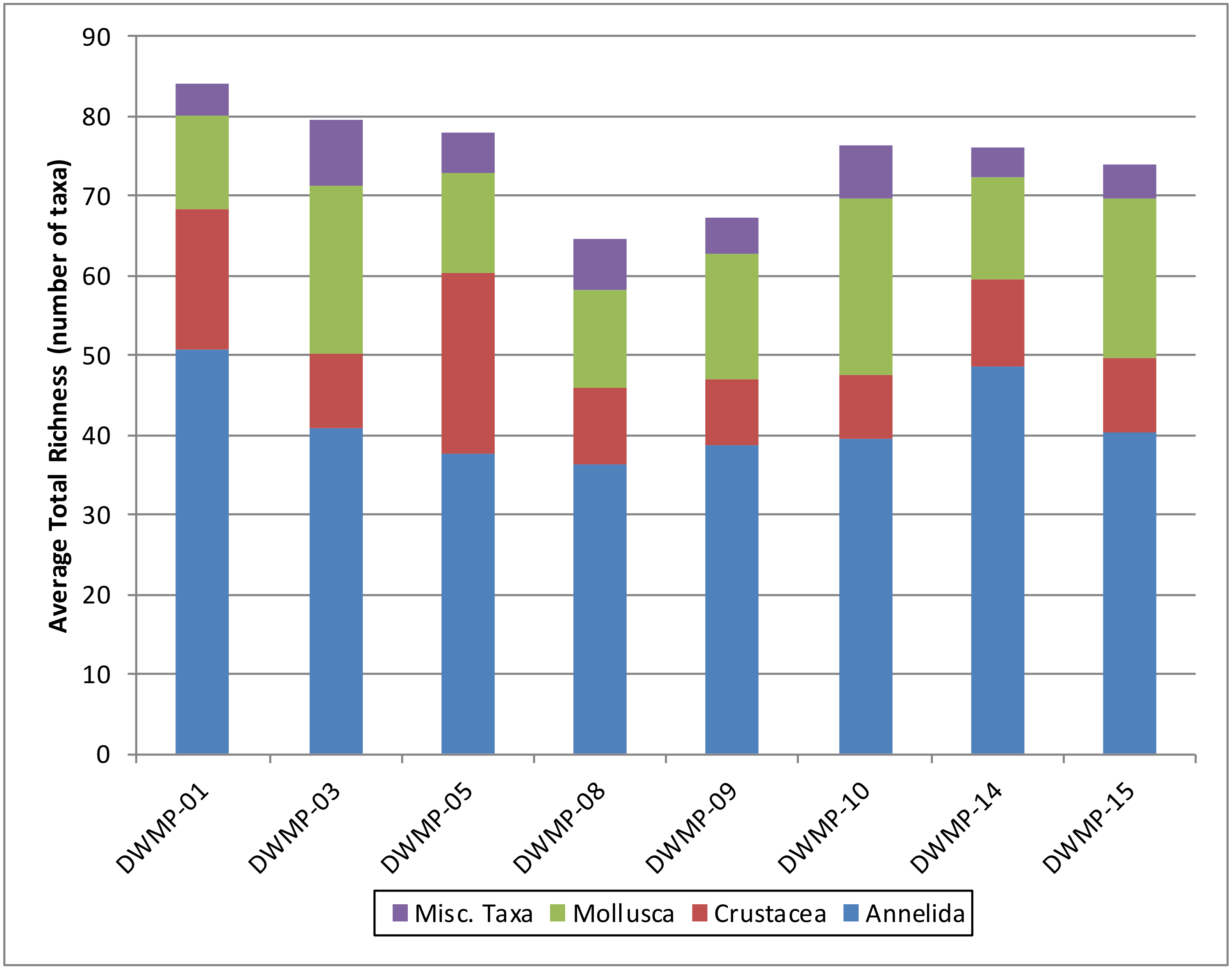


Figure 9. Benthic Community Structure Based on Average Richness - 2009

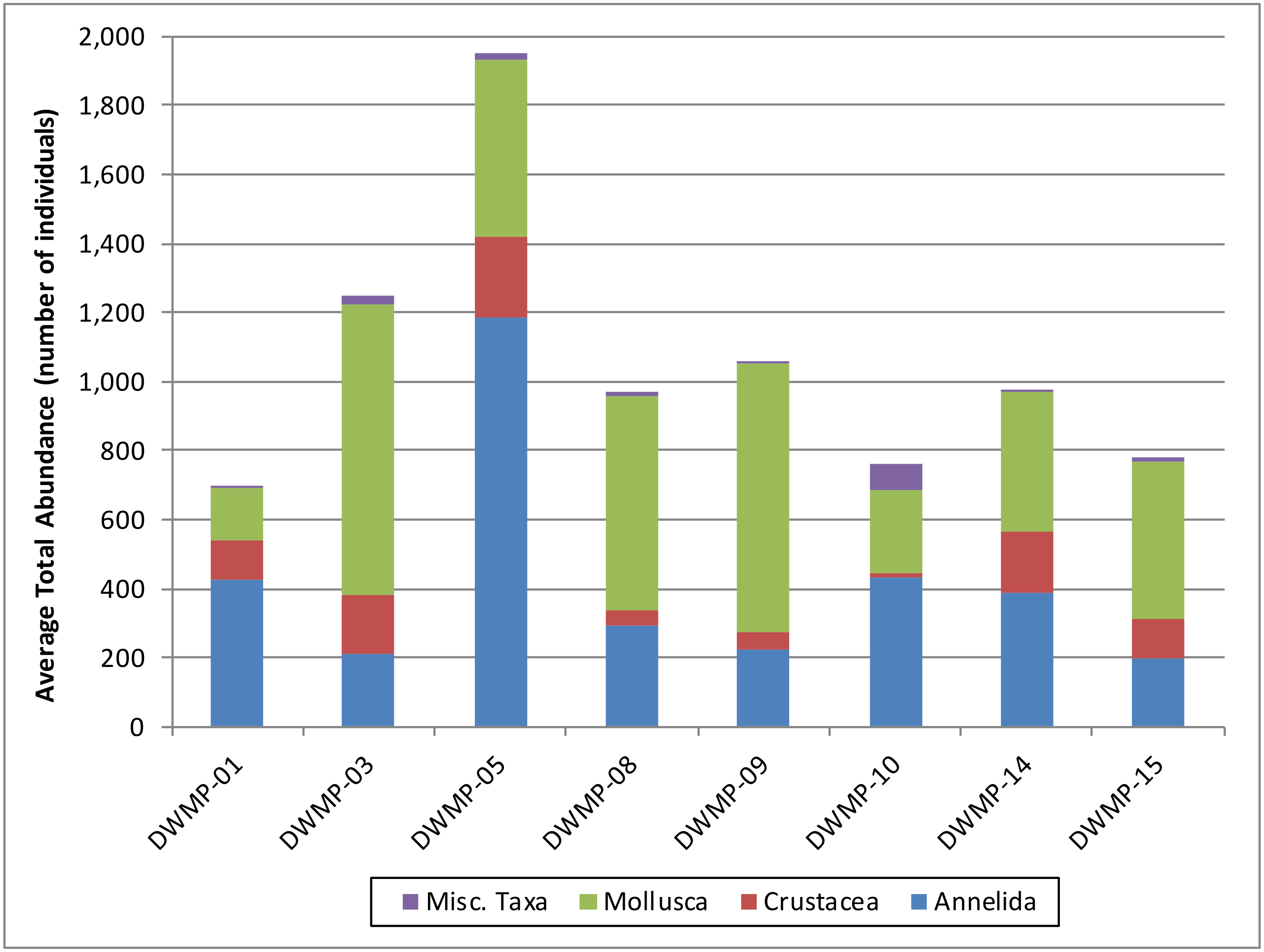


Figure 10. Benthic Community Structure Based on Average Abundance – 2009

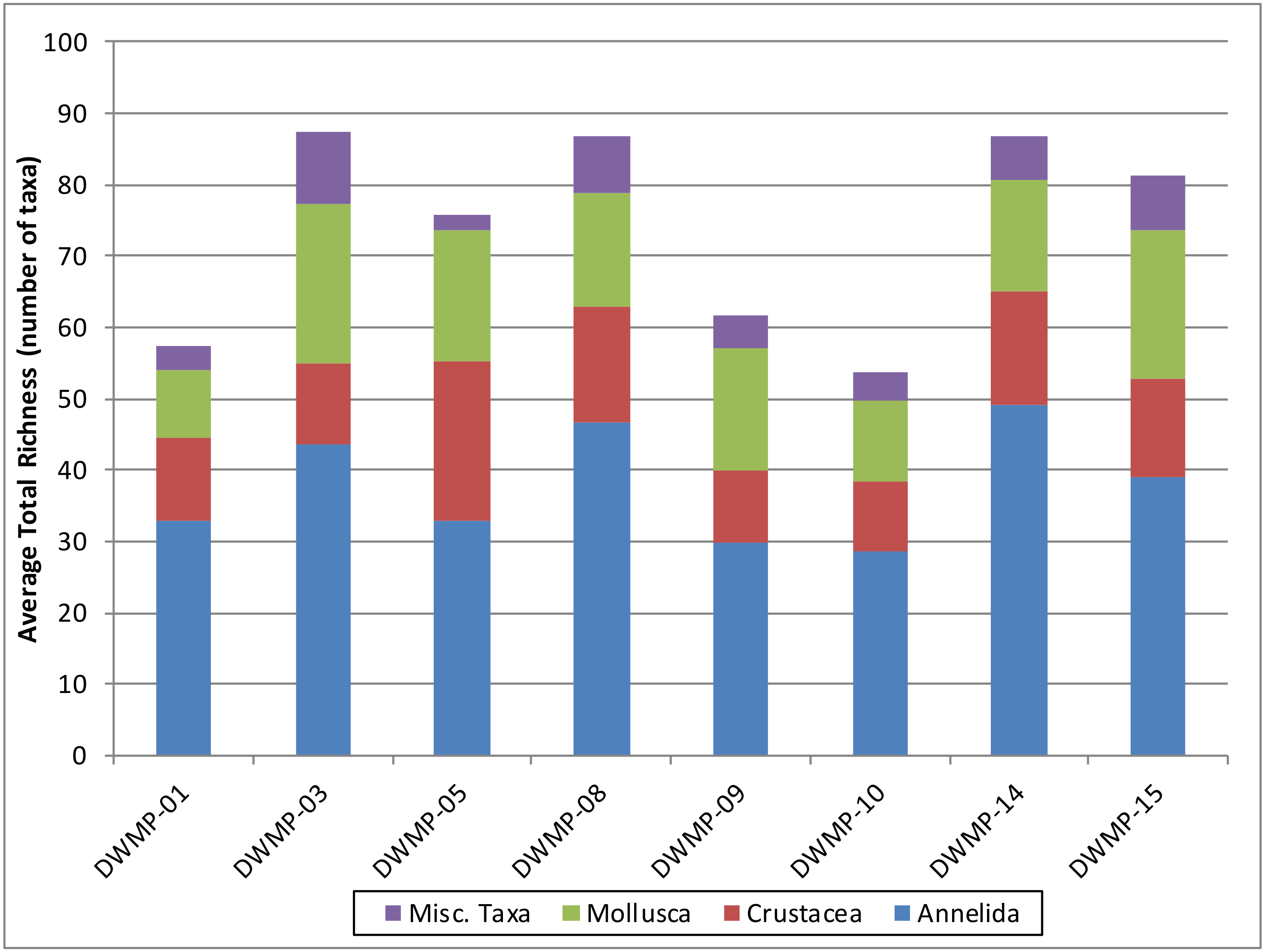


Figure 11. Benthic Community Structure Based on Average Richness - 2010

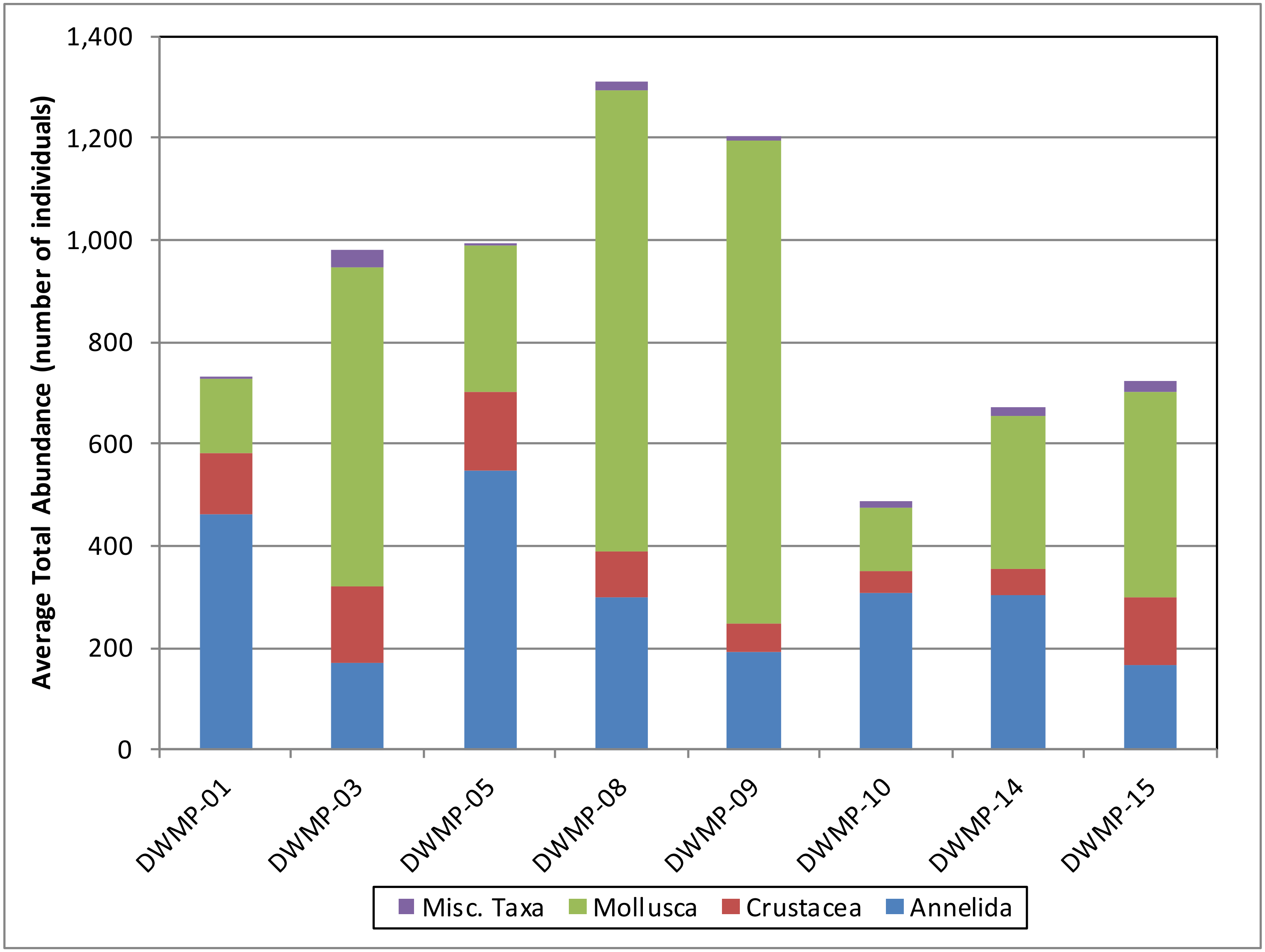


Figure 12. Benthic Community Structure Based on Average Abundance - 2010

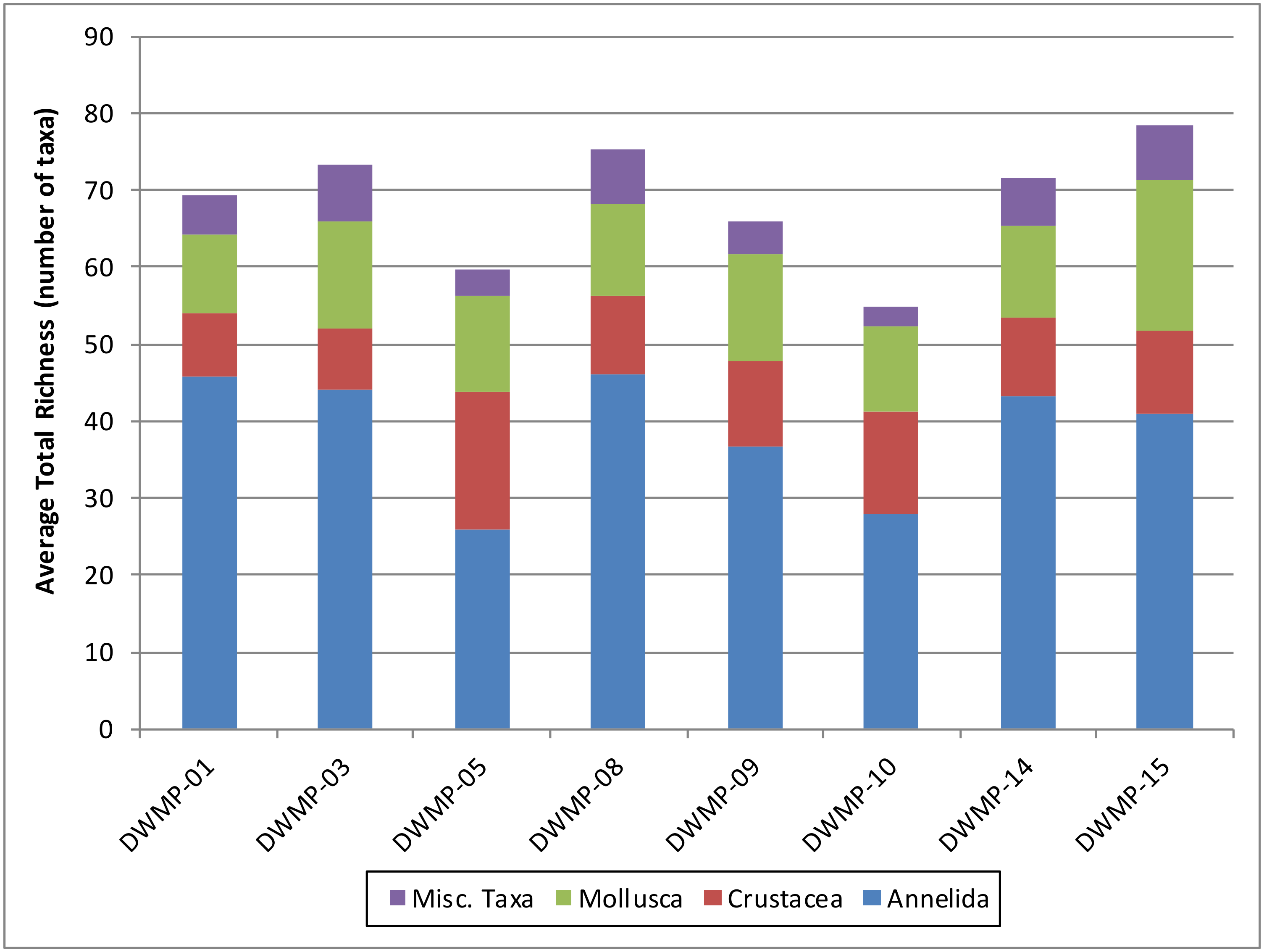


Figure 13. Benthic Community Structure Based on Average Richness - 2015

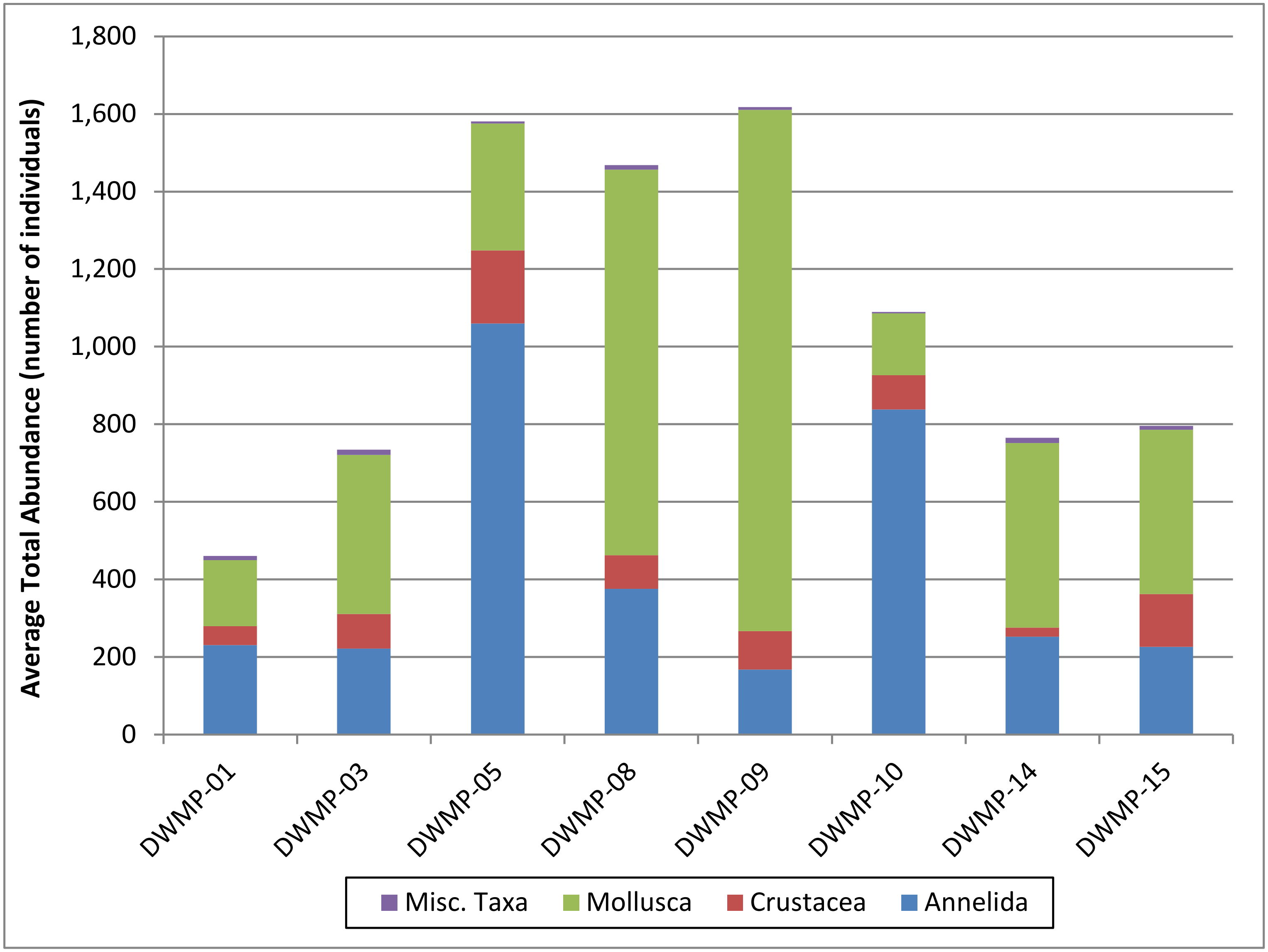


Figure 14. Benthic Community Structure Based on Average Abundance - 2015

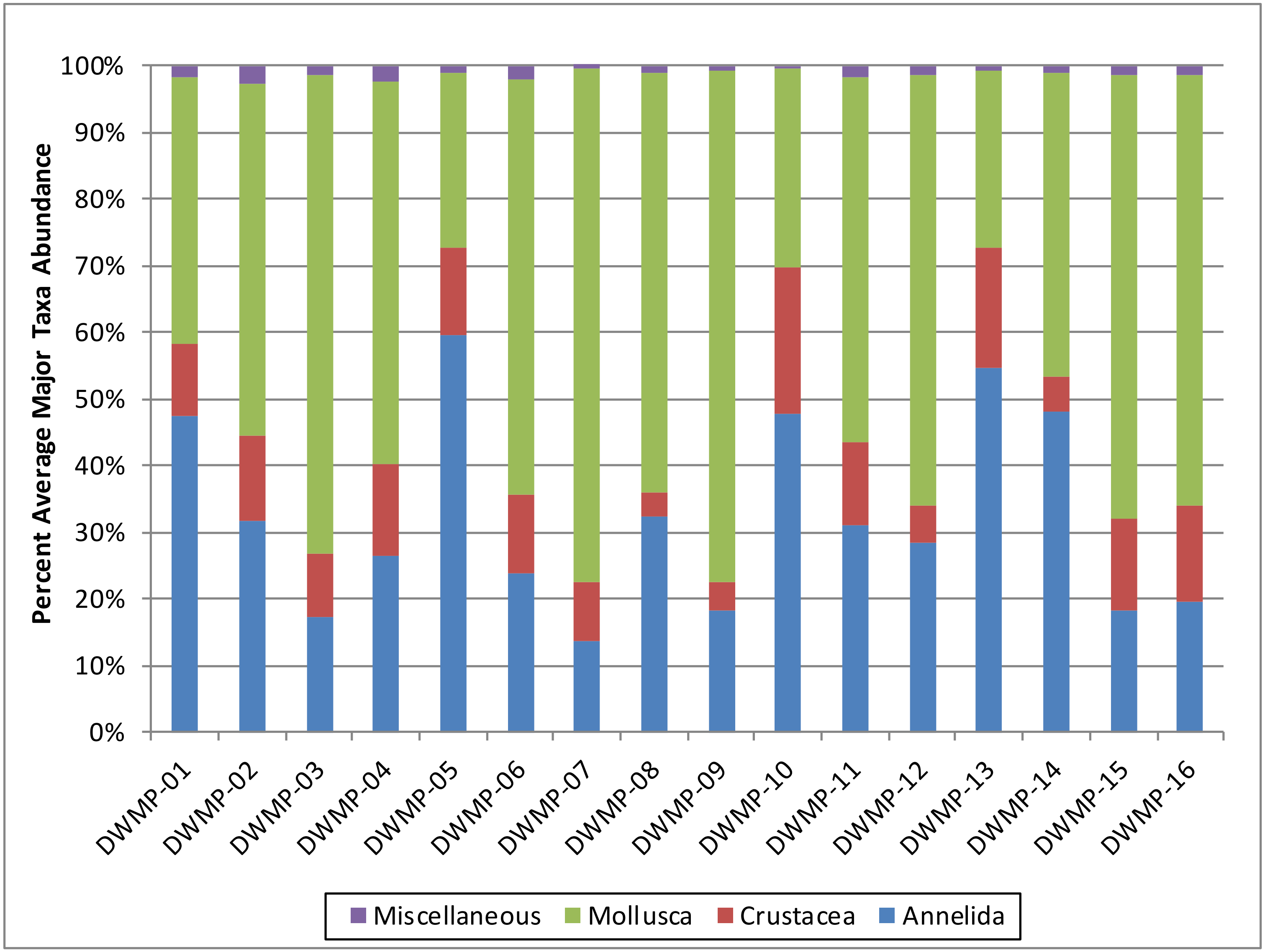


Figure 15. Percent Major Taxa Abundance of Average Total Abundance by Station – 2006

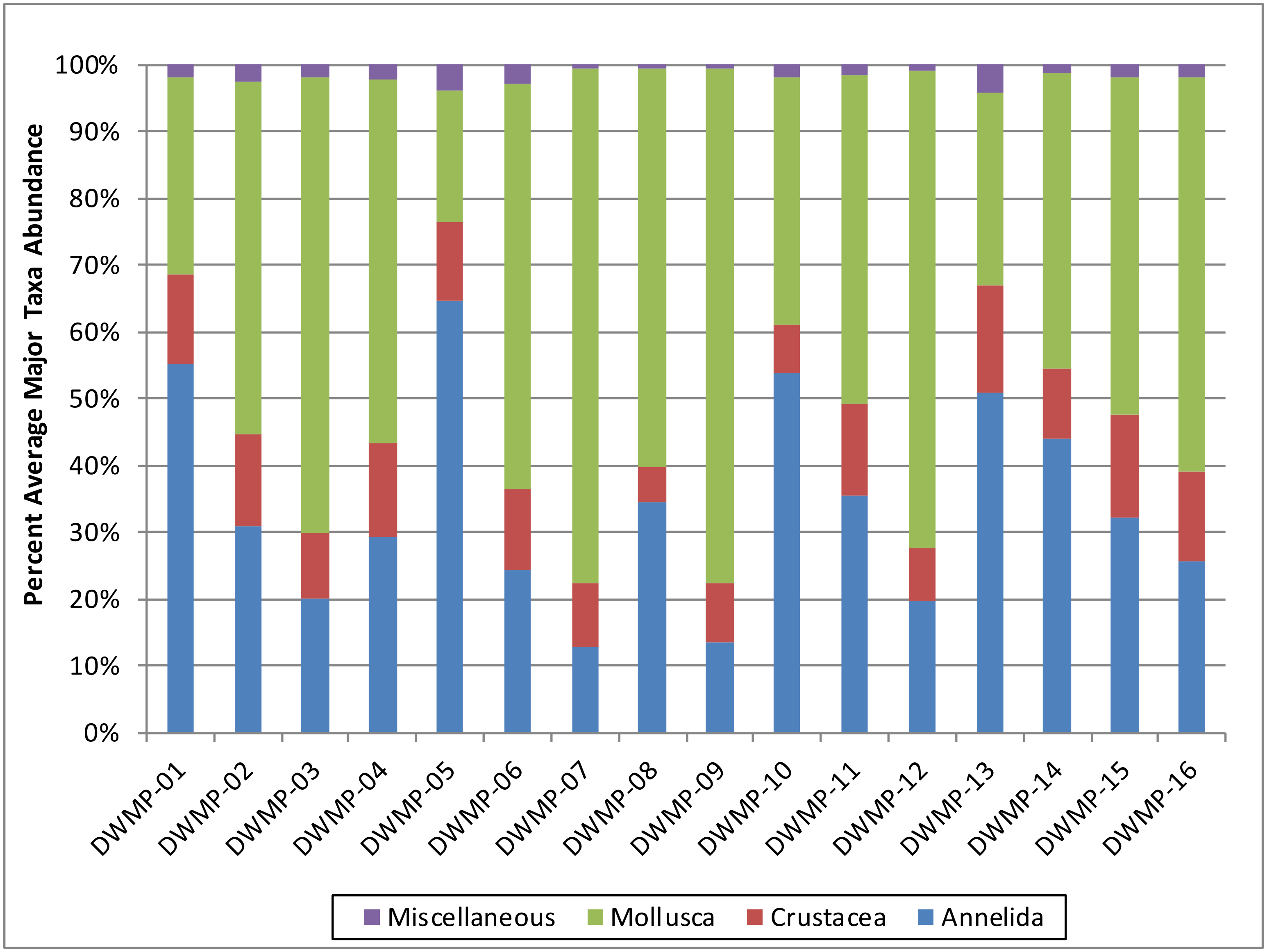


Figure 16. Percent Major Taxa Abundance of Average Total Abundance by Station – 2007

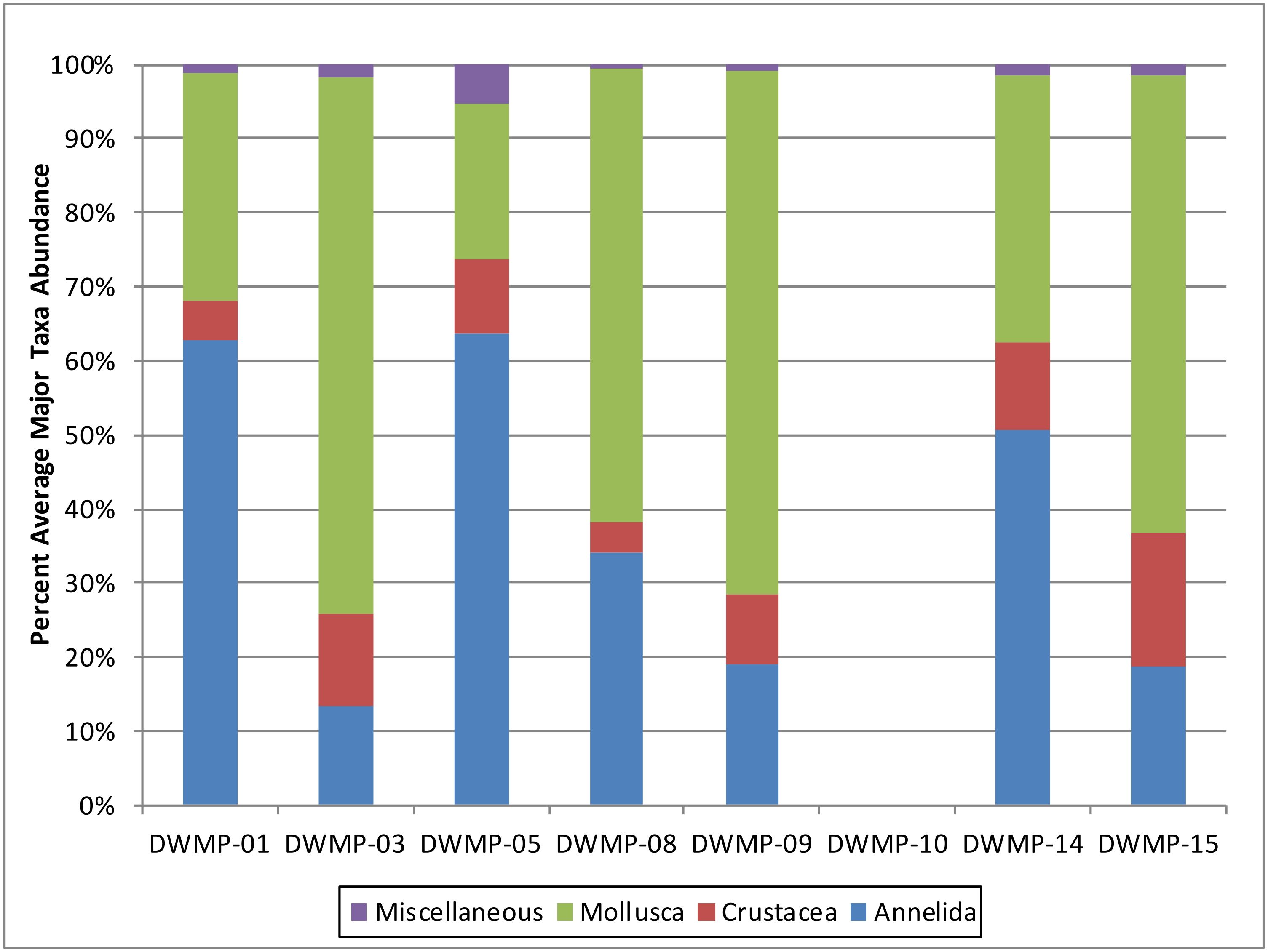


Figure 17. Percent Major Taxa Abundance of Average Total Abundance by Station – 2008

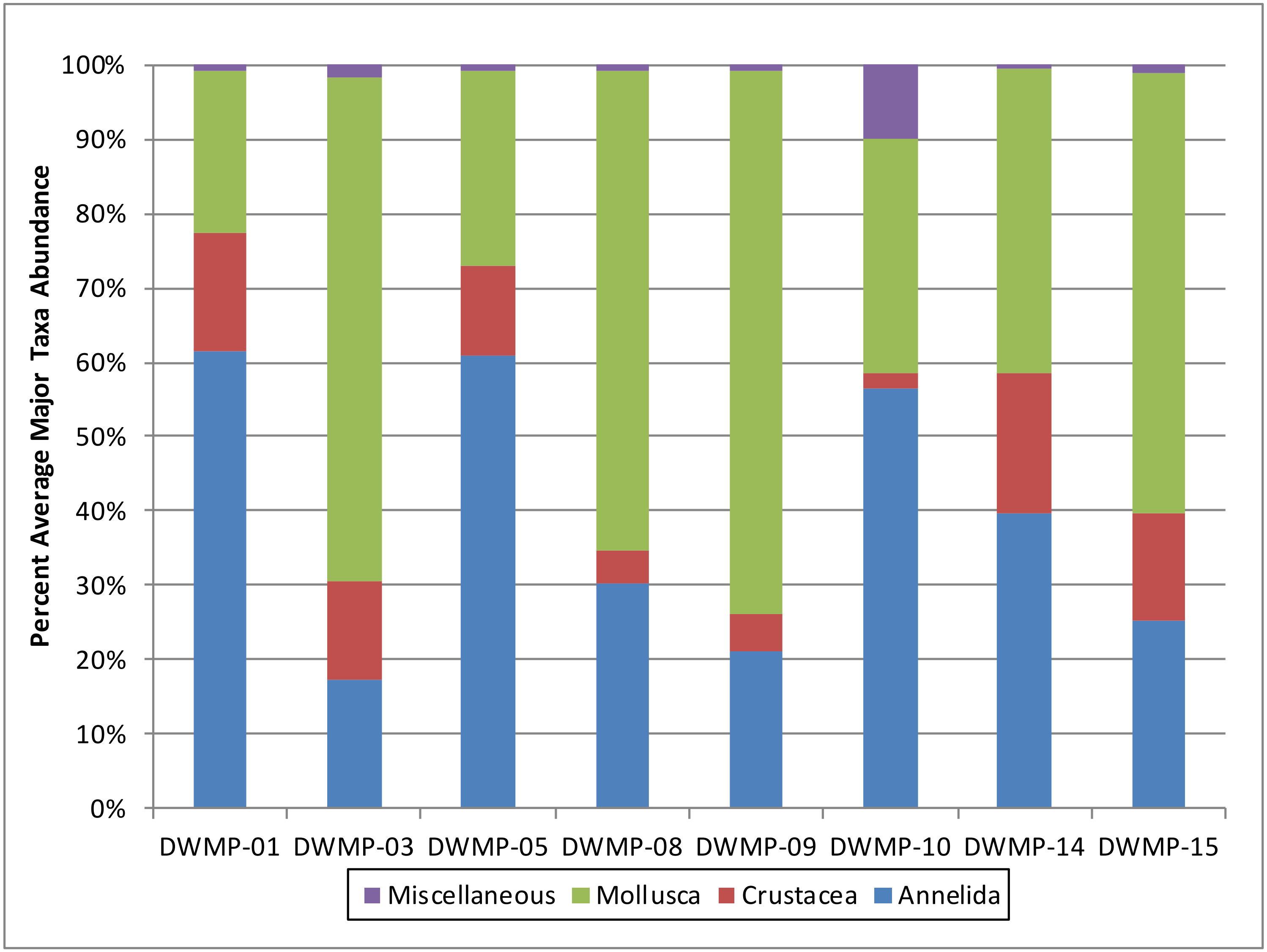


Figure 18. **Percent Major Taxa Abundance of Average Total Abundance by Station – 2009**

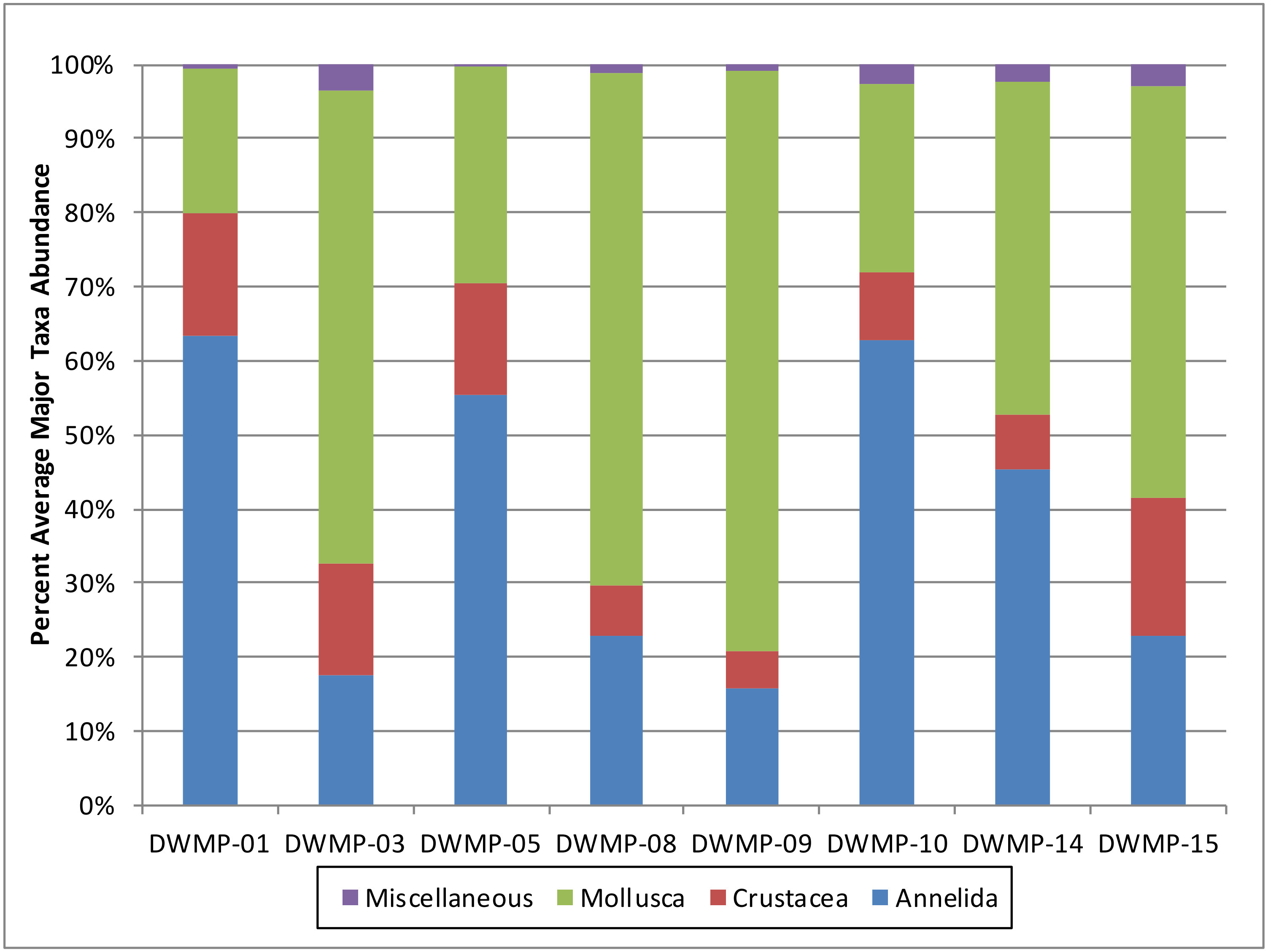


Figure 19. Percent Major Taxa Abundance of Average Total Abundance by Station – 2010

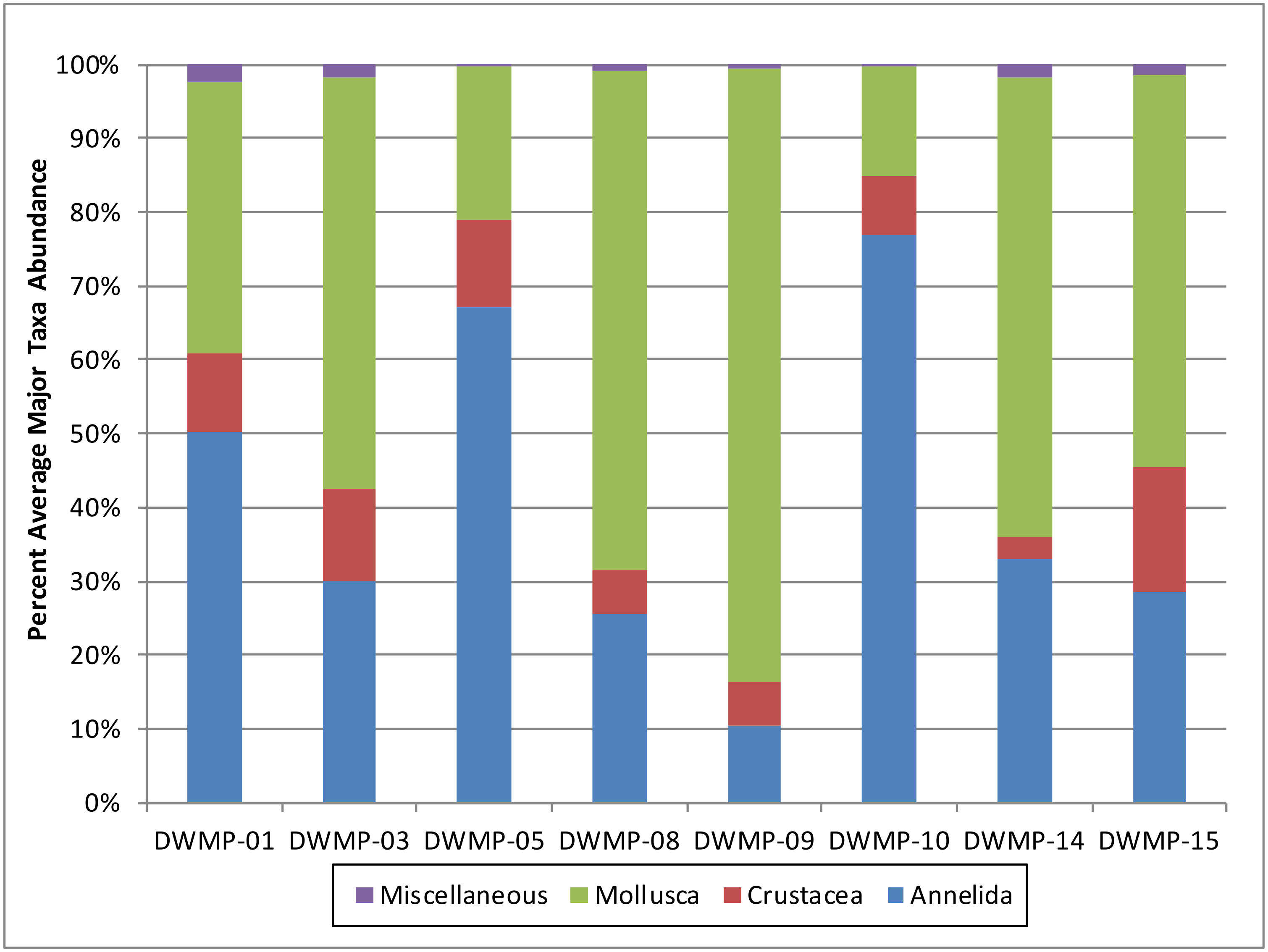


Figure 20. Percent Major Taxa Abundance of Average Total Abundance by Station – 2015

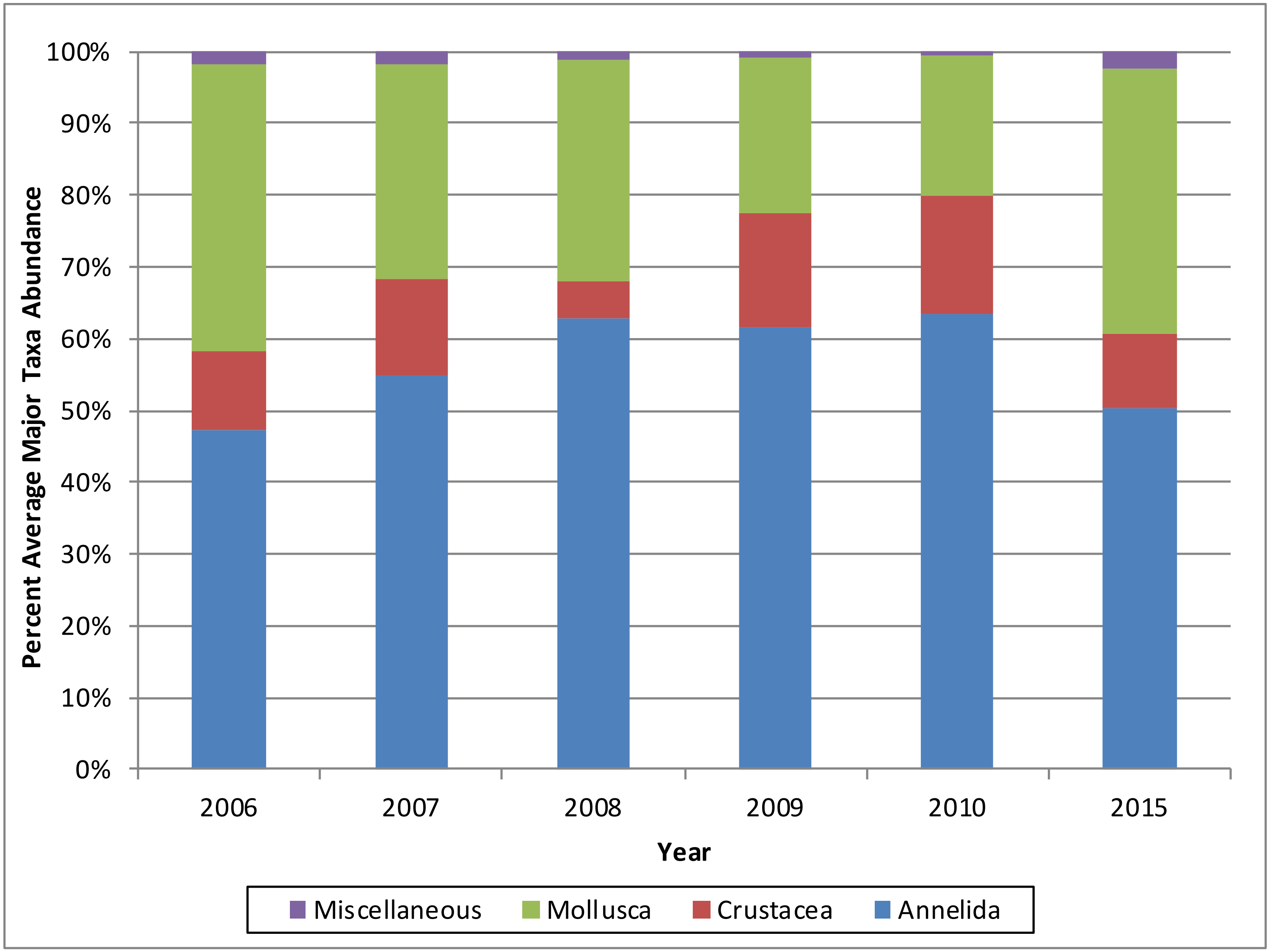


Figure 21. Percent Major Taxa Abundance of Average Total Abundance by Year – DWMP-01

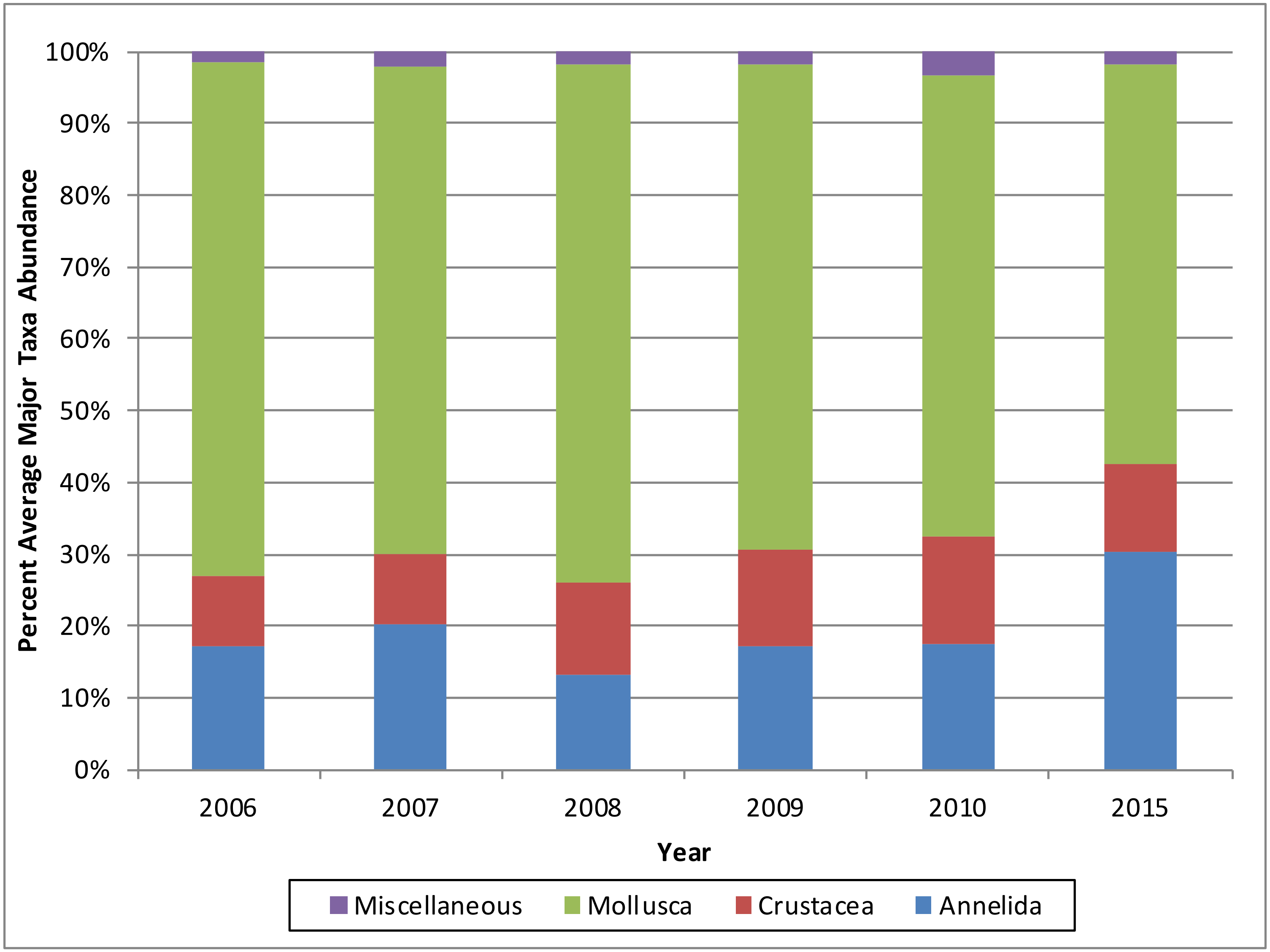


Figure 22. Percent Major Taxa Abundance of Average Total Abundance by Year – DWMP-03

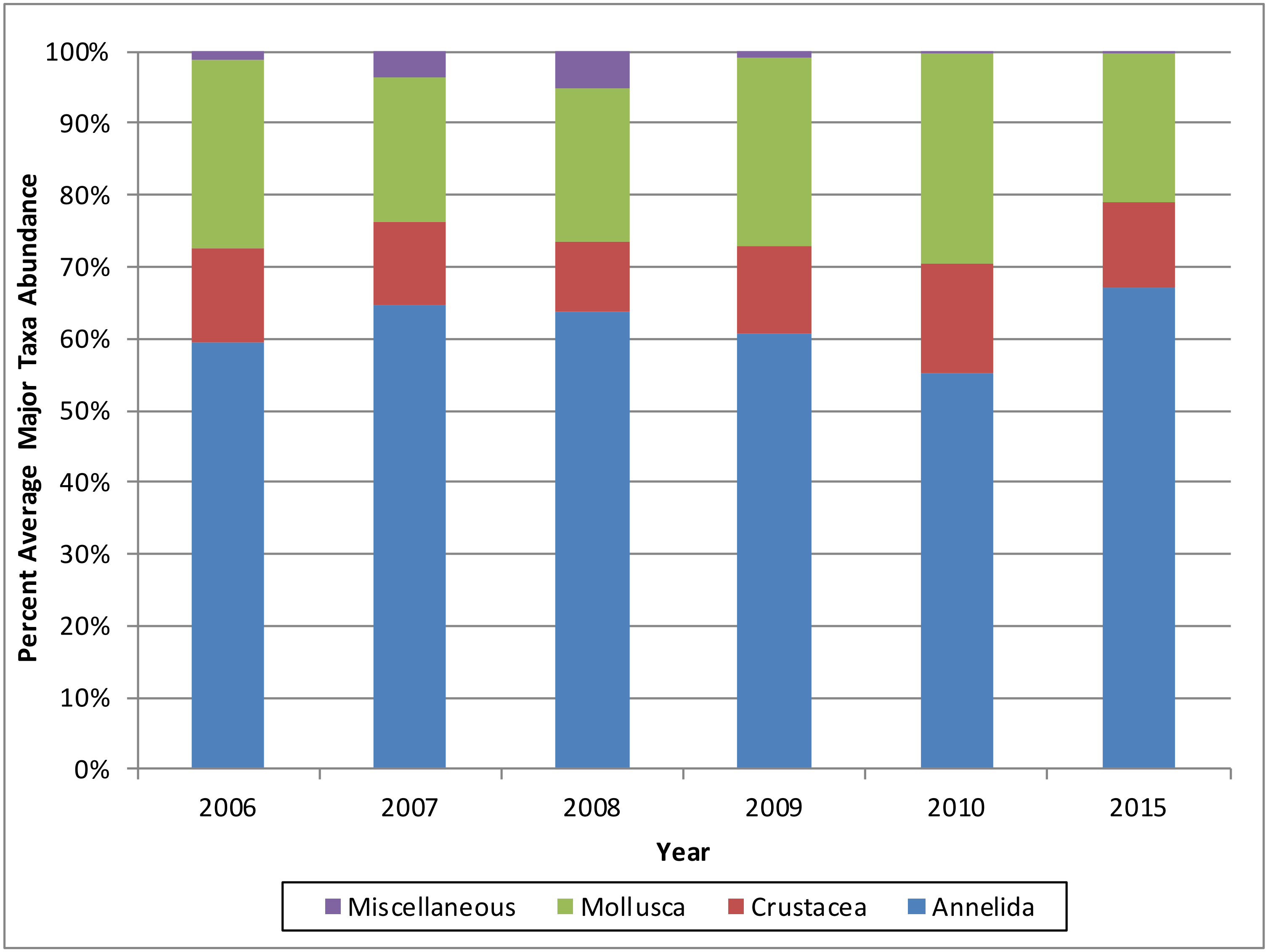


Figure 23. Percent Major Taxa Abundance of Average Total Abundance by Year – DWMP-05

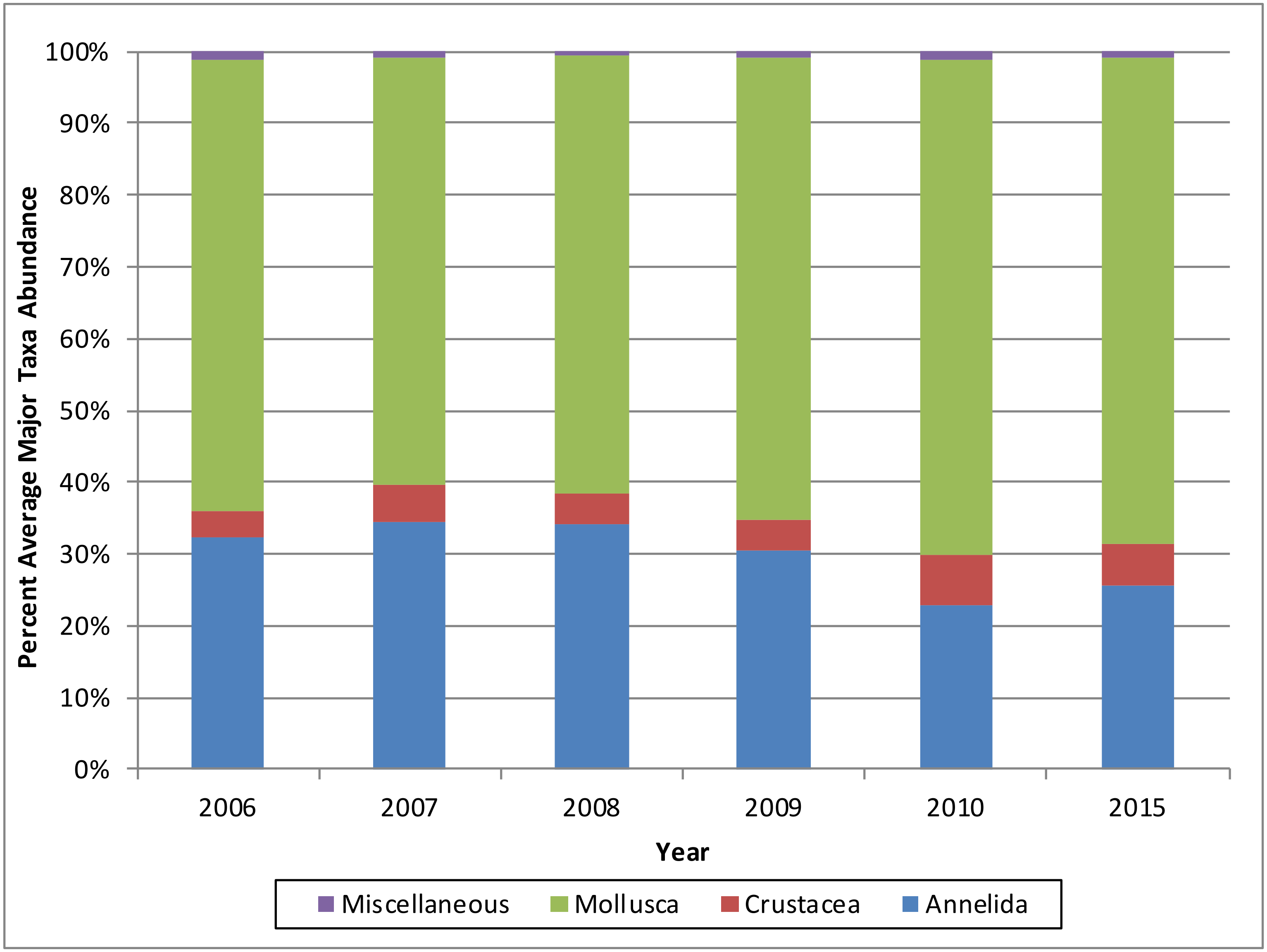


Figure 24. Percent Major Taxa Abundance of Average Total Abundance by Year – DWMP-08

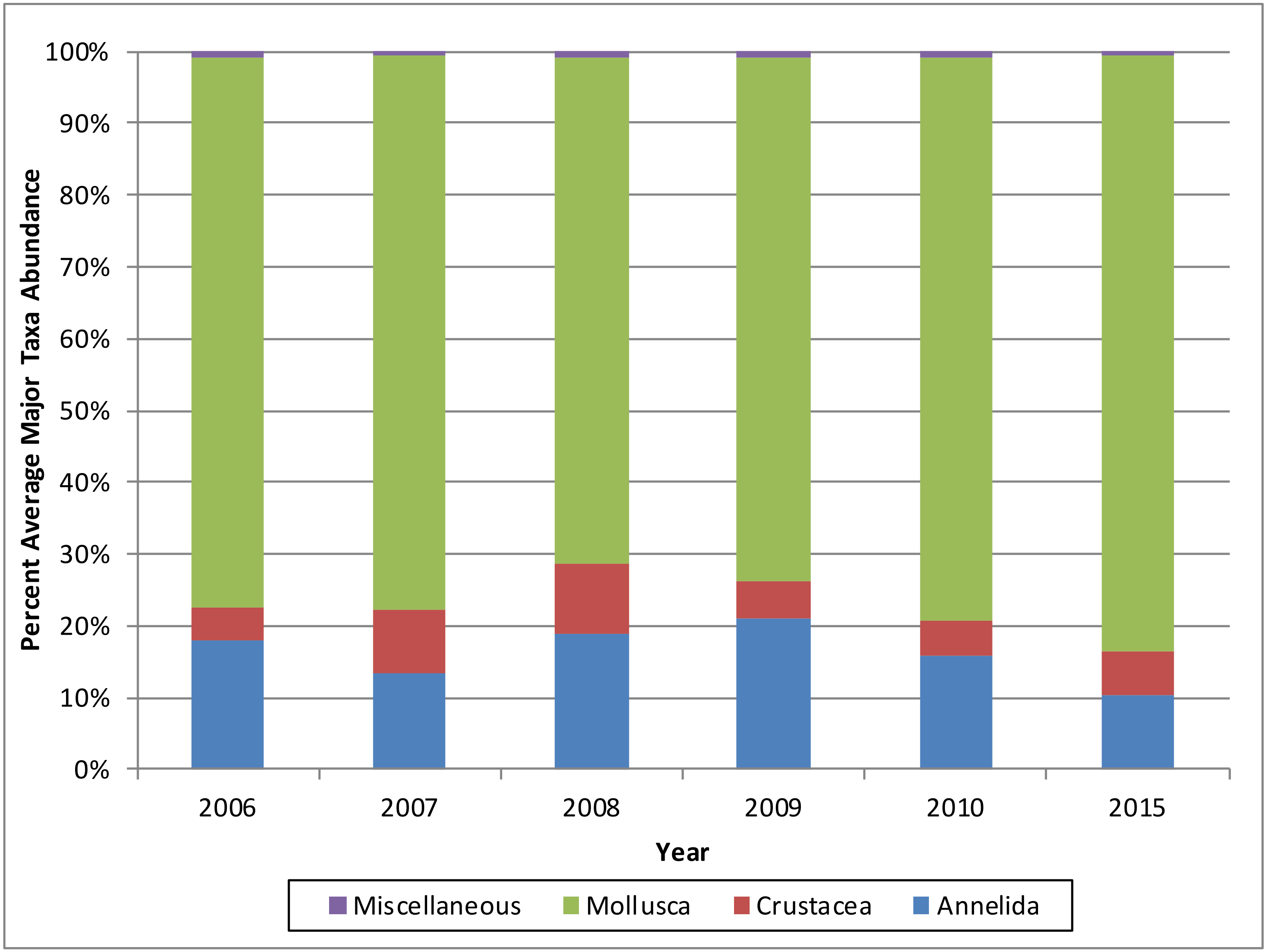


Figure 25. Percent Major Taxa Abundance of Average Total Abundance by Year – DWMP-09

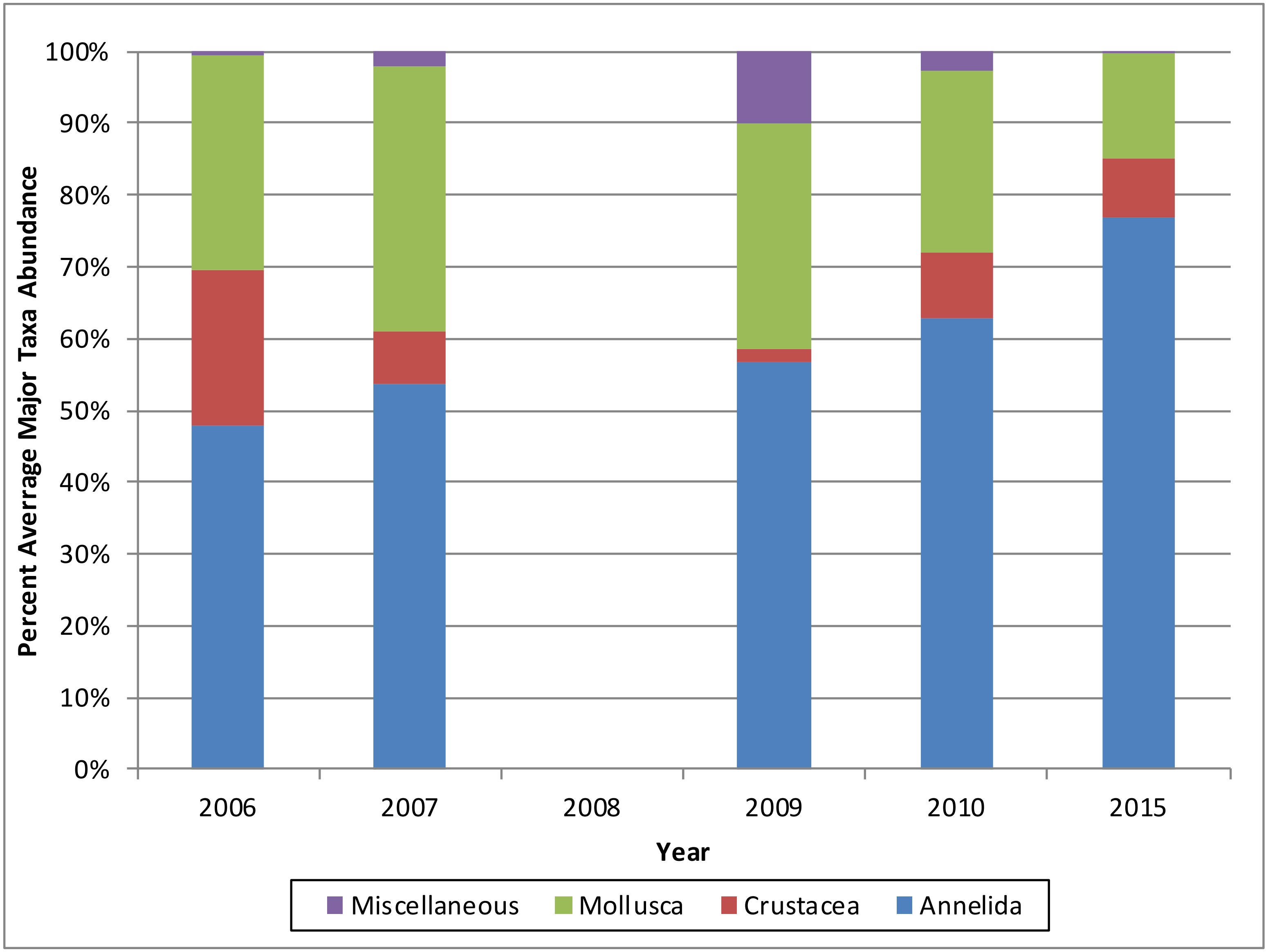


Figure 26. Percent Major Taxa Abundance of Average Total Abundance by Year – DWMP-10

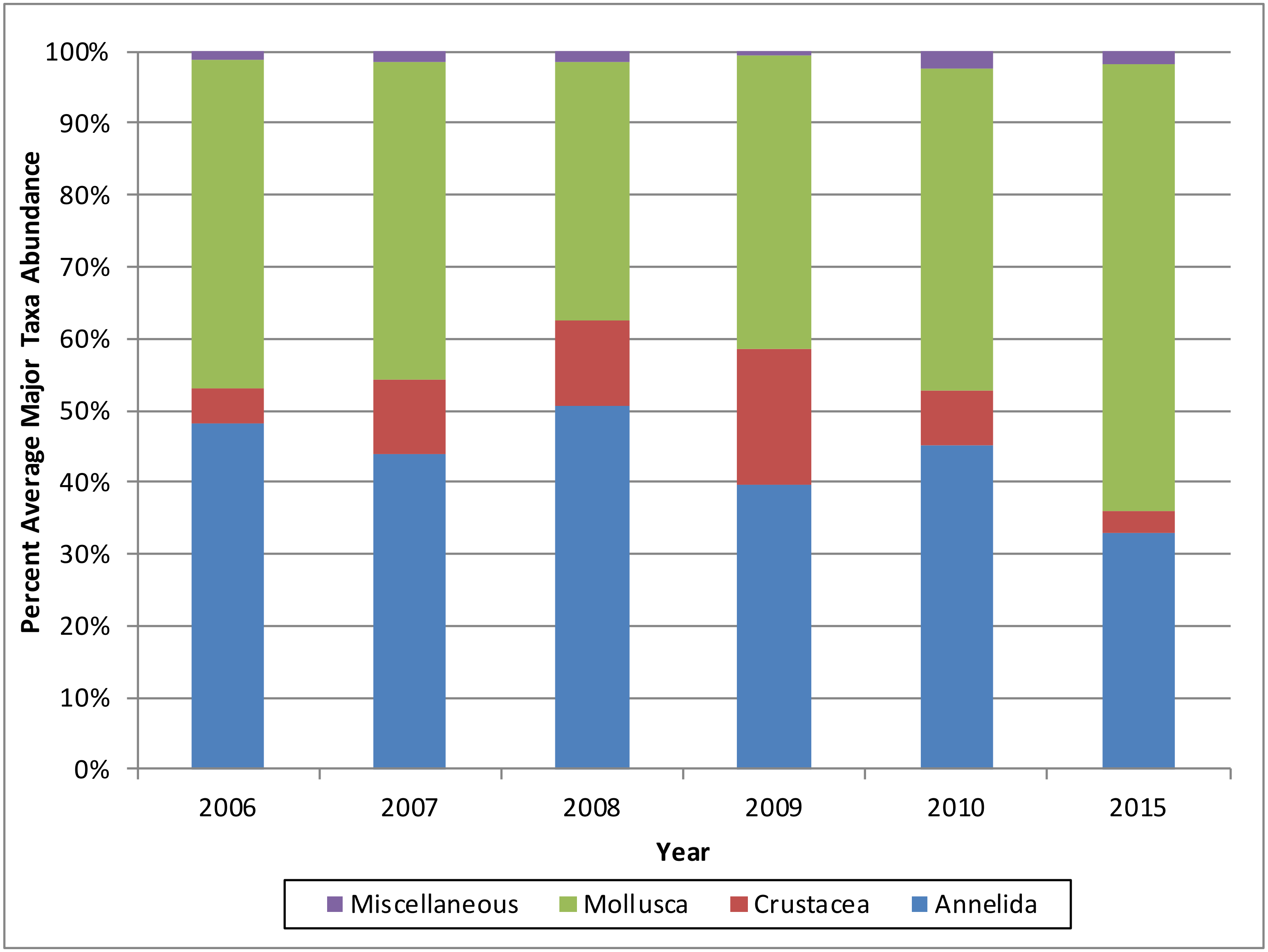


Figure 27. Percent Major Taxa Abundance of Average Total Abundance by Year – DWMP-14

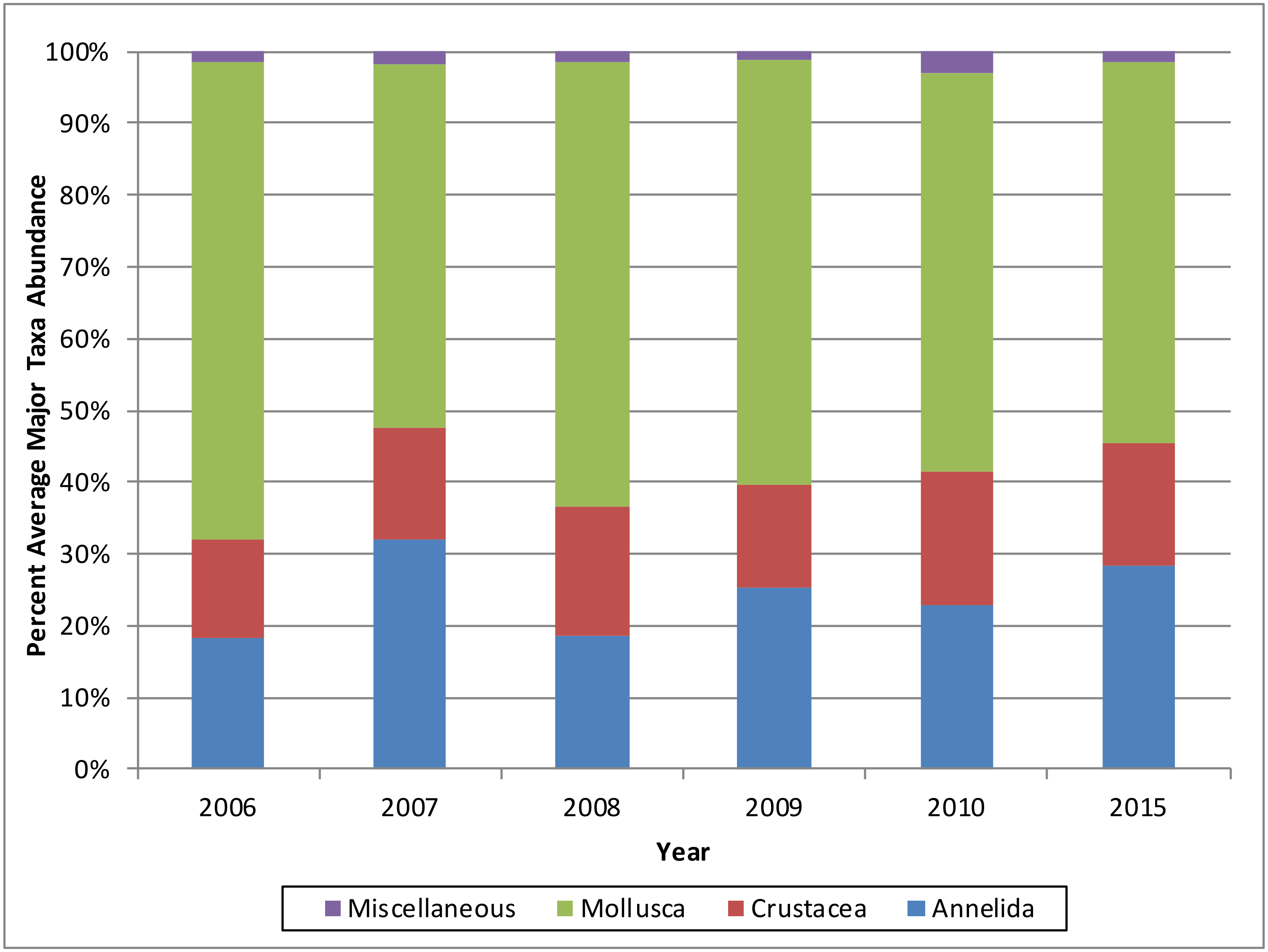
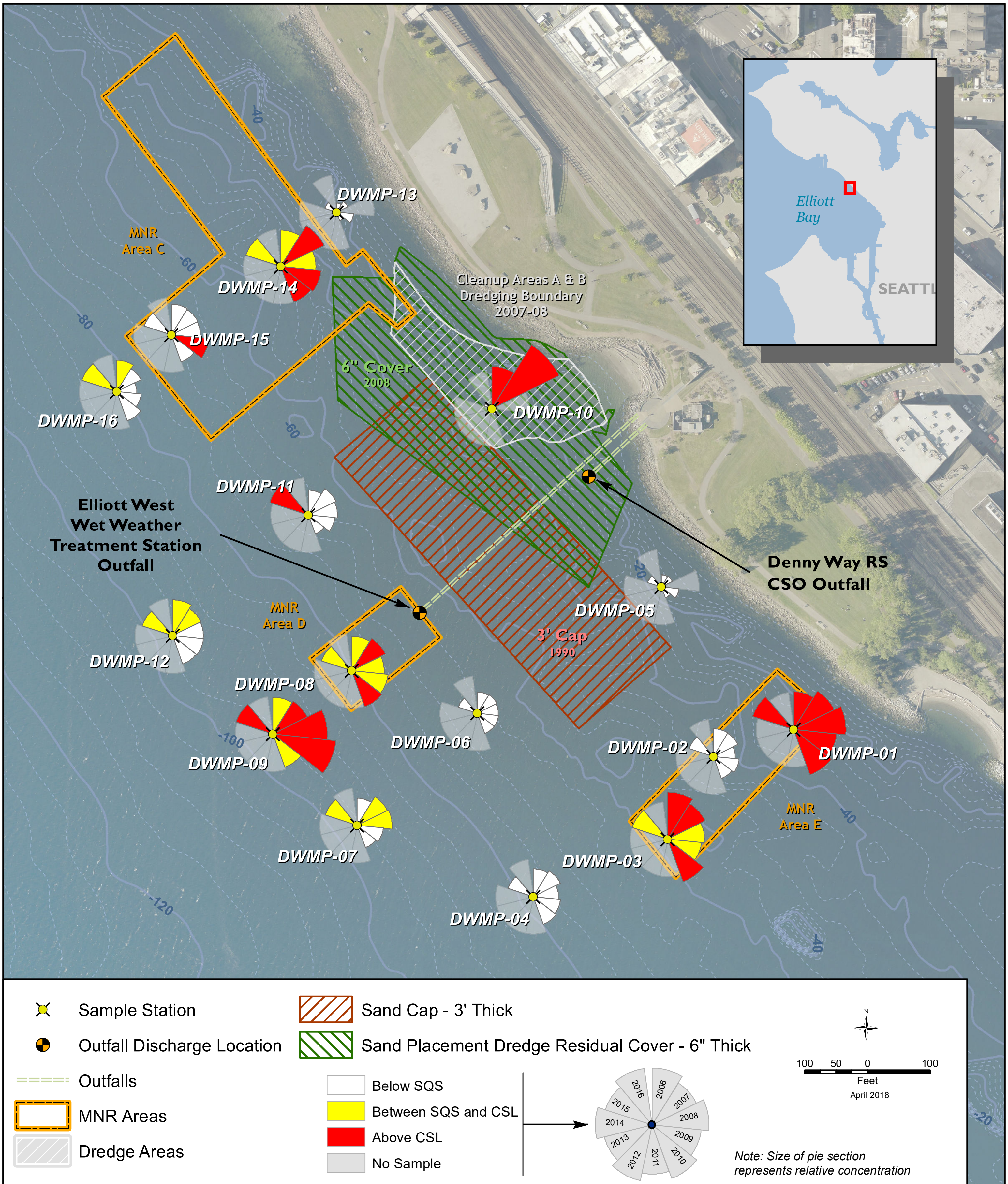


Figure 28. Percent Major Taxa Abundance of Average Total Abundance by Year – DWMP-15



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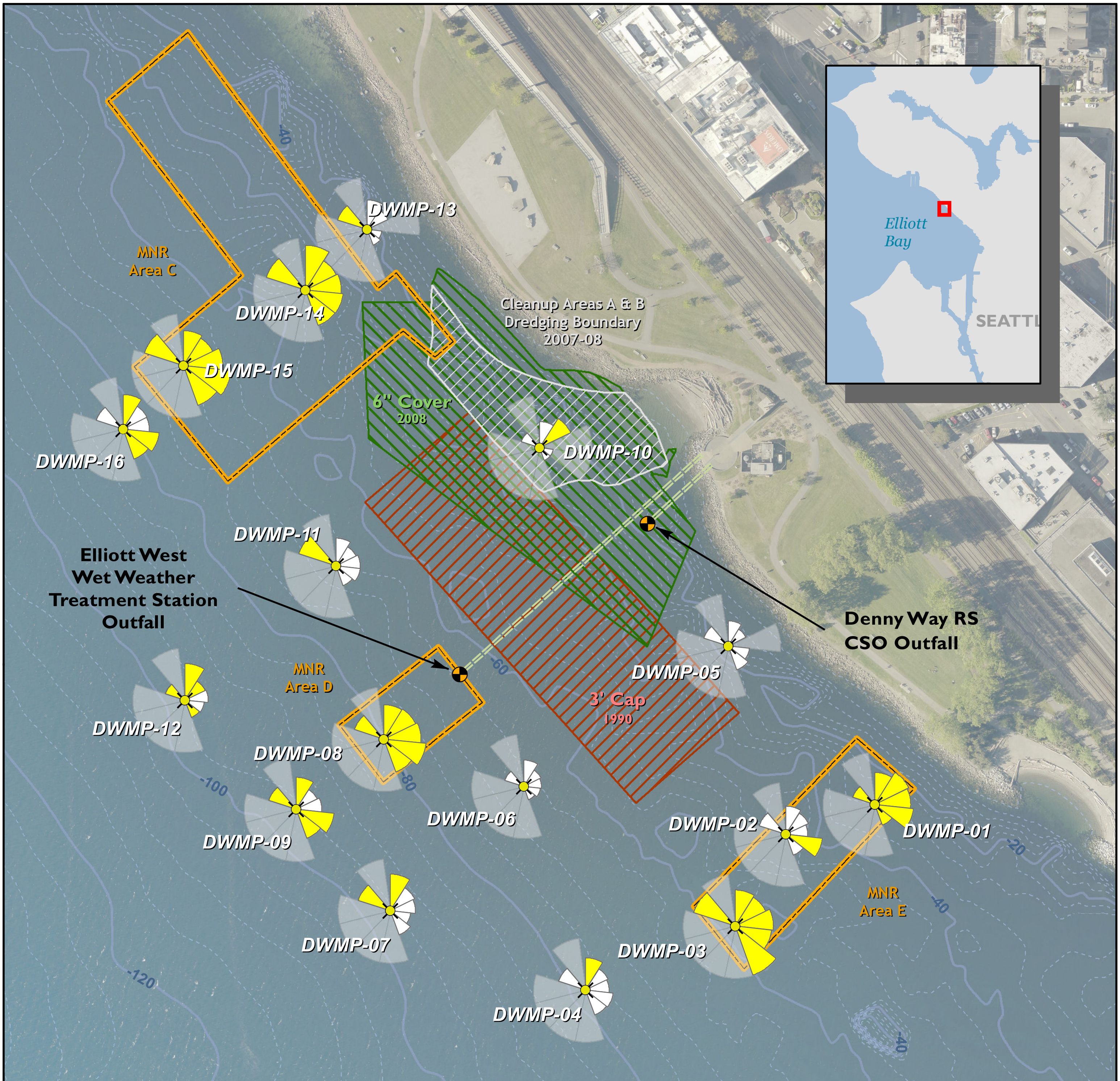
Wastewater Treatment Division

File Name: Q:\WTD\Projects\ElliottWest\Projects\EW_SedMonSampStations_HG.mxd oneilsh

Figure 29
Long-Term Sediment Monitoring Sampling Stations - Mercury
Denny Way/Lake Union CSO Control Project



Sample Station

Outfall Discharge Location

Outfalls

MNR Areas

Dredge Areas

Sand Cap - 3' Thick

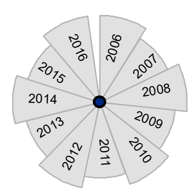
Sand Placement Dredge Residual Cover - 6" Thick

Below SQS

Between SQS and CSL

Above CSL

No Sample



N

100 50 0 100

Feet

April 2018

Note: Size of pie section represents relative concentration

King County

Department of Natural Resources and Parks

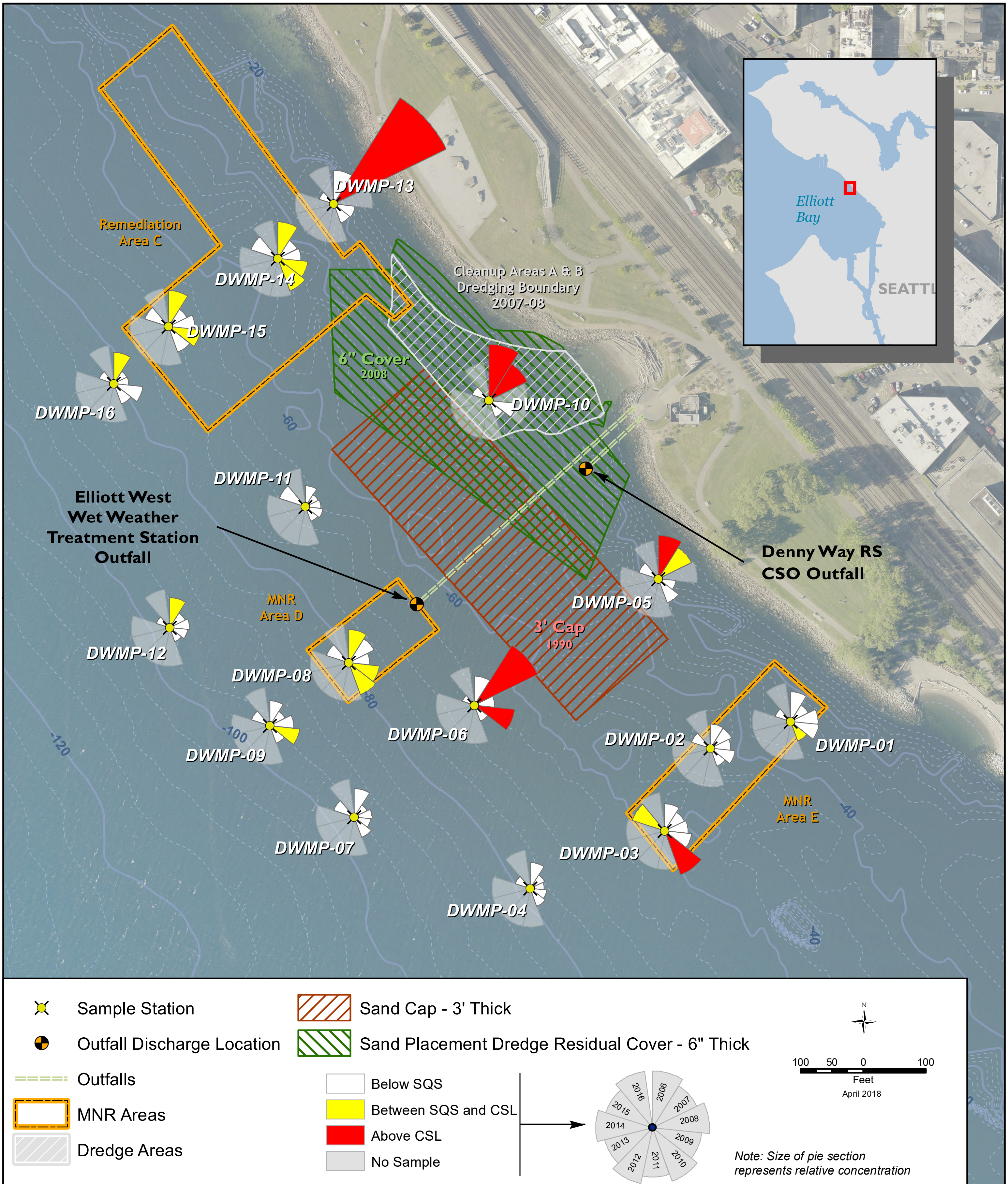
Wastewater Treatment Division

File Name: Q:\WTD\Projects\ElliottWest\Projects\EW_SedMonSampStations_PCB.mxd oneilsh

Figure 30

Long-Term Sediment Monitoring Sampling Stations - PCB

Denny Way/Lake Union CSO Control Project



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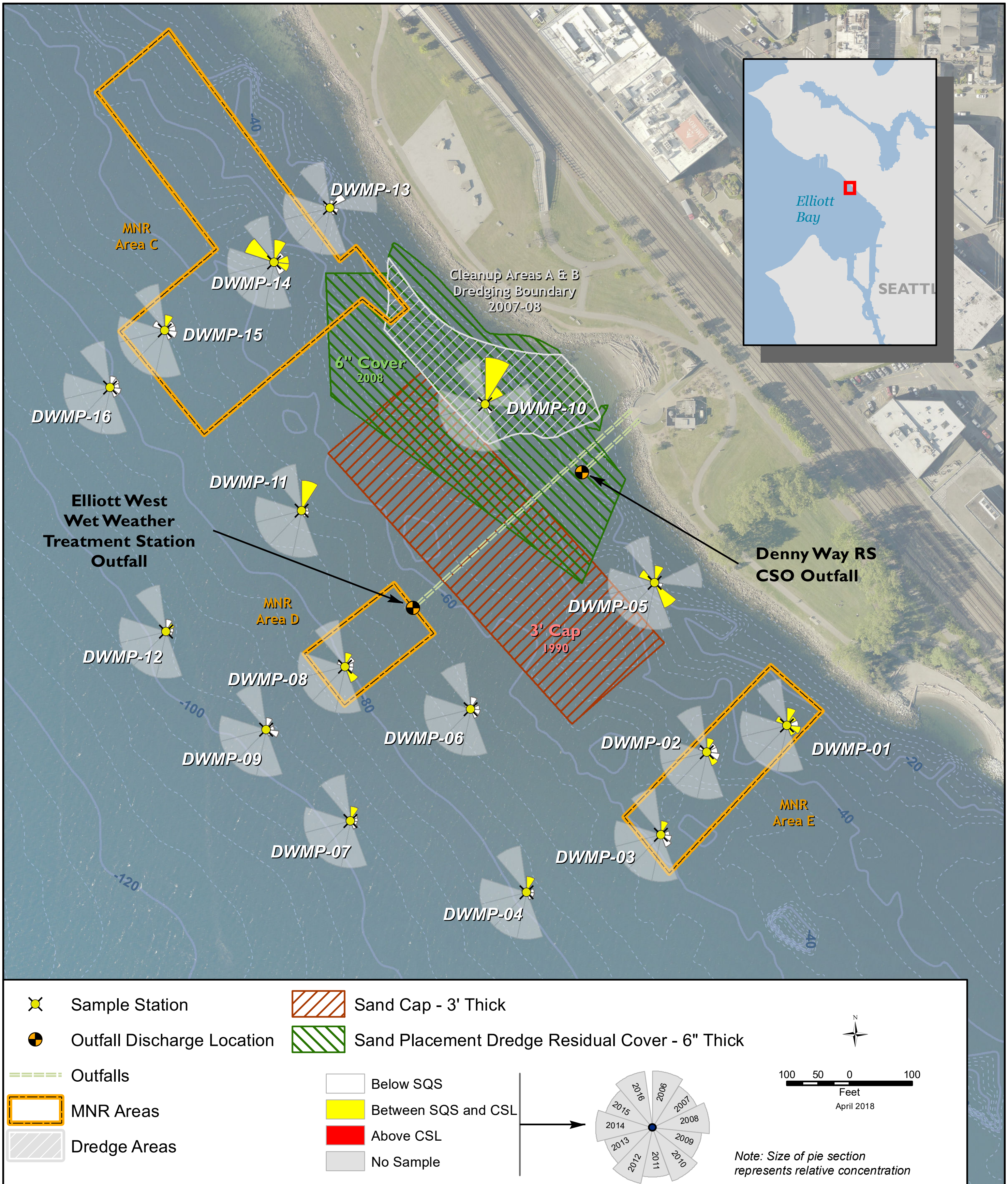
Department of
Natural Resources and Parks
Wastewater Treatment Division

File Name: Q:\WTD\Projects\ElliottWest\Projects\EW_SedMonSampStations_B2EHP.mxd oneilsh

Figure 31
Long-Term Sediment Monitoring Sampling Stations - BEHP
Denny Way/Lake Union CSO Control Project



King County
Department of Natural Resources and Parks
Wastewater Treatment Division

File Name: Q:\WTD\Projects\ElliottWest\Projects\EW_SedMonSampStations_BBP.mxd oneilsh

Figure 32
Long-Term Sediment Monitoring Sampling Stations - BBP
Denny Way/Lake Union CSO Control Project

Tables

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Table 1. Sediment Sampling Stations: Coordinates, Water Depths, Sediment Depth Strata, and Sample Collection Period

Station	Northing (NAD83)	Easting (NAD83)	Depth (-ft MLLW)	Sediment Depth Stratum (cm)	Sample Collection Period - Post-Operation of Wet Weather Treatment Station					
					Year 1 April 2006	Year 2 May 2007	Year 3 March 2008	Year 4 May 2009	Year 5 April 2010	Year 10 April 2015
DWMP-01	228813	1264047	35	0-2	✓	✓				
				0-10			✓	✓	✓	✓
DWMP-02	228770	1263919	41	0-2	✓	✓				
				0-10			✓	✓	✓	✓
DWMP-03	228638	1263846	56	0-2	✓	✓				
				0-10			✓	✓	✓	✓
DWMP-04	228546	1263631	81	0-2	✓	✓				
				0-10			✓	✓	✓	✓
DWMP-05	229041	1263836	13	0-2	✓	✓				
				0-10			2	✓[1]	✓	✓
DWMP-06	228839	1263542	66	0-2	✓	✓	✓	✓	✓	
				0-10						✓
DWMP-07	228660	1263350	96	0-2	✓	✓	✓	✓	✓	
				0-10						✓
DWMP-08	228907	1263341	81	0-2	✓	✓	✓	✓	✓	
				0-10			✓	✓	✓	✓
DWMP-09	228806	1263215	95	0-2	✓	✓	✓	✓	✓	
				0-10						✓
DWMP-10	229326	1263565	20	0-2	✓	✓				
				0-10				✓[1]	✓	✓
DWMP-11	229156	1263272	68	0-2	✓	✓	✓	✓	✓	
				0-10						✓
DWMP-12	228963	1263055	90	0-2	✓	✓	✓	✓	✓	
				0-10						✓
DWMP-13	229640	1263317	18	0-2	✓[1]	✓				
				0-10				✓[1]	✓	✓
DWMP-14	229553	1263228	42	0-2	✓	✓				
				0-10			✓	✓	✓	✓
DWMP-15	229444	1263053	72	0-2	✓	✓				
				0-10			✓	✓	✓	✓
DWMP-16	229353	1262966	82	0-2	✓	✓				
				0-10			✓	✓	✓	✓

Stations are referred to as ‘Locators’ in King County Laboratory Information Management System (LIMS) and analytical chemistry reports.
Coordinates are listed in WA State Plane North US Survey Feet North American Datum 1983 (NAD83). These are the target coordinates listed in the SAPs; the coordinates of individual casts are included in Appendix A. All casts were within 6 meters of the target coordinate unless otherwise noted.

[1] At least one cast in the sample was offset more than the 6 meter limit due to the presence of large rocks or insufficient material in the prescribed coordinate location.

[2] Sample was collected for benthic taxonomy but not chemistry.

Table 2a: Sediment Chemistry Results Compared to Benthic SMS Chemical Criteria - 2006

Locator	Marine SMS		DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)			0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
Lab Sample ID	SQS	CSL	L38758-1	L38758-2	L38758-3	L38758-4	L38758-5	L38758-6	L38758-7	L38758-8	L38758-9	L38758-10	L38758-11	L38758-12	L38758-13	L38758-14	L38758-15	L38758-16
Metals (mg/kg dw)																		
Arsenic	57	93	11	7.4	7.8	7.2	7.3	5.6	7.0	6.7	9.0	5.5	5.6	11	<MDL (3.0)	8.1	7.8	8.0
Cadmium	5.1	6.7	1.2	<MDL (0.29)	0.47	<MDL (0.27)	0.58	<MDL (0.29)	0.38	0.50	0.87	0.69	0.38	0.85	<MDL (0.18)	1.1	<MDL (0.29)	0.57
Chromium	260	270	46.9	35.9	37.6	43.3	21.2	26.3	34.0	38.6	45.4	30.1	29.9	50.6	14.1	43.9	50.3	56.2
Copper	390	390	76.9	43.3	53.9	42.8	38.6	34.6	41.1	75.5	58.2	58.9	39.2	59.4	11.7	61.7	48.0	58.1
Lead	450	530	119	58.3	70.2	43.5	46.0	30.5	45.1	65.5	74.6	69.0	47.0	78.7	10.5	94.1	45.3	67.0
Mercury	0.41	0.59	0.602	0.32	0.922	0.32	0.061	0.19	0.30	0.499	0.568	0.744	0.26	0.54	0.034	0.553	0.390	0.411
Silver	6.1	6.1	4.51	0.70	1.63	<MDL (0.36)	<MDL (0.27)	<MDL (0.39)	0.82	1.5	1.8	0.59	0.80	2.3	<MDL (0.24)	3.91	1.1	1.0
Zinc	410	960	141	88.0	106	89.2	357	74.9	76.2	102	108	88.7	81.3	118	37.1	114	95.0	116
Polychlorinated Biphenyls (PCBs) (mg/kg OC)																		
Total Aroclors	12	65	15.3	11.9	19.5	15.6	9.39	10.3	20.2	17.7	15.3	10.2	11.6	20.0	12.9	29.8	18.4	17.7
Polycyclic Aromatic Hydrocarbons (PAHs) (mg/kg OC)																		
2-Methylnaphthalene	38	64	<MDL (1.8)	1.09	0.77	2.74	1.31	0.54	0.62	1.07	0.81	<MDL (4.8)	1.05	0.39	1.70	0.61	1.37	<MDL (0.41)
Acenaphthene	16	57	2.9	3.70	1.90	16.6	2.37	1.01	1.69	6.47	1.83	6.6	1.69	0.71	1.83	1.93	1.48	1.76
Acenaphthylene	66	66	2.4	3.61	2.35	4.62	7.97	1.41	4.12	2.06	0.86	<MDL (4.8)	1.60	0.68	2.75	3.56	2.41	1.98
Anthracene	220	1200	39.0	15.7	12.8	45.8	22.2	9.25	13.2	20.1	10.8	22.6	10.7	5.22	30.5	14.0	12.4	10.0
Benz(a)anthracene	110	270	98.7	36.3	30.2	60.3	43.5	16.7	25.6	34.2	15.8	81.5	17.1	10.5	37.1	27.8	20.9	17.4
Benzo(a)pyrene	99	210	127	42.0	31.4	60.5	47.0	19.8	29.6	34.3	26.9	88.5	20.4	15.6	45.1	34.1	27.6	22.8
Benzo(b)fluoranthene	n/a[1]	n/a[1]	122	39.5	33.5	46.0	40.6	22.3	28.4	28.0	16.0	91.8	16.5	13.9	36.2	31.8	23.0	18.5
Benzo(g,h,i)perylene	31	78	54.2	24.7	18.2	32.3	<MDL (0.42)	12.3	17.8	18.7	13.1	51.1	11.6	8.8	21.5	21.0	16.1	13.5
Benzo(k)fluoranthene	n/a[1]	n/a[1]	134	49.8	33.4	61.1	52.7	17.7	30.8	30.6	20.5	83.5	18.3	13.1	44.2	34.9	28.5	19.1
Chrysene	110	460	189	50.7	42.6	69.0	63.5	22.3	37.4	41.2	33.2	95.9	23.2	15.6	67.8	36.3	32.3	23.7
Dibenzo(a,h)anthracene	12	33	18.6	7.93	5.75	11.7	7.25	3.49	5.34	7.07	3.35	18.8	3.13	2.09	5.92	6.97	4.85	3.56
Fluoranthene	160	1200	130	77.9	56.1	120	76.6	29.8	44.6	73.3	37.9	199	32.2	17.6	65.6	53.7	41.3	32.9
Fluorene	23	79	9.67	5.77	3.55	18.2	4.85	2.19	3.50	7.37	2.72	8.4	3.83	1.17	6.23	3.10	2.93	2.54
Indeno(1,2,3-c,d)Pyrene	34	88	56.1	23.1	17.3	30.8	19.8	11.5	17.1	17.9	11.7	48.7	10.2	7.7	18.2	19.3	14.9	12.3
Naphthalene	99	170	1.9	1.35	1.32	2.82	0.83	0.71	0.82	1.18	0.75	<MDL (4.8)	1.41	0.49	1.3	0.84	0.91	0.71
Phenanthrene	100	480	57.3	49.8	23.8	125	25.7	15.1	24.6	53.8	27.0	95.7	25.2	8.65	31.9	23.8	18.3	18.8
Pyrene	1000	1400	116	72.2	51.9	133	88.1	28.7	42.8	71.1	41.5	233	35.0	19.9	73.9	57.0	40.1	36.0
Total benzofluoranthenes	230	450	256	89.3	66.9	107	93.3	40.0	59.2	58.6	36.5	175	34.8	27.0	80.4	66.7	51.5	37.5
Total HPAHs (calc.)	960	5300	1045	424	320	625	439	185	279	356	220	992	188	125	416	323	250	200
Total LPAHs (calc.)	370	780	113	81.1	46.5	216	65.2	30.2	48.5	92.0	44.8	133	45.4	17.3	76.2	47.8	39.8	35.8
Phthalates (mg/kg OC)																		
Benzyl Butyl phthalate	4.9	64	8.04	5.33	5.13	6.67	7.77	3.82	5.66	5.07	3.78	58.4	24.5	3.86	<MDL (1.6)	13.4	6.45	3.42
Bis(2-Ethylhexyl)phthalate	47	78	46.3	30.8	38.7	35.3	98.4	44.3	43.0	57.6	33.1	166	23.3	47.1	59.8	70.3	68.5	50.9
Diethyl phthalate	61	110	<MDL (3.5)	1.1	<MDL (0.80)	<MDL (1.1)	<MDL (0.83)	<MDL (0.75)	<MDL (1.1)	<MDL (0.59)	<MDL (0.59)	<MDL (9.5)	<MDL (0.54)	<MDL (0.59)	<MDL (1.6)	<MDL (0.54)	<MDL (0.93)	<MDL (0.80)
Dimethyl phthalate	53	53	<MDL (3.5)	<MDL (0.89)	<MDL (0.80)	<MDL (1.1)	<MDL (0.83)	<MDL (0.75)	<MDL (1.1)	1.46	<MDL (0.59)	<MDL (9.5)	0.82	<MDL (0.59)	<MDL (1.6)	<MDL (0.54)	<MDL (0.93)	<MDL (0.80)
Di-n-butyl phthalate	220	1700	7.12	14.7	14.6	27.2	15.9	11.6	17.8	11.0	4.20	17.4	1.63	2.18	21.6	2.72	3.57	2.49
Di-n-octyl phthalate	58	4500	<MDL (3.5)	<MDL (0.89)	<MDL (0.80)	<MDL (1.1)	<MDL (0.83)	<MDL (0.75)	<MDL (1.1)	<MDL (0.59)	<MDL (0.59)	<MDL (9.5)	<MDL (0.54)	<MDL (0.59)	<MDL (1.6)	<MDL (0.54)	<MDL (0.93)	<MDL (0.80)
OC-normalized Organic Chemicals (mg/kg OC)																		
1,2,4-Trichlorobenzene	0.81	1.8	<MDL (0.18)	<MDL (0.045)	<MDL (0.041)	<MDL (0.054)	<MDL (0.042)	<MDL (0.038)	<MDL (0.054)	<MDL (0.030)	<MDL (0.030)	<MDL (0.48)	<MDL (0.028)	<MDL (0.030)	<MDL (0.083)	<MDL (0.027)	<MDL (0.047)	<MDL (0.041)
1,2-Dichlorobenzene	2.3	2.3	<MDL (0.18)	<MDL (0.045)	<MDL (0.041)	<MDL (0.054)	<MDL (0.042)	<MDL (0.038)	<MDL (0.054)	<MDL (0.030)	<MDL (0.030)	<MDL (0.48)	<MDL (0.028)	<MDL (0.030)	<MDL (0.083)	<MDL (0.027)	<MDL (0.047)	<MDL (0.041)
1,4-Dichlorobenzene	3.1	9	<MDL (0.18)	<MDL (0.045)	<MDL (0.041)	<MDL (0.054)	<MDL (0.042)	<MDL (0.038)	<MDL (0.054)	0.912	<MDL (0.030)	2.60	0.123	0.143	<MDL (0.083)	0.206	<MDL (0.047)	<MDL (0.041)
Dibenzofuran	15	58	2.4	2.19	1.39	5.28	1.46	0.842	1.21	3.12	1.23	<MDL (4.8)	1.78	0.48	2.84	1.22	1.07	1.01
Hexachlorobenzene	0.38	2.3	<MDL (0.35)	<MDL (0.089)	<MDL (0.080)	<MDL (0.11)	<MDL (0.083)	<MDL (0.075)	<MDL (0.11)	<MDL (0.059)	<MDL (0.059)	<MDL (0.95)	<MDL (0.054)	<MDL (0.059)	<MDL (0.16)	<MDL (0.054)	<MDL (0.093)	<MDL (0.080)
Hexachlorobutadiene	3.9	6.2	<MDL (0.85)	<MDL (0.22)	<MDL (0.20)	<MDL (0.26)	<MDL (0.20)	<MDL (0.18)	<MDL (0.26)	<MDL (0.14)	<MDL (0.14)	<MDL (2.3)	<MDL (0.13)	<MDL (0.14)	<MDL (0.40)	<MDL (0.13)	<MDL (0.23)	<MDL (0.20)
N-nitrosodiphenylamine	11	11	<MDL (3.5)	<MDL (0.89)	<MDL (0.80)	<MDL (1.1)	<MDL (0.83)	<MDL (0.75)	<MDL (1.1)	<MDL (0.59)	<MDL (0.59)	<MDL (9.5)	<MDL (0.54)	<MDL (0.59)	<MDL (1.6)	<MDL (0.54)	<MDL (0.93)	<MDL (0.80)
Pentachlorophenol	360	690	<MDL (8.5)	<MDL (2.2)	<MDL (2.0)	<MDL (2.6)	<MDL (2.0)	<MDL (1.8)	<MDL (2.6)	<MDL (1.4)	<MDL (1.4)	<MDL (23)	<MDL (1.3)	<MDL (1.4)	<MDL (4.0)	<MDL (1.3)	<MDL (2.3)	<MDL (1.9)
Other Organic Chemicals (µg/kg dw)																		
2,4-Dimethylphenol	29	29	<MDL (61)	<MDL (5.1)	<MDL (6.0)	<MDL (4.9)	<MDL (3.6)	<MDL (5.2)	<MDL (5.1)	<MDL (6.5)	<MDL (7.4)	<MDL (38)	<MDL (5.4)	<MDL (7.7)	<MDL (3.3)	<MDL (5.5)	<MDL (5.2)	<MDL (5.1)
2-Methylphenol	63	63	<MDL (121)	<MDL (10)	<MDL (12)	<MDL (9.5)	<MDL (7.0)	<MDL (10)	<MDL (10)	<MDL (13)	<MDL (14)	<MDL (75)	<MDL (11)	<MDL (15)	<MDL (6.4)	<MDL (11)	<MDL (10)	<MDL (10)
4-Methylphenol	670	670	<MDL (121)	<MDL (10)	<MDL (12)	<MDL (9.5)	<MDL (7.0)	<MDL (10)	<MDL (10)	<MDL (13)	<MDL (14)	<MDL (75)	<MDL (11)	<MDL (15)	<MDL (6.4)	<MDL (11)	<MDL (10)	<MDL (10)
Benzoic acid	650	650	<MDL (297)	128	145	109	475	137	117	181	178	<MDL (183)	137	169	116	146	111	115
Benzyl alcohol	57	73	<MDL (121)	<MDL (10)	<MDL (12)	<MDL (9.5)	16.4	<MDL (10)	<MDL (10)	<MDL (13)	<MDL (14)	<MDL (75)	<MDL (11)	<MDL (15)	<MDL (6.4)	<MDL (11)	<MDL (10)	<MDL (25)
Phenol	420	1200	<MDL (121)	<MDL (10)	<MDL (12)	12	8.75	13.7	<MDL (10)	19.9	<MDL (14)	<MDL (75)	<MDL (11)	<MDL (15)	7.9	<MDL (11)	<MDL (10)	<MDL (10)

SMS = Sediment Management Standards
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
SQS = Sediment Quality Standards from Table I of Washington Administrative Code (WAC) 173-204-320
CSL = Cleanup Screening Level from Table III of WAC 173-204-562
mg/kg dw = Milligrams per kilogram dry weight
µg/kg dw = Micrograms per kilogram dry weight
mg/kg OC = Milligrams per kilogram normalized to organic carbon (OC)
(yellow) = Greater than SMS Marine SQS
(orange) = Greater than SMS Marine CSL
(grey) = Greater than Marine Sediment LAET (dry weight equivalent of SQS) due to percent TOC <0.5 or >3.5
(pink) = Greater than Marine Sediment 2LAET (dry weight equivalent of CSL) due to percent TOC <0.5 or >3.5

[1] The sum of the benzo(b)fluoranthene and benzo(k)fluoranthene concentrations is compared to the total benzofluoranthenes SMS Marine standard.
See Appendix B for lab reports with data qualifiers and dry weight concentrations for OC-normalized compounds

Table 2b: Sediment Chemistry Results Compared to DMMP Chemical Guidelines - 2006

Locator	DMMP Marine Guidelines[1]		DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)			0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
Lab Sample ID	**SL**	**ML**	L38758-1	L38758-2	L38758-3	L38758-4	L38758-5	L38758-6	L38758-7	L38758-8	L38758-9	L38758-10	L38758-11	L38758-12	L38758-13	L38758-14	L38758-15	L38758-16
Metals (mg/kg dw)																		
Antimony	150	200	<MDL (3.4)	<MDL (2.8)	<MDL (3.3)	<MDL (2.7)	<MDL (2.0)	<MDL (2.9)	<MDL (2.9)	<MDL (3.6)	<MDL (4.1)	<MDL (2.1)	<MDL (3.0)	<MDL (4.3)	<MDL (1.8)	<MDL (3.0)	<MDL (2.9)	<MDL (2.9)
Nickel	140	370	38.9	35.1	35.6	44.2	25.1	24.9	31.2	33.6	42.3	22.4	26.1	48.3	19.2	38.9	53.7	57.3
Pesticides (µg/kg dw)																		
4,4'-DDD	---	---	14.5	3.0	11.1	3.63	1.9	1.9	4.33	9.74	3.0	1.7	5.22	7.67	<MDL (1.2)	14.0	4.09	3.8
4,4'-DDE	---	---	<MDL (2.3)	<MDL (1.9)	<MDL (2.2)	<MDL (1.8)	<MDL (1.3)	<MDL (1.9)	<MDL (1.9)	<MDL (2.4)	<MDL (2.7)	<MDL (1.4)	<MDL (2.0)	<MDL (2.8)	<MDL (1.2)	<MDL (2.0)	<MDL (1.9)	<MDL (1.9)
4,4'-DDT	---	---	27.2	<MDL (1.9)	<MDL (2.2)	<MDL (1.8)	<MDL (1.3)	<MDL (1.9)	<MDL (1.9)	<MDL (2.4)	<MDL (2.7)	<MDL (1.4)	<MDL (2.0)	<MDL (2.8)	3.36	<MDL (2.0)	<MDL (1.9)	<MDL (1.9)
Sum of 4,4'-DDD, 4,4'DDE, and 4,4'-DDT	6.9	69	41.8	3.04	11.1	3.63	1.9	1.9	4.33	9.74	3.0	1.7	5.22	7.67	3.36	14.0	4.09	3.8
Aldrin	10	---	<MDL (2.3)	<MDL (1.9)	<MDL (2.2)	<MDL (1.8)	<MDL (1.3)	<MDL (1.9)	<MDL (1.9)	<MDL (2.4)	<MDL (2.7)	<MDL (1.4)	<MDL (2.0)	<MDL (2.8)	<MDL (1.2)	<MDL (2.0)	<MDL (1.9)	<MDL (1.9)
Alpha-Chlordane	10	---	2.63	<MDL (0.95)	2.27	<MDL (0.90)	<MDL (0.66)	<MDL (0.97)	<MDL (0.95)	1.4	2.0	<MDL (0.70)	<MDL (1.0)	<MDL (1.4)	<MDL (0.61)	1.9	<MDL (0.96)	<MDL (0.95)
Dieldrin	10	---	<MDL (2.3)	<MDL (1.9)	<MDL (2.2)	<MDL (1.8)	<MDL (1.3)	<MDL (1.9)	<MDL (1.9)	<MDL (2.4)	<MDL (2.7)	<MDL (1.4)	<MDL (2.0)	<MDL (2.8)	<MDL (1.2)	<MDL (2.0)	<MDL (1.9)	<MDL (1.9)
Heptachlor	10	---	<MDL (1.1)	<MDL (0.95)	<MDL (1.1)	<MDL (0.90)	<MDL (0.66)	<MDL (0.97)	<MDL (0.95)	<MDL (1.2)	<MDL (1.4)	<MDL (0.70)	<MDL (1.0)	<MDL (1.4)	<MDL (0.61)	<MDL (1.0)	<MDL (0.96)	<MDL (0.95)
Gamma-BHC (Lindane)	10	---	<MDL (1.1)	<MDL (0.95)	<MDL (1.1)	<MDL (0.90)	<MDL (0.66)	<MDL (0.97)	<MDL (0.95)	<MDL (1.2)	<MDL (1.4)	<MDL (0.70)	<MDL (1.0)	<MDL (1.4)	<MDL (0.61)	<MDL (1.0)	<MDL (0.96)	<MDL (0.95)
Volatile Organics (µg/kg dw)																		
Trichloroethene	160	1,600	<MDL (2.3)	<MDL (1.9)	<MDL (2.2)	<MDL (1.8)	<MDL (1.3)	<MDL (1.9)	<MDL (1.9)	<MDL (2.4)	<MDL (2.7)	<MDL (1.4)	<MDL (2.0)	<MDL (2.8)	<MDL (1.2)	<MDL (2.0)	<MDL (1.9)	<MDL (1.9)
Tetrachloroethene	57	210	<MDL (2.3)	<MDL (1.9)	<MDL (2.2)	<MDL (1.8)	<MDL (1.3)	<MDL (1.9)	<MDL (1.9)	<MDL (2.4)	<MDL (2.7)	<MDL (1.4)	<MDL (2.0)	<MDL (2.8)	<MDL (1.2)	<MDL (2.0)	<MDL (1.9)	<MDL (1.9)
Ethylbenzene	10	50	<MDL (2.3)	<MDL (1.9)	<MDL (2.2)	<MDL (1.8)	<MDL (1.3)	<MDL (1.9)	<MDL (1.9)	<MDL (2.4)	<MDL (2.7)	<MDL (1.4)	<MDL (2.0)	<MDL (2.8)	<MDL (1.2)	<MDL (2.0)	<MDL (1.9)	<MDL (1.9)
Total Xylene (sum of o-, m-, p-)	40	160	<MDL (2.3)	<MDL (1.9)	<MDL (2.2)	<MDL (1.8)	<MDL (1.3)	<MDL (1.9)	<MDL (1.9)	<MDL (2.4)	<MDL (2.7)	<MDL (1.4)	<MDL (2.0)	<MDL (2.8)	<MDL (1.2)	<MDL (2.0)	<MDL (1.9)	<MDL (1.9)

DMMP = Dredge Material Management Program
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
SL = Screening Level
ML = Maximum level
mg/kg dw = Milligrams per kilogram dry weight
µg/kg dw = Micrograms per kilogram dry weight
(yellow) = Greater than DMMP Marine Guideline SL
See Appendix B for lab reports with data qualifiers
[1] ACOE 2000; per the Biological Opinion the most current guidance at the time the data was collected is used.

Table 2c: Physical and Conventional Parameter Characteristics - 2006

Location	DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
Lab Sample ID	L38758-1	L38758-2	L38758-3	L38758-4	L38758-5	L38758-6	L38758-7	L38758-8	L38758-9	L38758-10	L38758-11	L38758-12	L38758-13	L38758-14	L38758-15	L38758-16
Percent Fines (Clay plus Silt)	53.7	30.1	44.1	52.5	2.8	28.1	36.3	43.1	63.2	8.4	36.3	75.9	1.1	62.3	47.1	51.5
Percent Clay	13.4	7.1	9.9	16.3	0.7	6.6	7.1	8.4	10.5	3.6	8.5	12.0	1.1	14.6	15.4	15.3
Percent Silt	40.3	23	34.2	36.2	2.1	21.5	29.2	34.7	52.6	4.8	27.7	63.9	<MDL (0.5)	47.8	31.7	36.3
Percent Sand	32.9	51.1	44.4	42.2	33.3	67.2	48.6	45.4	27.5	90.9	61.0	20.8	67.7	32.6	30.3	24.5
Percent Gravel	7.4	8.3	4.6	10.8	62.5	1.2	8.1	5.8	2.5	1.5	2.0	0.6	26.9	0.8	13.1	19.9
Total Organic Carbon (percent dw)	3.50	1.13	1.47	0.892	0.850	1.36	0.951	2.16	2.47	0.786	1.94	2.55	0.395	1.99	1.09	1.27
Ammonia (mg/kg dw)	6.00	2.35	2.52	1.94	7.29	3.61	3.71	5.64	3.99	4.69	2.67	3.92	2.82	2.25	2.24	1.6
Sulfide (mg/kg dw)	49.9	<MDL (0.95)	2.9	6.33	43.9	26.8	13.5	259	55.2	77.2	39.2	33.5	33.3	22.1	1.5	32.8

mg/kg dw = Milligrams per kilogram dry weight
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)

Table 3a: Sediment Chemistry Results Compared to Benthic SMS Chemical Criteria - 2007

Locator	Marine SMS		DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)			0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
Lab Sample ID	SQS	CSL	L42475-1	L42475-2	L42475-3	L42475-4	L42475-5	L42475-6	L42475-7	L42475-8	L42475-9	L42475-10	L42475-11	L42475-12	L42475-13	L42475-14	L42475-15	L42475-16
Metals (mg/kg dw)																		
Arsenic	57	93	14	7.5	10	9.4	14.3	6.8	7.8	9.4	9.4	6.2	6.5	11	2.8	8.1	9.7	8.8
Cadmium	5.1	6.7	1.38	0.27	1.10	0.42	0.31	0.34	0.43	0.80	0.67	0.918	0.42	0.62	0.24	0.73	0.43	0.42
Chromium	260	270	52.9	41.8	47.5	47.7	616	28.2	36.6	57.0	47.7	31.0	28.5	46.8	18.5	50.1	61.6	64.3
Copper	390	390	88.3	49.1	64.2	48.7	76.7	35.2	46.8	62.3	66.5	94.1	43.0	59.7	16.5	69.9	55.8	56.1
Lead	450	530	160	58.4	95.1	48.1	24.4	31.6	69.4	79.7	76.9	86.8	42.1	59.1	13.7	105	49.0	39.9
Mercury	0.41	0.59	0.861	0.311	0.731	0.387	0.0647	0.201	0.476	0.605	0.622	2.36	0.398	0.422	0.0668	0.970	0.368	0.305
Silver	6.1	6.1	5.29	1.5	3.67	1.3	1.1	1.0	1.5	3.77	3.08	4.77	1.7	2.5	0.40	4.50	1.7	1.4
Zinc	410	960	171	93.2	123	97.4	62.9	81.3	91.0	119	113	111	87.0	100	165	118	109	112
Polychlorinated Biphenyls (PCBs) (mg/kg OC)																		
Total Aroclors	12	65	21.2	9.36	17.3	9.37	5.79	5.51	11.1	18.5	8.11	17.8	7.55	7.54	7.84	17.7	15.7	10.6
Polycyclic Aromatic Hydrocarbons (PAHs) (mg/kg OC)																		
2-Methylnaphthalene	38	64	0.770	1.68	0.510	<MDL (0.27)	0.451	<MDL (0.22)	0.28	0.399	0.23	0.846	0.25	0.23	0.79	0.427	0.47	0.669
Acenaphthene	16	57	1.72	7.71	1.02	0.90	2.07	0.477	0.64	0.910	0.63	3.16	1.33	0.33	1.55	0.97	1.05	1.09
Acenaphthylene	66	66	8.79	1.55	1.61	1.07	1.90	0.603	0.56	<MDL (0.18)	0.59	1.61	0.48	0.42	<MDL (0.66)	0.53	0.66	0.49
Anthracene	220	1200	37.2	16.2	6.66	4.35	13.6	2.27	3.04	3.30	2.82	16.9	3.41	1.77	9.70	3.91	4.42	3.49
Benz(a)anthracene	110	270	70.3	39.7	14.5	8.80	16.0	5.79	7.59	6.67	6.85	44.2	6.58	4.00	20.6	11.7	13.2	6.45
Benzo(a)pyrene	99	210	98.8	31.2	13.1	9.45	16.7	6.95	8.60	7.10	7.93	42.8	7.73	5.08	26.9	12.1	14.7	8.73
Benzo(b)fluoranthene	n/a[1]	n/a[1]	119	37.3	18.4	10.9	19.0	9.20	11.4	8.03	10.9	62.4	9.91	5.80	23.4	14.3	19.5	9.70
Benzo(g,h,i)perylene	31	78	41.8	17.1	7.98	5.09	6.21	3.44	4.15	3.50	4.31	22.4	3.99	2.69	12.4	6.83	8.41	4.61
Benzo(k)fluoranthene	n/a[1]	n/a[1]	92.1	22.7	16.1	8.35	22.8	5.56	5.78	6.65	5.25	32.4	7.79	4.43	28.3	11.6	11.9	6.96
Chrysene	110	460	125	42.9	15.5	12.2	25.0	8.64	10.2	8.05	9.27	54.6	9.12	6.20	32.7	14.7	18.5	10.0
Dibenzo(a,h)anthracene	12	33	24.9	4.89	2.84	1.70	3.11	1.16	1.62	1.41	1.52	8.31	1.45	0.803	4.13	1.90	2.24	1.55
Fluoranthene	160	1200	50.8	78.9	25.4	15.4	36.2	13.1	14.0	16.0	12.3	112	14.8	6.81	61.1	22.3	22.7	14.1
Fluorene	23	79	4.73	6.72	1.66	1.14	2.85	0.831	0.93	1.26	0.84	5.14	1.25	0.51	2.96	1.25	1.40	1.17
Indeno(1,2,3-Cd)Pyrene	34	88	53.6	20.7	8.73	5.91	8.91	4.23	5.38	4.55	4.95	27.9	4.78	3.22	13.2	7.47	9.33	5.39
Naphthalene	99	170	1.25	1.96	0.62	<MDL (0.27)	0.29	0.28	0.50	0.53	0.32	0.79	0.46	0.29	0.69	0.53	0.59	0.75
Phenanthrene	100	480	23.2	56.1	10.6	7.31	19.7	6.65	7.55	9.10	6.25	49.4	8.26	3.47	23.3	10.0	10.3	7.71
Pyrene	1000	1400	72.7	69.2	26.8	15.1	34.2	12.0	13.4	16.9	13.0	105	13.7	7.45	56.4	23.8	23.8	14.3
Total benzofluoranthenes	230	450	211	60.0	34.6	19.3	41.7	14.8	17.2	14.7	16.2	94.8	17.7	10.2	51.7	25.9	31.4	16.7
Total HPAHs (calc.)	960	5300	749	364	149	93.0	188	70.1	82.1	78.9	76.3	512	79.8	46.5	279	127	144	81.8
Total LPAHs (calc.)	370	780	77.6	91.9	22.7	14.8	40.9	11.1	13.5	15.5	11.7	77.8	15.4	7.0	39.0	17.6	18.9	15.4
Phthalates (mg/kg OC)																		
Benzyl Butyl phthalate	4.9	64	3.22	3.17	<MDL (0.37)	<MDL (0.14)	<MDL (0.095)	1.41	1.70	3.32	1.72	11.0	<MDL (0.094)	2.43	8.02	3.32	3.29	2.78
Bis(2-Ethylhexyl)phthalate	47	78	20.0	29.2	25.4	13.4	71.0	261	10.8	41.7	15.2	96.1	10.7	15.7	825	23.9	22.2	10.9
Diethyl phthalate	61	110	<MDL (0.24)	<MDL (0.50)	<MDL (0.42)	<MDL (0.54)	<MDL (0.38)	<MDL (0.44)	<MDL (0.50)	<MDL (0.36)	<MDL (0.36)	<MDL (0.65)	<MDL (0.37)	<MDL (0.35)	<MDL (1.3)	<MDL (0.35)	<MDL (0.58)	<MDL (0.66)
Dimethyl phthalate	53	53	<MDL (0.24)	<MDL (0.50)	<MDL (0.42)	<MDL (0.54)	<MDL (0.38)	<MDL (0.44)	<MDL (0.50)	<MDL (0.36)	<MDL (0.36)	<MDL (0.65)	<MDL (0.37)	<MDL (0.35)	<MDL (1.3)	<MDL (0.35)	<MDL (0.58)	<MDL (0.66)
Di-n-butyl phthalate	220	1700	<MDL (0.24)	1.40	<MDL (0.42)	2.69	<MDL (0.38)	<MDL (0.44)	0.67	<MDL (0.36)	0.75	2.45	0.88	<MDL (0.35)	<MDL (1.3)	3.35	2.74	1.45
Di-n-octyl phthalate	58	4500	<MDL (0.24)	<MDL (0.50)	<MDL (0.42)	<MDL (0.54)	<MDL (0.38)	<MDL (0.44)	<MDL (0.50)	<MDL (0.36)	<MDL (0.36)	<MDL (0.65)	<MDL (0.37)	<MDL (0.35)	<MDL (1.3)	<MDL (0.35)	<MDL (0.58)	<MDL (0.66)
OC-Normalized Organic Chemicals(mg/kg OC)																		
1,2,4-Trichlorobenzene	0.81	1.8	<MDL (0.0061)	<MDL (0.012)	<MDL (0.010)	<MDL (0.013)	<MDL (0.0095)	<MDL (0.011)	<MDL (0.012)	<MDL (0.0090)	<MDL (0.0090)	<MDL (0.016)	<MDL (0.0094)	<MDL (0.0087)	<MDL (0.033)	<MDL (0.0087)	<MDL (0.015)	<MDL (0.016)
1,2-Dichlorobenzene	2.3	2.3	<MDL (0.012)	<MDL (0.025)	<MDL (0.021)	<MDL (0.027)	<MDL (0.019)	<MDL (0.022)	<MDL (0.025)	<MDL (0.018)	<MDL (0.018)	<MDL (0.032)	<MDL (0.019)	<MDL (0.017)	<MDL (0.066)	<MDL (0.018)	<MDL (0.029)	<MDL (0.033)
1,4-Dichlorobenzene	3.1	9	<MDL (0.012)	0.11	<MDL (0.021)	<MDL (0.027)	<MDL (0.019)	<MDL (0.022)	<MDL (0.025)	0.22	0.33	1.16	0.17	<MDL (0.017)	<MDL (0.066)	<MDL (0.018)	<MDL (0.029)	0.16
Dibenzofuran	15	58	0.95	3.34	0.51	0.32	0.98	0.25	0.30	0.73	0.28	2.07	0.60	0.18	1.37	0.56	0.51	0.53
Hexachlorobenzene	0.38	2.3	<MDL (0.0061)	<MDL (0.012)	<MDL (0.010)	<MDL (0.013)	<MDL (0.0095)	<MDL (0.011)	<MDL (0.012)	<MDL (0.0090)	<MDL (0.0090)	<MDL (0.016)	<MDL (0.0094)	<MDL (0.0087)	<MDL (0.033)	<MDL (0.0088)	<MDL (0.015)	<MDL (0.016)
Hexachlorobutadiene	3.9	6.2	<MDL (0.030)	<MDL (0.062)	<MDL (0.052)	<MDL (0.067)	<MDL (0.048)	<MDL (0.055)	<MDL (0.062)	<MDL (0.045)	<MDL (0.045)	<MDL (0.081)	<MDL (0.047)	<MDL (0.0043)	<MDL (0.17)	<MDL (0.0044)	<MDL (0.073)	<MDL (0.082)
N-nitrosodiphenylamine	11	11	<MDL (0.24)	<MDL (0.50)	<MDL (0.42)	<MDL (0.54)	<MDL (0.38)	<MDL (0.44)	<MDL (0.50)	<MDL (0.36)	<MDL (0.36)	<MDL (0.65)	<MDL (0.38)	<MDL (0.38)	<MDL (1.3)	<MDL (0.35)	<MDL (0.58)	<MDL (0.66)
Pentachlorophenol	360	690	<MDL (0.61)	<MDL (1.2)	<MDL (1.04)	<MDL (1.3)	<MDL (0.95)	<MDL (1.1)	<MDL (1.2)	<MDL (0.90)	<MDL (0.90)	<MDL (1.6)	<MDL (0.94)	<MDL (0.87)	<MDL (3.3)	<MDL (0.88)	<MDL (1.5)	<MDL (1.6)
Other Organic Chemicals (µg/kg dw)																		
2,4-Dimethylphenol	29	29	<MDL (2.2)	<MDL (1.8)	<MDL (2.1)	<MDL (2.0)	<MDL (1.3)	<MDL (2.0)	<MDL (1.9)	<MDL (2.0)	<MDL (2.7)	<MDL (1.4)	<MDL (2.1)	<MDL (3.2)	<MDL (1.3)	<MDL (2.0)	<MDL (1.9)	<MDL (1.9)
2-Methylphenol	63	63	<MDL (4.5)	<MDL (3.7)	<MDL (4.2)	<MDL (4.0)	<MDL (2.7)	<MDL (4.0)	<MDL (3.9)	<MDL (4.1)	<MDL (5.4)	<MDL (2.8)	<MDL (4.2)	<MDL (6.5)	<MDL (2.5)	<MDL (4.0)	<MDL (3.9)	<MDL (3.8)
4-Methylphenol	670	670	<MDL (9.0)	<MDL (7.3)	<MDL (8.5)	<MDL (8.0)	<MDL (5.4)	<MDL (8.0)	<MDL (7.8)	<MDL (8.2)	<MDL (11)	<MDL (5.7)	<MDL (8.4)	<MDL (13)	<MDL (5.0)	<MDL (7.9)	<MDL (7.8)	<MDL (7.6)
Benzoic acid	650	650	126	130	<MDL (21.1)	91.6	163	98.2	86.0	97.3	117	82.2	97.3	159	117	101	100	86.3
Benzyl alcohol	57	73	<MDL (4.5)	<MDL (3.7)	<MDL (4.2)	<MDL (4.0)	<MDL (13)	<MDL (4.0)	<MDL (3.9)	<MDL (4.1)	<MDL (5.4)	<MDL (2.8)	<MDL (4.2)	<MDL (6.5)	<MDL (2.5)	<MDL (4.0)	<MDL (3.9)	<MDL (3.8)
Phenol	420	1200	<MDL (9.0)	<MDL (7.3)	<MDL (8.5)	<MDL (8.0)	<MDL (5.4)	<MDL (8.0)	<MDL (7.8)	<MDL (8.2)	<MDL (11)	11.9	14	<MDL (13)	13.9	<MDL (8.0)	<MDL (7.8)	<MDL (7.6)

SMS = Sediment Management Standards
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
SQS = Sediment Quality Standards from Table I of Washington Administrative Code (WAC) 173-204-320
CSL = Cleanup Screening Level from Table III of WAC 173-204-562
mg/kg dw = Milligrams per kilogram dry weight
µg/kg dw = Micrograms per kilogram dry weight
mg/kg OC = Milligrams per kilogram normalized to organic carbon (OC)
(yellow) = Greater than SMS MarineSQS
(orange) = Greater than SMS Marine CSL
(light purple) = Greater than Marine Sediment LAET (dry weight equivalent of SQS) due to percent TOC <0.5 or >3.5
(salmon) = Greater than Marine Sediment 2LAET (dry weight equivalent of CSL) due to percent TOC <0.5 or >3.5

[1] The sum of the benzo(b)fluoranthene and benzo(k)fluoranthene concentrations is compared to the total benzofluoranthenes SMS Marine standard.
See Appendix B for lab reports with data qualifiers and dry weight concentrations for OC-normalized compounds

Table 3b: Sediment Chemistry Results Compared to DMMP Chemical Guidelines - 2007

Locator	DMMP Marine Guidelines[1]		DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)			0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
Lab Sample ID	**SL**	**ML**	L42475-1	L42475-2	L42475-3	L42475-4	L42475-5	L42475-6	L42475-7	L42475-8	L42475-9	L42475-10	L42475-11	L42475-12	L42475-13	L42475-14	L42475-15	L42475-16
Metals (mg/kg dw)																		
Antimony	150	200	<MDL (1.7)	<MDL (1.4)	<MDL (1.6)	<MDL (1.5)	<MDL (1.0)	<MDL (1.5)	<MDL (1.5)	<MDL (1.5)	<MDL (2.0)	<MDL (1.1)	<MDL (1.6)	<MDL (2.4)	<MDL (0.95)	<MDL (1.5)	<MDL (1.5)	<MDL (1.4)
Nickel	140	370	45.5	43.4	46.4	49.9	69.0	27.2	33.5	51.2	42.1	25.6	26.2	46.4	22.2	43.8	63.0	68.5
Pesticides (µg/kg dw)																		
4,4'-DDD	---	---	<MDL (1.5)	3.63	12.3	3.11	<MDL (0.90)	1.8	3.49	<MDL (1.4)	6.84	3.45	3.88	4.2	0.91	11.4	3.88	1.8
4,4'-DDE	---	---	<MDL (1.5)	<MDL (1.2)	<MDL (1.4)	<MDL (1.3)	<MDL (0.90)	<MDL (1.3)	<MDL (1.3)	41.0	<MDL (1.8)	<MDL (0.95)	<MDL (1.4)	<MDL (2.2)	<MDL (0.84)	<MDL (1.3)	<MDL (1.3)	<MDL (1.3)
4,4'-DDT	---	---	<MDL (1.5)	<MDL (1.2)	<MDL (1.4)	<MDL (1.3)	<MDL (0.90)	<MDL (1.3)	<MDL (1.3)	<MDL (1.4)	<MDL (1.8)	<MDL (0.95)	<MDL (1.4)	<MDL (2.2)	<MDL (0.84)	<MDL (1.3)	<MDL (1.3)	<MDL (1.3)
Sum of 4,4'-DDD, 4,4'DDE, and 4,4'-DDT	6.9	69	<MDL (1.5)	3.63	12.3	3.11	<MDL (0.90)	1.8	3.49	41.0	6.84	3.45	3.88	4.2	0.91	11.4	3.88	1.8
Aldrin	10	---	<MDL (1.5)	<MDL (1.2)	<MDL (1.4)	<MDL (1.3)	<MDL (0.90)	<MDL (1.3)	<MDL (1.3)	<MDL (1.4)	<MDL (1.8)	<MDL (0.95)	<MDL (1.4)	<MDL (2.2)	<MDL (0.84)	<MDL (1.3)	<MDL (1.3)	<MDL (1.3)
Alpha-Chlordane	10	---	<MDL (0.74)	0.73	2.56	<MDL (0.66)	<MDL (0.44)	<MDL (0.66)	<MDL (0.64)	1.45	1.07	0.75	<MDL (0.69)	<MDL (1.1)	<MDL (0.42)	1.39	<MDL (0.64)	<MDL (0.63)
Dieldrin	10	---	<MDL (1.5)	<MDL (1.5)	<MDL (1.4)	<MDL (1.3)	<MDL (0.90)	<MDL (1.3)	<MDL (1.3)	<MDL (1.4)	<MDL (1.8)	<MDL (0.95)	<MDL (1.4)	<MDL (2.2)	<MDL (0.84)	<MDL (1.3)	<MDL (1.3)	<MDL (1.3)
Heptachlor	10	---	<MDL (0.74)	<MDL (0.75)	<MDL (0.70)	<MDL (0.66)	<MDL (0.44)	<MDL (0.66)	<MDL (0.64)	<MDL (0.68)	<MDL (0.88)	<MDL (0.47)	<MDL (0.69)	<MDL (1.1)	<MDL (0.42)	<MDL (0.65)	<MDL (0.64)	<MDL (0.63)
Gamma-BHC (Lindane)	10	---	<MDL (0.74)	<MDL (0.75)	<MDL (0.70)	<MDL (0.66)	<MDL (0.44)	<MDL (0.66)	<MDL (0.64)	<MDL (0.68)	<MDL (0.88)	<MDL (0.47)	<MDL (0.69)	<MDL (1.1)	<MDL (0.42)	<MDL (0.65)	<MDL (0.64)	<MDL (0.63)
Volatile Organics (µg/kg dw)																		
Trichloroethene	160	1,600	<MDL (2.2)	<MDL (1.8)	<MDL (2.1)	<MDL (2.0)	<MDL (1.3)	<MDL (2.0)	<MDL (1.9)	<MDL (2.0)	<MDL (2.7)	<MDL (1.4)	<MDL (2.1)	<MDL (3.2)	<MDL (1.3)	<MDL (2.0)	<MDL (1.9)	<MDL (1.9)
Tetrachloroethene	57	210	<MDL (2.2)	<MDL (1.8)	<MDL (2.1)	<MDL (2.0)	<MDL (1.3)	<MDL (2.0)	<MDL (1.9)	<MDL (2.0)	<MDL (2.7)	<MDL (1.4)	<MDL (2.1)	<MDL (3.2)	<MDL (1.3)	<MDL (2.0)	<MDL (1.9)	<MDL (1.9)
Ethylbenzene	10	50	<MDL (2.2)	<MDL (1.8)	<MDL (2.1)	<MDL (2.0)	<MDL (1.3)	<MDL (2.0)	<MDL (1.9)	<MDL (2.0)	<MDL (2.7)	<MDL (1.4)	<MDL (2.1)	<MDL (3.2)	<MDL (1.3)	<MDL (2.0)	<MDL (1.9)	<MDL (1.9)
Total Xylene (sum of o-, m-, p-)	40	160	<MDL (2.2)	<MDL (1.8)	<MDL (2.1)	<MDL (2.0)	<MDL (1.3)	<MDL (2.0)	<MDL (1.9)	<MDL (2.0)	<MDL (2.7)	<MDL (1.4)	<MDL (2.1)	<MDL (3.2)	<MDL (1.3)	<MDL (2.0)	<MDL (1.9)	<MDL (1.9)

DMMP = Dredge Material Management Program
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
SL = Screening Level
ML = Maximum level
mg/kg dw = Milligrams per kilogram dry weight
µg/kg dw = Micrograms per kilogram dry weight
= Greater than DMMP Marine Guideline SL
See Appendix B for lab reports with data qualifiers
[1] ACOE 2000; per the Biological Opinion the most current guidance at the time the data was collected is used.

Table 3c: Physical and Conventional Parameter Characteristics - 2007

Parameter	DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
Lab Sample ID	L42475-1	L42475-2	L42475-3	L42475-4	L42475-5	L42475-6	L42475-7	L42475-8	L42475-9	L42475-10	L42475-11	L42475-12	L42475-13	L42475-14	L42475-15	L42475-16
Percent Fines (Clay plus Silt)	57.7	39.4	59.1	49.3	8.5	33.7	45.0	45.8	61.2	4.6	31.1	75.9	3.2	54.3	44.1	65.5
Percent Clay	17.7	12.0	15.6	12.8	4.9	10.3	13.1	13.4	14.6	2.6	10.0	16.5	1.3	12.6	13.4	29.0
Percent Silt	40.0	27.4	43.6	36.5	3.6	23.4	31.9	32.5	46.6	2.0	21.1	59.4	1.9	41.7	30.7	36.5
Percent Sand	28.8	53.5	33.7	39.4	30.9	62.6	46.9	42.8	28.5	91.7	64.6	19.6	67.8	35.2	36.7	21.8
Percent Gravel	5.7	3.4	1.2	5.5	61.6	1.8	2.6	9.2	2.2	1.9	2.5	0.7	29.5	0.6	10.1	6.2
Total Organic Carbon (percent dw)	3.70	1.47	2.03	1.48	1.42	1.82	1.58	2.27	2.95	0.873	2.22	3.73	0.382	2.26	1.33	1.16
Ammonia (mg/kg dw)	5.90	0.582	1.77	1.40	7.13	1.80	1.16	3.30	1.92	4.88	2.81	1.68	4.39	2.53	1.54	1.76
Sulfide (mg/kg dw)	122	<MDL (0.92)	4.2	4.61	121	<MDL (1.0)	18.2	1031	26.6	5.76	121	32.8	19.9	6.44	9.46	11.2

mg/kg dw = Milligrams per kilogram dry weight
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)

Table 4a: Sediment Chemistry Results Compared to Benthic SMS Chemical Criteria - 2008

Locator	Marine SMS		DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-06	DWMP-07	DWMP-08	DWMP-08	DWMP-09	DWMP-11	DWMP-12	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)			0 - 10	0 - 10	0 - 10	0 - 10	0 - 2	0 - 2	0 - 2	0 - 10	0 - 2	0 - 2	0 - 2	0 - 10	0 - 10	0 - 10
Lab Sample ID	SQS	CSL	L45313-1	L45313-2	L45313-3	L45313-4	L45313-6	L45313-7	L45313-8	L45313-17	L45313-9	L45313-11	L45313-12	L45313-14	L45313-15	L45313-16
Metals (mg/kg dw)																
Arsenic	57	93	13.3	6.3	9.6	8.0	6.69	8.46	7.8	9.3	11	7.3	11	8.9	9.0	10
Cadmium	5.1	6.7	1.23	0.26	0.83	0.29	0.306	0.374	0.83	0.77	0.75	0.50	1.0	0.85	0.896	0.34
Chromium	260	270	55.1	35.4	49.1	54.3	29.1	33.3	43.7	43.7	50.4	32.5	49.7	48.6	54.5	70.6
Copper	390	390	87.9	37.0	56.8	49.1	31.7	40.4	63.7	53.6	62.0	42.2	62.7	70.1	51.9	53.7
Lead	450	530	148	60.4	81.4	41.3	28.9	45.3	69.1	88.2	80.6	52.7	62.7	102.0	55.9	29.8
Mercury	0.41	0.59	1.16	0.200	0.570	0.270	0.184	0.512	0.460	0.447	1.25	0.354	0.399	0.520	0.354	0.167
Silver	6.1	6.1	4.93	1.1	2.54	0.87	0.535	0.965	2.2	2.84	2.4	1.5	1.9	3.82	1.71	0.85
Zinc	410	960	161	82.0	113	96.6	77.1	75.4	132	127	113	87.1	131	118	137	117
Polychlorinated Biphenyls (PCBs) (mg/kg OC)																
Total Aroclors	12	65	19.2	7.16	22.0	8.24	4.68	9.58	9.40	20.6	9.72	8.81	8.05	19.3	23.0	10.2
Polycyclic Aromatic Hydrocarbons (PAHs) (mg/kg OC)																
2-Methylnaphthalene	38	64	0.975	9.36	1.67	0.857	0.649	0.922	0.509	0.748	0.619	0.472	0.512	0.769	0.880	0.873
Acenaphthene	16	57	1.54	31.4	2.83	0.873	0.553	1.16	0.624	0.639	0.876	0.681	0.517	0.970	0.932	0.781
Acenaphthylene	66	66	2.90	1.59	0.971	0.592	0.566	1.160	0.531	0.440	0.652	0.519	0.594	0.888	0.827	0.68
Anthracene	220	1200	13.1	48.7	8.74	3.60	2.91	5.60	3.14	2.93	3.98	3.08	2.61	4.77	4.39	4.33
Benz(a)anthracene	110	270	27.7	63.6	13.0	9.78	7.56	13.3	7.73	7.40	8.31	7.89	6.70	12.0	10.9	9.00
Benzo(a)pyrene	99	210	49.5	52.9	15.2	11.9	9.55	15.8	9.20	8.57	10.1	8.81	8.38	13.3	13.6	10.6
Benzo(b)fluoranthene	n/a[1]	n/a[1]	54.2	50.2	14.5	12.1	10.7	18.1	11.4	9.68	11.5	10.3	9.64	16.3	15.5	12.1
Benzo(g,h,i)perylene	31	78	23.3	28.5	8.30	5.74	3.83	5.48	4.57	4.04	4.83	3.30	3.40	7.15	5.24	4.33
Benzo(k)fluoranthene	n/a[1]	n/a[1]	51.1	35.4	14.9	11.4	9.98	14.8	8.60	7.72	10.3	8.43	8.63	12.8	14.5	11.1
Chrysene	110	460	44.4	64.7	17.0	13.3	11.3	17.8	10.1	8.65	10.8	10.2	9.55	15.5	15.2	12.0
Dibenzo(a,h)anthracene	12	33	11.7	7.96	3.35	2.14	1.75	2.36	1.86	1.62	1.86	1.49	1.44	2.97	2.27	1.88
Fluoranthene	160	1200	35.6	152	25.0	16.0	12.4	19.2	14.0	12.8	13.7	14.7	11.1	20.2	17.7	13.9
Fluorene	23	79	2.49	24.3	3.25	1.18	0.672	1.48	0.827	0.905	1.17	0.890	0.744	1.31	1.41	1.27
Indeno(1,2,3-Cd)Pyrene	34	88	27.2	26.0	7.99	6.33	4.40	6.08	4.62	4.03	5.11	3.62	3.56	7.61	5.70	4.62
Naphthalene	99	170	1.22	6.96	1.82	0.50	0.45	0.840	0.534	0.849	0.503	0.424	0.442	0.896	0.665	0.58
Phenanthrene	100	480	19.3	195	23.2	10.3	7.13	11.5	8.07	6.10	8.82	7.55	6.13	11.0	10.0	8.83
Pyrene	1000	1400	75.3	158	30.8	17.6	11.9	17.5	13.4	17.0	13.1	12.7	9.46	22.1	17.9	12.9
Total benzofluoranthenes	230	450	105	85.6	29.3	23.5	20.7	32.9	20.0	17.4	21.8	18.8	18.3	29.1	29.9	23.1
Total HPAHs (calc.)	960	5300	400	639	150	106	83.4	130	85.5	81.5	89.6	81.4	71.8	130	118	92.4
Total LPAHs (calc.)	370	780	41.5	317	42.5	17.9	12.9	22.6	14.2	12.6	16.6	13.6	11.5	20.6	19.1	17.3
Phthalates (mg/kg OC)																
Benzyl Butyl phthalate	4.9	64	3.51	3.13	1.92	1.57	2.08	1.45	1.74	1.97	1.76	1.22	1.54	5.84	3.27	2.19
Bis(2-Ethylhexyl)phthalate	47	78	39.8	21.7	28.5	10.3	21.2	16.4	20.0	23.3	29.8	12.4	20.9	27.6	36.4	11.4
Diethyl phthalate	61	110	<MDL (0.25)	<MDL (0.44)	<MDL (0.38)	<MDL (0.58)	<MDL (0.45)	<MDL (0.55)	<MDL (0.26)	<MDL (0.32)	<MDL (0.37)	<MDL (0.34)	<MDL (0.36)	<MDL (0.30)	<MDL (0.61)	<MDL (0.68)
Dimethyl phthalate	53	53	0.541	<MDL (0.44)	<MDL (0.38)	<MDL (0.58)	<MDL (0.45)	<MDL (0.55)	<MDL (0.26)	<MDL (0.32)	<MDL (0.37)	<MDL (0.34)	<MDL (0.36)	<MDL (0.30)	<MDL (0.61)	<MDL (0.68)
Di-n-butyl phthalate	220	1700	1.31	3.31	1.14	1.20	0.980	1.88	0.987	1.31	1.10	0.74	1.01	1.34	1.34	1.32
Di-n-octyl phthalate	58	4500	<MDL (0.25)	<MDL (0.44)	<MDL (0.38)	<MDL (0.58)	<MDL (0.45)	<MDL (0.55)	<MDL (0.26)	<MDL (0.32)	<MDL (0.37)	<MDL (0.34)	<MDL (0.36)	<MDL (0.30)	<MDL (0.61)	<MDL (0.68)
OC-normalized Organic Chemicals (mg/kg OC)																
1,2,4-Trichlorobenzene	0.81	1.8	<MDL (0.0062)	<MDL (0.011)	<MDL (0.0095)	<MDL (0.015)	<MDL (0.011)	<MDL (0.014)	<MDL (0.0067)	<MDL (0.0079)	<MDL (0.0093)	<MDL (0.0085)	<MDL (0.0090)	<MDL (0.0075)	<MDL (0.015)	<MDL (0.017)
1,2-Dichlorobenzene	2.3	2.3	0.017	<MDL (0.022)	<MDL (0.019)	<MDL (0.029)	<MDL (0.023)	<MDL (0.027)	<MDL (0.013)	0.045	<MDL (0.019)	<MDL (0.017)	<MDL (0.018)	<MDL (0.015)	<MDL (0.030)	<MDL (0.034)
1,4-Dichlorobenzene	3.1	9	0.093	0.110	0.097	<MDL (0.029)	0.384	0.218	0.621	0.523	0.118	0.372	0.146	0.177	0.165	0.137
Dibenzofuran	15	58	<MDL (0.12)	7.09	0.876	0.45	0.417	0.671	0.405	0.440	0.431	0.354	0.31	0.546	0.53	0.46
Hexachlorobenzene	0.38	2.3	0.076	<MDL (0.011)	<MDL (0.0095)	<MDL (0.015)	<MDL (0.011)	<MDL (0.014)	<MDL (0.0067)	<MDL (0.0079)	<MDL (0.0093)	<MDL (0.0085)	<MDL (0.0090)	<MDL (0.0075)	0.127272727	<MDL (0.017)
Hexachlorobutadiene	3.9	6.2	<MDL (0.031)	<MDL (0.055)	<MDL (0.048)	<MDL (0.073)	<MDL (0.056)	<MDL (0.068)	<MDL (0.033)	<MDL (0.040)	<MDL (0.046)	<MDL (0.042)	<MDL (0.045)	<MDL (0.037)	<MDL (0.076)	<MDL (0.085)
N-nitrosodiphenylamine	11	11	<MDL (0.25)	2.06	<MDL (0.38)	<MDL (0.58)	<MDL (0.45)	<MDL (0.55)	<MDL (0.27)	<MDL (0.32)	<MDL (0.37)	<MDL (0.34)	<MDL (0.36)	<MDL (0.30)	<MDL (0.61)	<MDL (0.68)
Pentachlorophenol	360	690	<MDL (0.62)	<MDL (1.1)	<MDL (0.95)	<MDL (1.5)	<MDL (1.1)	<MDL (1.4)	<MDL (0.67)	<MDL (0.79)	<MDL (0.93)	<MDL (0.85)	<MDL (0.90)	<MDL (0.75)	<MDL (1.5)	<MDL (1.7)
Other Organic Chemicals (µg/kg dw)																
2,4-Dimethylphenol	29	29	<MDL (2.1)	<MDL (1.5)	<MDL (2.2)	<MDL (1.7)	<MDL (1.9)	<MDL (2.0)	<MDL (2.2)	<MDL (1.9)	<MDL (2.9)	<MDL (2.0)	<MDL (3.2)	<MDL (2.0)	<MDL (1.7)	<MDL (1.8)
2-Methylphenol	63	63	<MDL (4.2)	<MDL (3.1)	<MDL (4.4)	<MDL (3.4)	<MDL (3.8)	<MDL (3.9)	<MDL (4.5)	<MDL (3.9)	<MDL (5.8)	<MDL (4.0)	<MDL (6.3)	<MDL (3.9)	<MDL (3.5)	<MDL (3.6)
4-Methylphenol	670	670	18.4	19.9	<MDL (8.9)	<MDL (6.8)	<MDL (7.6)	<MDL (7.9)	136	48.5	13	<MDL (7.9)	<MDL (13)	10	<MDL (6.9)	<MDL (7.3)
Benzoic acid	650	650	181	138	192	117	166	139	190	139	241	130	270	134	110	118
Benzyl alcohol	57	73	<MDL (4.2)	<MDL (3.1)	<MDL (4.4)	<MDL (3.4)	<MDL (3.8)	<MDL (3.9)	<MDL (4.5)	<MDL (3.9)	<MDL (5.8)	<MDL (4.0)	<MDL (6.3)	<MDL (3.9)	<MDL (3.5)	<MDL (3.6)
Phenol	420	1200	43.9	435	200	<MDL (6.8)	20.7	<MDL (7.9)	217	261	251	<MDL (7.9)	39.9	38.6	8.2	<MDL (7.3)

SMS = Sediment Management Standards
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
SQS = Sediment Quality Standards from Table I of Washington Administrative Code (WAC) 173-204-320
CSL = Cleanup Screening Level from Table III of WAC 173-204-562
mg/kg dw = Milligrams per kilogram dry weight
µg/kg dw = Micrograms per kilogram dry weight
mg/kg OC = Milligrams per kilogram normalized to organic carbon (OC)
= Greater than SMS Marine SQS
= Greater than SMS Marine CSL
= Greater than Marine Sediment LAET (dry weight equivalent of SQS) due to percent TOC <0.5 or >3.5
= Greater than Marine Sediment 2LAET (dry weight equivalent of CSL) due to percent TOC <0.5 or >3.5
= Red border indicates an exceedance of the SMS Marine SQS or benthic CSL since these apply to the 0-10 cm depth stratum, which is the biologically active zone and point of compliance.
[1] The sum of the benzo(b)fluoranthene and benzo(k)fluoranthene concentrations is compared to the total benzofluoranthenes SMS Marine standard.
No chemistry samples collected from DWMP-05, DWMP-10, and DWMP-13 in 2008. See Section 2.1 of the report and the 2008 QA1 report in Appendix A for more detail.
See Appendix B for lab reports with data qualifiers and dry weight concentrations for OC-normalized compounds

Table 4b: Sediment Chemistry Results Compared to DMMP Chemical Guidelines - 2008

Locator	**DMMP Marine Guidelines¹**		**DWMP-01**	**DWMP-02**	**DWMP-03**	**DWMP-04**	**DWMP-06**	**DWMP-07**	**DWMP-08**	**DWMP-08**	**DWMP-09**	**DWMP-11**	**DWMP-12**	**DWMP-14**	**DWMP-15**	**DWMP-16**
Depth Stratum (cm)			0 -10	0 - 10	0 - 10	0 - 10	0 - 2	0 - 2	0 - 2	0 - 10	0 - 2	0 - 2	0 - 2	0 - 10	0 - 10	0 - 10
Lab Sample ID	**SL**	**ML**	L45313-1	L45313-2	L45313-3	L45313-4	L45313-6	L45313-7	L45313-8	L45313-17	L45313-9	L45313-11	L45313-12	L45313-14	L45313-15	L45313-16
Metals (mg/kg dw)																
Antimony	150	200	<MDL (1.5)	<MDL (1.1)	<MDL (1.6)	<MDL (1.3)	<MDL (1.5)	<MDL (1.4)	<MDL (1.8)	<MDL (1.4)	<MDL (2.2)	<MDL (1.4)	<MDL (2.5)	<MDL (1.5)	<MDL (1.3)	<MDL (1.3)
Nickel	140	370	46.2	37.1	48.5	57.4	28.3	30.5	37.4	42.6	49.6	25.7	47.8	42.7	56.8	77.9
Pesticides (µg/kg dw)																
4,4'-DDD	---	---	<MDL (2.1)	3.37	<MDL (2.2)	2.4	<MDL (1.9)	3.7	11.1	12.9	8.00	7.56	5.4	<MDL (2.0)	6.13	<MDL (1.8)
4,4'-DDE	---	---	<MDL (2.1)	<MDL (1.5)	<MDL (2.2)	<MDL (1.7)	<MDL (1.9)	<MDL (2.0)	<MDL (2.2)	<MDL (1.9)	<MDL (2.9)	<MDL (1.4)	<MDL (3.2)	<MDL (2.0)	<MDL (1.7)	<MDL (1.8)
4,4'-DDT	---	---	<MDL (2.1)	<MDL (1.5)	<MDL (2.2)	<MDL (1.7)	<MDL (1.9)	<MDL (2.0)	<MDL (2.2)	<MDL (1.9)	<MDL (2.9)	<MDL (1.4)	<MDL (3.2)	<MDL (2.0)	<MDL (1.7)	<MDL (1.8)
Sum of 4,4'-DDD, 4,4'DDE, and 4,4'-DDT	6.9	69	<MDL (2.1)	3.37	<MDL (2.2)	2.4	<MDL (1.9)	3.7	11.1	12.9	8.00	7.56	5.4	<MDL (2.0)	6.13	<MDL (1.8)
Aldrin	10	---	<MDL (2.1)	<MDL (1.5)	<MDL (2.2)	<MDL (1.7)	<MDL (1.9)	<MDL (2.0)	<MDL (1.1)	<MDL (1.9)	<MDL (2.9)	<MDL (1.4)	<MDL (3.2)	<MDL (2.0)	<MDL (1.7)	<MDL (1.8)
Alpha-Chlordane	10	---	<MDL (1.0)	<MDL (0.77)	1.5	<MDL (0.85)	<MDL (0.96)	<MDL (0.98)	<MDL (1.1)	1.4	<MDL (1.4)	<MDL (0.99)	<MDL (1.6)	1.8	<MDL (0.87)	<MDL (0.91)
Dieldrin	10	---	<MDL (2.1)	<MDL (1.5)	<MDL (2.2)	<MDL (1.7)	<MDL (1.9)	<MDL (2.0)	<MDL (2.2)	<MDL (1.9)	<MDL (2.9)	<MDL (1.4)	<MDL (3.2)	<MDL (2.0)	<MDL (1.7)	<MDL (1.8)
Heptachlor	10	---	<MDL (1.0)	<MDL (0.77)	<MDL (1.1)	<MDL (0.85)	<MDL (0.96)	<MDL (0.98)	<MDL (1.1)	<MDL (0.97)	<MDL (1.4)	<MDL (0.69)	<MDL (1.6)	<MDL (0.98)	<MDL (0.87)	<MDL (0.91)
Gamma-BHC (Lindane)	10	---	<MDL (1.0)	<MDL (0.77)	<MDL (1.1)	<MDL (0.85)	<MDL (0.96)	<MDL (0.98)	<MDL (1.1)	<MDL (0.97)	<MDL (1.4)	<MDL (0.69)	<MDL (1.6)	<MDL (0.98)	<MDL (0.87)	<MDL (0.91)
Volatile Organics (µg/kg dw)																
Trichloroethene	160	1,600	<MDL (2.1)	<MDL (1.5)	<MDL (2.2)	<MDL (1.7)	<MDL (1.9)	<MDL (2.0)	<MDL (2.2)	<MDL (1.9)	<MDL (2.9)	<MDL (2.0)	<MDL (3.2)	<MDL (2.0)	<MDL (1.7)	<MDL (1.8)
Tetrachloroethene	57	210	<MDL (2.1)	<MDL (1.5)	<MDL (2.2)	<MDL (1.7)	<MDL (1.9)	<MDL (2.0)	<MDL (2.2)	<MDL (1.9)	<MDL (2.9)	<MDL (2.0)	<MDL (3.2)	<MDL (2.0)	<MDL (1.7)	<MDL (1.8)
Ethylbenzene	10	50	<MDL (2.1)	<MDL (1.5)	<MDL (2.2)	<MDL (1.7)	<MDL (1.9)	<MDL (2.0)	<MDL (2.2)	<MDL (1.9)	<MDL (2.9)	<MDL (2.0)	<MDL (3.2)	<MDL (2.0)	<MDL (1.7)	<MDL (1.8)
Total Xylene (sum of o-, m-, p-)	40	160	<MDL (2.1)	<MDL (1.5)	<MDL (2.2)	<MDL (1.7)	<MDL (1.9)	<MDL (2.0)	<MDL (2.2)	<MDL (1.9)	<MDL (2.9)	<MDL (2.0)	<MDL (3.2)	<MDL (2.0)	<MDL (1.7)	<MDL (1.8)

DMMP = Dredge Material Management Program
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
SL = Screening Level
ML = Maximum level
mg/kg dw = Milligrams per kilogram dry weight
µg/kg dw = Micrograms per kilogram dry weight
= Greater than DMMP Marine Guideline SL
See Appendix B for lab reports with data qualifiers
¹ ACOE 2000; per the Biological Opinion the most current guidance at the time the data was collected is used.

Table 4c: Physical and Conventional Parameter Characteristics - 2008

Locator	**DWMP-01**	**DWMP-02**	**DWMP-03**	**DWMP-04**	**DWMP-06**	**DWMP-07**	**DWMP-08**	**DWMP-08**	**DWMP-09**	**DWMP-11**	**DWMP-12**	**DWMP-14**	**DWMP-15**	**DWMP-16**
Depth Stratum (cm)	0 -10	0 - 10	0 - 10	0 - 10	0 - 2	0 - 2	0 - 2	0 - 10	0 - 2	0 - 2	0 - 2	0 - 10	0 - 10	0 - 10
Lab Sample ID	L45313-1	L45313-2	L45313-3	L45313-4	L45313-6	L45313-7	L45313-8	L45313-17	L45313-9	L45313-11	L45313-12	L45313-14	L45313-15	L45313-16
Percent Fines (Clay plus Silt)	61.2	24.6	59.7	46.7	30.5	39.1	40.9	40.7	65.1	32.6	77.0	55.8	48.4	48.0
Percent Clay	15.6	8.2	14.9	16.7	12.4	13.7	13.3	13.0	18.0	12.5	20.0	14.4	18.0	21.6
Percent Silt	45.7	16.4	44.8	30.0	18.1	25.4	27.6	27.8	47.1	20.2	57.0	41.4	30.3	26.4
Percent Sand	26.7	59.7	32.0	29.8	67.7	55.3	50.3	51.2	29.4	61.7	27.7	35.4	32.7	25.2
Percent Gravel	4.0	7.5	3.2	24.1	4.7	4.9	11.0	9.4	0.8	3.1	1.4	3.2	13.4	18.5
Total Organic Carbon (percent dw)	3.37	1.39	2.30	1.16	1.70	1.44	3.36	2.44	3.13	2.34	3.51	2.64	1.15	1.07
Ammonia (mg/kg dw)	4.32	1.49	2.50	1.57	2.41	2.46	7.33	3.33	4.00	3.03	3.83	2.99	1.56	1.51
Sulfide (mg/kg dw)	356	2.9	86.4	5.21	88.0	11.2	619	224	59.7	14.4	77.2	6.93	34.9	12.5

DWMP-05, DWMP-10, and DWMP-13 were not collected for chemistry analysis in 2008; see Section 2.1 of report.
mg/kg dw = Milligrams per kilogram dry weight

Table 5a: Sediment Chemistry Results Compared to Benthic SMS Chemical Criteria - 2009

Locator	Marine SMS		DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)			0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 2	0 - 2	0 - 2	0 - 10	0 - 2	0 - 10	0 - 2	0 - 2	0 - 10	0 - 10	0 - 10	0 - 10
Lab Sample ID	SQS	CSL	L47904-1	L47904-2	L47904-3	L47904-4	L47904-5	L47904-6	L47904-7	L47904-8	L47904-17	L47904-9	L47904-10	L47904-11	L47904-12	L47904-13	L47904-14	L47904-15	L47904-16
Metals (mg/kg dw)																			
Arsenic	57	93	13	6.4	9.1	11	5.0	7.4	6.7	7.9	9.2	11	2.6	7.1	13	4.7	8.9	8.0	9.1
Cadmium	5.1	6.7	1.1	0.39	0.89	0.49	0.35	0.34	0.29	0.85	1.07	0.92	<MDL (0.11)	0.65	0.88	0.33	0.91	0.60	0.47
Chromium	260	270	50.4	40.5	47.7	48.7	17.0	33.5	31.2	33.7	43.6	63.2	14.8	28.9	54.2	19.7	51.6	56.8	60.6
Copper	390	390	80.5	44.8	57.6	48.1	32.4	37.6	33.4	66.2	56.8	109	11.9	41.2	62.6	24.7	73.0	54.6	55.7
Lead	450	530	117	50.2	78.8	44.8	32.4	30.8	29.3	68.7	78.5	88.3	2.2	44.4	90.5	23.2	102	52.6	42.9
Mercury	0.41	0.59	0.794	0.282	0.487	0.318	0.133	0.189	0.290	0.470	0.562	1.70	0.013	0.297	0.403	0.124	0.688	0.610	0.252
Silver	6.1	6.1	3.80	0.95	2.18	0.79	<MDL (0.28)	0.53	0.81	2.07	3.49	3.14	<MDL (0.22)	1.2	2.5	0.38	4.23	1.82	1.0
Zinc	410	960	153	87.2	112	94.1	62.4	82.9	66.3	100	114	121	24.6	84.7	108	50.1	117	101	104
Polychlorinated Biphenyls (PCBs) (mg/kg OC)																			
Total Aroclors	12	65	22.5	20.1	20.1	11.4	6.85	4.18	6.35	8.49	26.6	21.6	NC	8.91	5.59	3.22	21.5	34.1	19.7
Polycyclic Aromatic Hydrocarbons (PAHs) (mg/kg OC)																			
2-Methylnaphthalene	38	64	2.35	1.49	0.797	1.15	0.704	0.46	0.45	0.616	1.04	1.22	NC	0.694	0.39	1.37	1.36	0.791	0.65
Acenaphthene	16	57	3.27	2.22	1.90	0.963	0.815	0.607	0.591	0.836	0.713	1.40	NC	0.909	0.526	1.09	2.32	0.844	1.12
Acenaphthylene	66	66	5.68	2.01	1.54	1.43	2.75	0.862	0.948	1.25	0.715	1.41	NC	0.914	0.762	1.11	2.16	1.16	1.36
Anthracene	220	1200	25.4	9.69	11.4	5.52	25.5	4.14	5.31	5.16	3.62	6.37	NC	4.41	3.07	30.9	10.4	5.46	7.22
Benz(a)anthracene	110	270	57.7	24.5	24.6	14.0	135	10.5	11.4	17.8	7.35	15.7	NC	9.16	7.42	21.5	22.8	13.2	14.8
Benzo(a)pyrene	99	210	102	27.5	26.3	16.9	105	11.5	11.1	18.1	10.0	19.9	NC	11.7	9.44	18.5	29.2	16.7	19.0
Benzo(b)fluoranthene	n/a[1]	n/a[1]	120	30.6	24.9	16.8	117	10.6	11.6	14.3	8.72	18.8	NC	10.6	9.17	22.5	30.7	14.5	15.8
Benzo(g,h,i)perylene	31	78	48.2	20.1	19.1	12.9	36.2	8.20	7.96	12.3	6.39	14.4	NC	8.16	6.78	9.48	18.5	10.6	11.8
Benzo(k)fluoranthene	n/a[1]	n/a[1]	85.9	24.8	20.6	15.7	92.7	11.3	10.9	12.3	9.61	19.0	NC	11.7	8.70	17.0	24.1	15.6	21.8
Chrysene	110	460	89.8	28.8	26.7	15.5	140	12.9	14.9	16.5	8.45	17.5	NC	12.4	9.21	32.2	27.2	16.7	19.1
Dibenzo(a,h)anthracene	12	33	27.7	9.66	8.28	5.17	20.6	3.05	3.10	4.82	2.96	6.61	NC	3.12	2.89	5.31	8.53	5.22	5.39
Fluoranthene	160	1200	73.0	38.4	41.5	19.7	221	13.1	19.6	22.9	11.6	22.9	NC	15.5	9.93	39.2	39.1	19.3	21.4
Fluorene	23	79	4.81	2.44	2.12	1.43	3.10	0.996	1.29	1.27	1.03	1.64	NC	1.21	0.780	3.45	2.52	1.14	1.77
Indeno(1,2,3-Cd)Pyrene	34	88	49.8	18.6	17.4	11.4	38.0	7.27	7.20	9.86	5.58	13.0	NC	7.45	5.82	9.91	17.6	9.39	10.6
Naphthalene	99	170	2.15	1.41	0.839	0.892	0.721	0.509	0.508	0.579	0.948	1.03	NC	1.09	0.42	0.654	1.22	0.61	0.76
Phenanthrene	100	480	41.6	24.4	28.2	10.9	19.9	7.27	9.95	12.7	7.39	15.3	NC	8.82	6.09	23.2	23.3	11.0	12.8
Pyrene	1000	1400	139	56.0	62.9	26.5	155	17.3	22.4	32.1	33.1	39.1	NC	21.2	15.9	43.4	58.5	36.3	32.2
Total benzofluoranthenes	230	450	206	55.4	45.5	32.5	210	21.9	22.5	26.6	18.3	37.8	NC	22.3	17.9	39.5	54.8	30.1	37.7
Total HPAHs (calc.)	960	5300	793	279	272	155	1060	106	120	161	104	187	NC	111	85.2	219	276	157	172
Total LPAHs (calc.)	370	780	85.3	43.6	46.8	22.3	53.5	14.8	19.1	22.4	15.5	28.4	NC	18.0	12.0	61.7	43.3	21.0	25.7
Phthalates (mg/kg OC)																			
Benzyl Butyl phthalate	4.9	64	5.36	4.71	3.05	1.68	1.76	2.44	1.23	1.45	1.99	4.43	NC	1.52	1.27	2.00	6.25	4.15	3.27
Bis(2-Ethylhexyl)phthalate	47	78	42.5	31.9	38.1	14.3	16.0	85.5	14.2	23.4	50.0	47.4	NC	16.1	17.1	24.2	47.4	54.8	44.1
Diethyl phthalate	61	110	<MDL (0.31)	<MDL (0.59)	<MDL (0.42)	<MDL (0.61)	<MDL (0.36)	<MDL (0.51)	<MDL (0.46)	<MDL (0.27)	<MDL (0.40)	<MDL (0.49)	NC	<MDL (0.41)	<MDL (0.49)	<MDL (0.34)	<MDL (0.45)	<MDL (0.74)	<MDL (0.82)
Dimethyl phthalate	53	53	<MDL (0.31)	<MDL (0.59)	<MDL (0.42)	<MDL (0.61)	<MDL (0.36)	<MDL (0.51)	<MDL (0.46)	<MDL (0.27)	<MDL (0.40)	<MDL (0.49)	NC	<MDL (0.41)	<MDL (0.49)	<MDL (0.34)	<MDL (0.45)	<MDL (0.74)	<MDL (0.82)
Di-n-butyl phthalate	220	1700	<MDL (0.31)	1.45	2.47	1.43	1.40	1.20	0.81	1.51	1.40	16.7	NC	0.82	0.97	0.857	2.33	2.37	3.51
Di-n-octyl phthalate	58	4500	<MDL (0.31)	<MDL (0.59)	<MDL (0.42)	<MDL (0.61)	<MDL (0.36)	<MDL (0.51)	<MDL (0.46)	<MDL (0.27)	<MDL (0.40)	<MDL (0.49)	NC	<MDL (0.41)	<MDL (0.49)	<MDL (0.34)	<MDL (0.45)	<MDL (0.74)	<MDL (0.82)
OC-normalized Organic Chemicals (mg/kg OC)																			
1,2,4-Trichlorobenzene	0.81	1.8	<MDL (0.0078)	<MDL (0.015)	<MDL (0.010)	<MDL (0.015)	<MDL (0.0091)	<MDL (0.013)	<MDL (0.012)	<MDL (0.0068)	<MDL (0.0099)	<MDL (0.012)	NC	<MDL (0.010)	<MDL (0.012)	<MDL (0.0086)	<MDL (0.011)	<MDL (0.019)	<MDL (0.020)
1,2-Dichlorobenzene	2.3	2.3	<MDL (0.016)	<MDL (0.030)	<MDL (0.021)	<MDL (0.030)	<MDL (0.018)	<MDL (0.025)	<MDL (0.023)	<MDL (0.014)	0.099082569	<MDL (0.024)	NC	<MDL (0.020)	<MDL (0.024)	<MDL (0.017)	<MDL (0.022)	<MDL (0.037)	<MDL (0.041)
1,4-Dichlorobenzene	3.1	9	0.198	0.183	0.125	<MDL (0.030)	0.115	0.240	0.115	0.436	0.382	<MDL (0.024)	NC	0.263	<MDL (0.024)	0.151	0.267	0.209	<MDL (0.041)
Dibenzofuran	15	58	1.77	1.19	0.916	0.654	0.873	0.42	0.45	0.614	0.621	0.761	NC	0.707	0.33	1.37	1.25	0.50	0.69
Hexachlorobenzene	0.38	2.3	<MDL (0.0078)	<MDL (0.015)	<MDL (0.010)	<MDL (0.015)	<MDL (0.0091)	<MDL (0.013)	<MDL (0.012)	<MDL (0.0068)	<MDL (0.0099)	<MDL (0.012)	NC	<MDL (0.010)	<MDL (0.012)	<MDL (0.0086)	<MDL (0.011)	<MDL (0.019)	<MDL (0.020)
Hexachlorobutadiene	3.9	6.2	<MDL (0.039)	<MDL (0.074)	<MDL (0.052)	<MDL (0.076)	<MDL (0.045)	<MDL (0.063)	<MDL (0.058)	<MDL (0.034)	<MDL (0.050)	<MDL (0.061)	NC	<MDL (0.051)	<MDL (0.061)	<MDL (0.043)	<MDL (0.056)	<MDL (0.093)	<MDL (0.10)
N-nitrosodiphenylamine	11	11	<MDL (0.31)	<MDL (0.59)	<MDL (0.42)	<MDL (0.61)	<MDL (0.36)	<MDL (0.51)	<MDL (0.46)	<MDL (0.27)	<MDL (0.40)	<MDL (0.49)	NC	<MDL (0.41)	<MDL (0.49)	<MDL (0.34)	<MDL (0.45)	<MDL (0.74)	<MDL (0.82)
Pentachlorophenol	360	690	<MDL (0.78)	<MDL (1.5)	<MDL (1.0)	<MDL (1.5)	2.09	<MDL (1.3)	<MDL (1.2)	<MDL (0.68)	<MDL (0.99)	<MDL (1.2)	NC	<MDL (1.0)	<MDL (1.2)	<MDL (0.86)	<MDL (1.1)	<MDL (1.9)	<MDL (2.0)
Other Organic Chemicals (µg/kg dw)																			
2,4-Dimethylphenol	29	29	<MDL (2.1)	<MDL (1.6)	<MDL (2.1)	<MDL (1.9)	<MDL (1.4)	<MDL (2.1)	<MDL (1.7)	<MDL (1.9)	<MDL (2.0)	<MDL (2.3)	NC	<MDL (1.9)	<MDL (3.7)	<MDL (1.4)	<MDL (2.0)	<MDL (1.7)	<MDL (1.8)
2-Methylphenol	63	63	<MDL (4.3)	<MDL (3.1)	<MDL (4.2)	<MDL (3.9)	<MDL (2.8)	<MDL (4.2)	<MDL (3.4)	<MDL (3.9)	<MDL (4.0)	<MDL (4.6)	NC	<MDL (3.8)	<MDL (7.3)	<MDL (2.8)	<MDL (4.0)	<MDL (3.4)	<MDL (3.6)
4-Methylphenol	670	670	97.9	<MDL (6.3)	<MDL (8.5)	<MDL (7.9)	20.3	<MDL (8.4)	<MDL (6.7)	18.2	146	<MDL (9.2)	NC	<MDL (7.7)	<MDL (15)	100	<MDL (8.0)	<MDL (6.8)	<MDL (7.3)
Benzoic acid	650	650	197	263	244	224	99.0	127	113	167	182	228	NC	185	370	196	176	100	156
Benzyl alcohol	57	73	<MDL (4.3)	<MDL (3.1)	<MDL (4.2)	<MDL (3.9)	<MDL (2.8)	<MDL (4.2)	<MDL (3.4)	<MDL (3.9)	<MDL (4.0)	<MDL (4.6)	NC	<MDL (3.8)	<MDL (7.3)	<MDL (2.8)	<MDL (4.0)	<MDL (3.4)	<MDL (3.6)
Phenol	420	1200	<MDL (8.6)	<MDL (6.3)	<MDL (8.5)	<MDL (7.9)	<MDL (5.6)	<MDL (8.4)	<MDL (6.7)	<MDL (7.7)	<MDL (8.0)	<MDL (9.2)	NC	<MDL (7.7)	<MDL (15)	<MDL (5.6)	<MDL (8.0)	<MDL (6.8)	<MDL (7.3)

SMS = Sediment Management Standards
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
SQS = Sediment Quality Standards from Table I of Washington Administrative Code (WAC) 173-204-320
CSL = Cleanup Screening Level from Table III of WAC 173-204-562
mg/kg dw = Milligrams per kilogram dry weight
µg/kg dw = Micrograms per kilogram dry weight
mg/kg OC = Milligrams per kilogram normalized to organic carbon (OC)
(yellow) = Greater than SMS Marine SQS
(orange) = Greater than SMS Marine CSL
(lavender) = Greater than Marine Sediment LAET (dry weight equivalent of SQS) due to percent TOC <0.5 or >3.5
(salmon) = Greater than Marine Sediment 2LAET (dry weight equivalent of CSL) due to percent TOC <0.5 or >3.5
(red border) = Red border indicates an exceedance of the SMS Marine SQS or benthic CSL since these apply to the 0-10 cm depth stratum, which is the biologically active zone and point of compliance.
[1] The sum of the benzo(b)fluoranthene and benzo(k)fluoranthene concentrations is compared to the total benzofluoranthenes SMS Marine standard.
NC = Not calculated due to TOC being less than the MDL. None of the dry weight concentrations exceeded the Marine Sediment AETs.
See Appendix B for lab reports with data qualifiers and dry weight concentrations for OC-normalized compounds

Table 5b: Sediment Chemistry Results Compared to DMMP Chemical Guidelines - 2009

Locator	DMMP Marine Guidelines		DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)			0 -10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 2	0 - 2	0 - 2	0 - 10	0 - 2	0 - 10	0 - 2	0 - 2	0 - 10	0 - 10	0 - 10	0 - 10
Lab Sample ID	SL	ML	L47904-1	L47904-2	L47904-3	L47904-4	L47904-5	L47904-6	L47904-7	L47904-8	L47904-17	L47904-9	L47904-10	L47904-11	L47904-12	L47904-13	L47904-14	L47904-15	L47904-16
Pesticides (µg/kg dw)																			
4,4'-DDD	---	---	<MDL (2.1)	3.96	<MDL (2.1)	2.0	<MDL (1.4)	<MDL (2.1)	2.5	<MDL (1.9)	<MDL (2.0)	<MDL (2.3)	<MDL (1.1)	3.98	<MDL (3.7)	3.08	<MDL (2.0)	<MDL (1.7)	<MDL (1.8)
4,4'-DDE	---	---	<MDL (2.1)	1.6	<MDL (2.1)	<MDL (2.0)	<MDL (1.4)	<MDL (2.1)	<MDL (1.7)	<MDL (1.9)	<MDL (2.0)	<MDL (2.3)	<MDL (1.1)	<MDL (1.9)	<MDL (3.7)	<MDL (1.4)	2.0	<MDL (1.7)	<MDL (1.8)
4,4'-DDT	---	---	<MDL (2.1)	<MDL (1.6)	<MDL (2.1)	<MDL (2.0)	<MDL (1.4)	<MDL (2.1)	<MDL (1.7)	<MDL (1.9)	<MDL (2.0)	<MDL (2.3)	<MDL (1.1)	<MDL (1.9)	<MDL (3.7)	31.3	<MDL (2.0)	<MDL (1.7)	<MDL (1.8)
Sum of 4,4'-DDD, 4,4'DDE, and 4,4'-DDT	6.9[1]	69	<MDL (2.1)	5.52	<MDL (2.1)	2.0	<MDL (1.4)	<MDL (2.1)	2.5	<MDL (1.9)	<MDL (2.0)	<MDL (2.3)	<MDL (1.1)	3.98	<MDL (3.7)	34.3	2.0	<MDL (1.7)	<MDL (1.8)

DMMP = Dredge Material Management Program
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
SL = Screening Level
ML = Maximum level
mg/kg dw = Milligrams per kilogram dry weight
µg/kg dw = Micrograms per kilogram dry weight
= Greater than DMMP Marine Guideline SL
See Appendix B for lab reports with data qualifiers
[1] ACOE 2008; per the Biological Opinion the most current guidance at the time the data was collected is used.

Table 5c: Physical and Conventional Parameter Characteristics - 2009

Locator	DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)	0 -10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 2	0 - 2	0 - 2	0 - 10	0 - 2	0 - 10	0 - 2	0 - 2	0 - 10	0 - 10	0 - 10	0 - 10
Lab Sample ID	L47904-1	L47904-2	L47904-3	L47904-4	L47904-5	L47904-6	L47904-7	L47904-8	L47904-17	L47904-9	L47904-10	L47904-11	L47904-12	L47904-13	L47904-14	L47904-15	L47904-16
Percent Fines (Clay plus Silt)	61.7	37.6	56.2	53.5	7.4	31.3	21.2	44.1	49.8	62.9	1.6	31	80.2	7.2	58.5	53.3	67.8
Percent Clay	14.1	12.0	13.5	13.9	3.7	8.4	7.6	11.6	13.2	16	1.1	7.0	14.3	3.3	12.9	17.2	27.1
Percent Silt	47.7	25.6	42.7	39.7	3.7	23.0	13.6	32.6	36.7	46.9	0.55	24.0	65.9	3.9	45.6	36.1	40.7
Percent Sand	27.6	45.6	33.9	29.3	36.4	59.5	52.2	48.2	40.4	27.8	72.4	63.3	20.4	37.7	30.6	29.5	20.7
Percent Gravel	8.0	11.1	1.6	15.9	53.5	4.2	18	5.7	8	1.9	27.2	2.6	0.6	53.1	0.5	10.9	10.2
Total Organic Carbon (percent dw)	2.75	1.06	2.02	1.29	1.54	1.66	1.46	2.82	2.01	1.88	<MDL (0.049)	1.88	3.00	1.61	1.78	0.925	0.894
Ammonia (mg/kg dw)	6.52	2.33	2.39	1.81	6.58	2.55	2.16	4.66	2.55	2.10	0.438	1.99	2.99	5.78	2.52	1.30	1.44
Sulfide (mg/kg dw)	51.3	0.80	7.90	4.22	45.9	16.6	2.0	103	8.57	13.6	<MDL (0.53)	2.7	65.2	65.1	20.8	13.7	1.4

mg/kg dw = Milligrams per kilogram dry weight
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)

Table 6a: Sediment Chemistry Results Compared to Benthic SMS Chemical Criteria - 2010

Locator	Marine SMS		DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)			0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 2	0 - 2	0 - 2	0 - 10	0 - 2	0 - 10	0 - 2	0 - 2	0 - 10	0 - 10	0 - 10	0 - 10
Lab Sample ID	SQS	CSL	L50382-1	L50382-2	L50382-3	L50382-4	L50382-5	L50382-6	L50382-7	L50382-8	L50382-9	L50382-10	L50382-11	L50382-12	L50382-13	L50382-14	L50382-15	L50382-16	L50382-17
Metals (mg/kg dw)																			
Arsenic	57	93	13	5.7	9.2	9.2	4.0	7.6	7.1	9.6	7.0	9.0	1.8	5.2	10	2.3	8.7	9.4	9.0
Cadmium	5.1	6.7	1.22	0.18	1.19	0.29	0.22	0.31	0.19	1.13	0.68	0.56	<MDL (0.11)	0.24	0.55	<MDL (0.12)	0.91	0.44	0.48
Chromium	260	270	50.8	38.8	54.5	47.4	23.0	33.2	30.0	47.0	39.0	45.9	12.1	24.6	47.1	13.9	50.0	59.7	61.1
Copper	390	390	80.7	35.4	66.2	48.0	24.3	39.1	33.6	226	48.9	63.8	11.5	28.9	58.8	15.3	69.9	51.8	59.0
Lead	450	530	120	50.5	107	36.5	24.3	50.2	25.5	99.1	61.7	69.2	3.3	26.5	51.5	12.2	104	47.4	53.8
Mercury	0.41	0.59	0.974	0.23	0.862	0.362	0.057	0.19	0.24	0.632	0.619	0.528	0.020	0.17	0.38	0.035	0.606	0.350	0.40
Silver	6.1	6.1	5.03	2.10	5.60	2.25	0.96	2.34	1.96	7.17	4.23	3.85	0.78	2.13	3.75	0.80	5.61	3.54	3.45
Zinc	410	960	136	69.8	125	84.0	76.9	78.8	58.5	131	86.6	97.9	24.6	69.1	94.8	33.8	115	95.1	101
Polychlorinated Biphenyls (PCBs) (mg/kg OC)																			
Total Aroclors	12	65	7.19	7.26	40.6	10.4	9.63	2.99	9.77	17.6	18.3	14.2	2.7	6.50	5.02	4.22	21.2	26.5	15.3
Polycyclic Aromatic Hydrocarbons (PAHs) (mg/kg OC)																			
2-Methylnaphthalene	38	64	0.79	0.58	<MDL (1.9)	0.815	<MDL (1.5)	0.24	0.40	<MDL (0.87)	1.08	0.32	<MDL (1.6)	<MDL (0.21)	<MDL (0.16)	<MDL (3.22)	0.877	0.51	0.44
Acenaphthene	16	57	2.24	1.48	<MDL (1.9)	1.04	1.7	0.494	0.676	<MDL (0.87)	0.741	0.736	<MDL (1.6)	0.829	0.385	<MDL (3.22)	1.96	0.766	0.648
Acenaphthylene	66	66	3.55	1.12	<MDL (1.9)	1.08	1.5	0.795	0.701	<MDL (0.87)	2.97	0.619	<MDL (1.6)	0.430	0.596	<MDL (3.22)	1.03	0.884	0.721
Anthracene	220	1200	29.9	9.66	4.44	5.13	10.3	4.08	4.43	3.60	56.8	3.01	16.3	4.46	3.04	41.7	5.22	4.08	3.91
Benz(a)anthracene	110	270	94.7	16.9	12.1	17.3	25.5	9.72	12.8	8.24	223	7.39	14.2	8.52	5.84	32.7	17.1	10.5	9.46
Benzo(a)pyrene	99	210	144	18.8	15.6	17.0	31.5	10.7	12.0	10.5	171	9.67	13.0	9.01	8.25	23.8	21.6	13.1	10.9
Benzo(b)fluoranthene	n/a[1]	n/a[1]	172	22.4	22.0	22.6	32.5	13.1	14.9	12.3	202	9.50	17.3	10.0	8.33	24.2	21.8	14.1	11.5
Benzo(g,h,i)perylene	31	78	65.8	11.6	12.2	7.24	15.9	6.96	8.17	6.70	41.5	6.03	7.82	5.63	5.28	14.6	12.0	9.02	6.84
Benzo(k)fluoranthene	n/a[1]	n/a[1]	163	18.2	18.6	18.6	44.4	9.4	13.3	14.2	160	10.5	20.3	9.35	7.71	28.8	21.5	15.0	13.0
Chrysene	110	460	147	22.0	16.3	16.2	39.1	12.1	13.9	12.1	201	11.0	26.4	10.1	8.41	48.1	18.2	13.5	10.2
Dibenz(a,h)anthracene	12	33	31.0	5.17	4.26	3.00	6.95	3.14	3.28	3.03	31.3	2.34	3.44	2.29	1.96	7.79	3.48	3.71	2.61
Fluoranthene	160	1200	78.0	28.8	25.0	31.4	64.3	15.2	19.4	14.3	278	14.6	28.8	15.6	10.0	55.4	25.7	18.1	14.9
Fluorene	23	79	4.51	1.87	<MDL (1.9)	1.36	2.7	0.84	1.13	0.96	5.95	0.86	2.3	1.03	0.647	7.44	2.11	1.12	0.895
Indeno(1,2,3-Cd)Pyrene	34	88	66.4	10.0	10.6	6.62	14.2	5.97	7.04	5.89	57.3	5.08	7.46	4.80	4.32	10.3	10.0	8.01	5.56
Naphthalene	99	170	1.3	0.825	<MDL (1.9)	0.906	1.8	0.29	0.55	<MDL (0.87)	0.634	0.490	<MDL (1.6)	0.24	0.17	<MDL (3.22)	1.23	0.51	0.798
Phenanthrene	100	480	30.2	16.0	12.0	10.7	23.1	6.84	9.16	5.87	34.6	7.43	11.7	8.55	4.96	26.1	14.0	8.74	7.15
Pyrene	1000	1400	170	36.7	55.4	38.5	81.5	16.8	20.9	45.0	354	17.2	21.7	16.9	11.3	57.0	41.5	22.5	16.9
Total benzofluoranthenes	230	450	335	40.6	40.7	41.2	76.9	22.5	28.2	26.4	361	20.0	37.6	19.3	16.0	53.0	43.3	29.1	24.5
Total HPAHs (calc.)	960	5300	1131	191	192	179	356	103	126	132	1718	93.3	161	92.2	71.5	303	193	128	102
Total LPAHs (calc.)	370	780	72.5	31.5	16.5	21.0	41.1	13.6	17.1	10.4	103	13.5	30.2	15.5	9.79	75.2	26.5	16.6	14.6
Phthalates (mg/kg OC)																			
Benzyl Butyl phthalate	4.9	64	3.42	5.61	4.64	1.68	19.8	2.77	1.97	3.63	7.83	1.31	3.04	1.28	0.79	<MDL (1.6)	4.55	2.68	2.98
Bis(2-Ethylhexyl)phthalate	47	78	22.8	18.8	114	18.9	34.2	15.1	24.1	59.3	61.2	18.1	16.7	12.6	11.8	21.9	62.8	39.1	24.8
Diethyl phthalate	61	110	<MDL (1.3)	<MDL (0.46)	<MDL (3.8)	<MDL (0.61)	<MDL (3.1)	<MDL (0.38)	<MDL (0.65)	<MDL (1.7)	<MDL (0.37)	<MDL (0.33)	<MDL (3.3)	<MDL (0.42)	<MDL (0.32)	<MDL (6.4)	<MDL (0.33)	<MDL (0.65)	<MDL (0.45)
Dimethyl phthalate	53	53	<MDL (1.3)	<MDL (0.46)	<MDL (3.8)	<MDL (0.61)	<MDL (3.1)	<MDL (0.38)	<MDL (0.65)	<MDL (1.7)	<MDL (0.37)	<MDL (0.33)	<MDL (3.3)	<MDL (0.42)	0.64	<MDL (6.4)	<MDL (0.33)	<MDL (0.65)	<MDL (0.45)
Di-n-butyl phthalate	220	1700	1.4	1.08	<MDL (3.8)	5.41	<MDL (3.1)	1.10	1.32	<MDL (1.7)	<MDL (0.37)	0.75	5.1	0.97	0.81	<MDL (6.4)	2.11	1.70	1.45
Di-n-octyl phthalate	58	4500	<MDL (1.3)	<MDL (0.46)	<MDL (3.8)	<MDL (0.61)	<MDL (3.1)	<MDL (0.38)	<MDL (0.65)	<MDL (1.7)	<MDL (0.37)	<MDL (0.33)	<MDL (3.3)	<MDL (0.42)	<MDL (0.32)	<MDL (6.4)	<MDL (0.33)	<MDL (0.65)	<MDL (0.45)
OC-Normalized Organic Chemicals (mg/kg OC)																			
1,2,4-Trichlorobenzene	0.81	1.8	<MDL (0.033)	<MDL (0.015)	<MDL (0.097)	<MDL (0.014)	<MDL (0.076)	<MDL (0.0094)	<MDL (0.016)	<MDL (0.043)	<MDL (0.0092)	<MDL (0.0083)	<MDL (0.081)	<MDL (0.010)	<MDL (0.0079)	<MDL (0.16)	<MDL (0.0082)	<MDL (0.016)	<MDL (0.011)
1,2-Dichlorobenzene	2.3	2.3	<MDL (0.066)	<MDL (0.030)	<MDL (0.19)	0.064	<MDL (0.15)	0.032	0.060	<MDL (0.087)	0.099	0.044	0.25	0.046	0.040	<MDL (0.32)	<MDL (0.016)	0.097	0.073
1,4-Dichlorobenzene	3.1	9	<MDL (0.066)	0.095	<MDL (0.19)	0.11	<MDL (0.15)	0.13	0.28	0.44	0.38	0.10	0.49	0.12	0.07	<MDL (0.32)	<MDL (0.016)	0.20	0.16
Dibenzofuran	15	58	1.1	0.648	<MDL (1.9)	0.62	<MDL (1.5)	0.32	0.49	<MDL (21)	1.26	0.37	<MDL (1.6)	0.466	0.25	<MDL (24)	1.23	0.44	0.40
Hexachlorobenzene	0.38	2.3	<MDL (0.033)	<MDL (0.015)	<MDL (0.097)	<MDL (0.014)	<MDL (0.076)	0.156603774	<MDL (0.016)	<MDL (0.043)	<MDL (0.0092)	<MDL (0.0083)	<MDL (0.081)	<MDL (0.010)	<MDL (0.0079)	<MDL (0.16)	<MDL (0.0082)	<MDL (0.016)	<MDL (0.011)
Hexachlorobutadiene	3.9	6.2	<MDL (0.16)	<MDL (0.074)	<MDL (0.49)	<MDL (0.071)	<MDL (0.38)	<MDL (0.047)	<MDL (0.081)	<MDL (0.22)	<MDL (0.046)	<MDL (0.042)	<MDL (0.41)	<MDL (0.052)	<MDL (0.040)	<MDL (0.81)	<MDL (0.041)	<MDL (0.082)	<MDL (0.056)
N-nitrosodiphenylamine	11	11	<MDL (1.3)	<MDL (0.46)	<MDL (3.9)	<MDL (0.57)	<MDL (3.1)	<MDL (0.38)	<MDL (0.65)	<MDL (1.7)	<MDL (0.37)	<MDL (0.33)	<MDL (3.3)	<MDL (0.42)	<MDL (0.32)	<MDL (6.4)	<MDL (0.33)	<MDL (0.65)	<MDL (0.45)
Pentachlorophenol	360	690	<MDL (3.3)	<MDL (1.5)	<MDL (9.7)	<MDL (1.4)	<MDL (7.6)	<MDL (0.94)	<MDL (1.6)	<MDL (4.3)	<MDL (0.92)	<MDL (0.83)	<MDL (8.1)	<MDL (1.0)	<MDL (0.79)	<MDL (16)	<MDL (0.82)	<MDL (1.6)	<MDL (1.1)
Other Organic Chemicals (µg/kg dw)																			
2,4-Dimethylphenol	29	29	<MDL (22)	<MDL (1.5)	<MDL (19)	<MDL (1.7)	<MDL (6.5)	<MDL (2.2)	<MDL (1.7)	<MDL (10)	<MDL (1.8)	<MDL (2.6)	<MDL (1.2)	<MDL (1.7)	<MDL (3.4)	<MDL (12)	<MDL (1.9)	<MDL (1.6)	<MDL (2.1)
2-Methylphenol	63	63	<MDL (43)	<MDL (3.1)	<MDL (38)	<MDL (3.4)	<MDL (13)	<MDL (4.4)	<MDL (3.4)	<MDL (21)	<MDL (3.7)	<MDL (5.1)	<MDL (2.3)	<MDL (3.4)	<MDL (6.9)	<MDL (24)	<MDL (3.7)	<MDL (3.3)	<MDL (4.2)
4-Methylphenol	670	670	214	112	<MDL (76)	106	<MDL (26)	158	43.0	72.3	131	164	<MDL (4.6)	64.9	193	<MDL (48)	84.9	70.6	54.2
Benzoic acid	650	650	<MDL (217)	152	<MDL (190)	75.6	198	147	89.7	<MDL (100)	122	128	145	94.3	191	390	84.8	77.0	81.9
Benzyl alcohol	57	73	<MDL (43)	<MDL (3.1)	<MDL (38)	<MDL (3.4)	<MDL (13)	<MDL (4.4)	<MDL (0.32)	<MDL (21)	<MDL (3.7)	<MDL (5.1)	<MDL (2.3)	<MDL (3.4)	<MDL (6.9)	<MDL (24)	<MDL (3.7)	<MDL (3.3)	<MDL (4.2)
Phenol	420	1200	124	133	105	51.0	258	89.7	<MDL (6.7)	97.2	<MDL (7.3)	<MDL (10)	113	52.9	40.2	274	30.9	<MDL (6.6)	28.4

SMS = Sediment Management Standards
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
SQS = Sediment Quality Standards from Table I of Washington Administrative Code (WAC) 173-204-320
CSL = Cleanup Screening Level from Table III of WAC 173-204-562
mg/kg dw = Milligrams per kilogram dry weight
µg/kg dw = Micrograms per kilogram dry weight
mg/kg OC = Milligrams per kilogram normalized to organic carbon (OC)
(yellow) = Greater than SMS Marine SQS
(orange) = Greater than SMS Marine CSL
(light gray) = Greater than Marine Sediment LAET (dry weight equivalent of SQS) due to percent TOC <0.5 or >3.5
(salmon) = Greater than Marine Sediment 2LAET (dry weight equivalent of CSL) due to percent TOC <0.5 or >3.5
(red border) = Red border indicates an exceedance of the SMS Marine SQS or benthic CSL since these apply to the 0-10 cm depth stratum, which is the biologically active zone and point of compliance.

[1] The sum of the benzo(b)fluoranthene and benzo(k)fluoranthene concentrations is compared to the total benzofluoranthenes SMS Marine standard.
See Appendix B for lab reports with data qualifiers and dry weight concentrations for OC-normalized compounds

Table 6b: Sediment Chemistry Results Compared to DMMP Chemical Guidelines - 2010

Locator	DMMP Marine Guidelines		DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)			0 -10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 2	0 - 2	0 - 2	0 - 10	0 - 2	0 - 10	0 - 2	0 - 2	0 - 10	0 - 10	0 - 10	0 - 10
Lab Sample ID	**SL**	**ML**	L50382-1	L50382-2	L50382-3	L50382-4	L50382-5	L50382-6	L50382-7	L50382-8	L50382-9	L50382-10	L50382-11	L50382-12	L50382-13	L50382-14	L50382-15	L50382-16	L50382-17
Pesticides (µg/kg dw)																			
4,4'-DDD	---	---	9.67	2.6	14.8	3.2	2.3	2.2	3.0	16.0	11.3	5.18	<MDL (1.2)	2.2	<MDL (3.4)	1.3	17.4	5.25	4.87
4,4'-DDE	---	---	4.82	<MDL (1.5)	7.51	<MDL (1.7)	<MDL (1.3)	<MDL (2.2)	<MDL (1.7)	6.81	4.45	<MDL (2.6)	<MDL (1.2)	<MDL (1.7)	<MDL (3.4)	<MDL (1.2)	5.72	1.8	2.1
4,4'-DDT	---	---	5.01	1.7	7.88	2.2	1.4	2.4	4.40	7.30	5.33	3.1	<MDL (1.2)	<MDL (1.7)	<MDL (3.4)	<MDL (1.2)	14.6	3.1	3.8
Sum of 4,4'-DDD, 4,4'DDE, and 4,4'-DDT	6.9[1]	69	19.5	4.3	30.2	5.5	3.7	4.6	7.44	30.1	21.1	8.26	<MDL (1.2)	2.2	<MDL (3.4)	1.3	37.8	10.2	10.8

DMMP = Dredge Material Management Program
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
SL = Screening Level
ML = Maximum level
mg/kg dw = Milligrams per kilogram dry weight
µg/kg dw = Micrograms per kilogram dry weight
(yellow) = Greater than DMMP Marine Guideline SL
See Appendix B for lab reports with data qualifiers
[1] ACOE 2008; per the Biological Opinion the most current guidance at the time the data was collected is used.

Table 6c: Physical and Conventional Parameter Characteristics - 2010

Parameter	DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)	0 -10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 2	0 - 2	0 - 2	0 - 10	0 - 2	0 - 10	0 - 2	0 - 2	0 - 10	0 - 10	0 - 10	0 - 10
Lab Sample ID	L50382-1	L50382-2	L50382-3	L50382-4	L50382-5	L50382-6	L50382-7	L50382-8	L50382-9	L50382-10	L50382-11	L50382-12	L50382-13	L50382-14	L50382-15	L50382-16	L50382-17
Percent Fines (Clay plus Silt)	51.2	19.9	63.9	37.9	5.3	29.8	32.0	46.1	43.1	91.7	1.2	26.0	79.0	10.4	45.8	47.5	68.8
Percent Clay	4.7	3.0	12	7	1.5	10.9	5.9	10.7	8.6	34.4	0.6	10.0	20.6	6.5	1.9	18.7	18.4
Percent Silt	46.5	17.0	51.9	30.8	3.8	18.9	26.1	35.4	34.5	57.3	0.6	16.0	58.4	3.9	43.8	28.9	50.5
Percent Sand	34.4	46.1	40.8	32.4	67.9	61.5	53.9	58.8	44.5	50.6	57.3	50.7	24.6	56.4	42.7	31.2	34.1
Percent Gravel	13.0	9.2	4.3	34.2	27.4	1.9	16.2	9.7	11.9	4.8	41.1	2.5	3.0	42.3	1.6	20.9	6.6
Total Organic Carbon (percent dw)	6.59	1.32	1.97	1.20	0.846	2.31	1.04	2.45	2.00	3.08	0.142	1.64	4.33	0.749	2.27	1.01	1.88
Ammonia (mg/kg dw)	3.41	0.95	1.55	1.34	1.28	2.64	1.19	2.19	2.12	2.37	0.773	1.16	2.82	2.26	1.75	1.40	1.77
Sulfide (mg/kg dw)	241	2.30	40.3	38.6	56.7	306	1.6	16.0	32.4	10.8	0.854	23.5	143	35.5	87.7	9.34	51.5

mg/kg dw = Milligrams per kilogram dry weight

Table 7a: Sediment Chemistry Results Compared to Benthic SMS Chemical Criteria - 2015

Locator	Marine SMS		DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)			0 -10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10
Lab Sample ID	SQS	CSL	L62484-1	L62484-2	L62484-3	L62484-4	L62484-5	L62484-6	L62484-7	L62484-8	L62484-9	L62484-10	L62484-11	L62484-12	L62484-13	L62484-14	L62484-15	L62484-16
Metals (mg/kg dw)																		
Arsenic	57	93	12	5.0	8.3	7.7	3.6	7.4	8.2	8.4	11	1.8	7.4	13	2.5	8.6	9.5	8.5
Cadmium	5.1	6.7	0.74	0.17	0.76	0.28	0.17	0.23	0.38	1.1	2.01	<MDL (0.14)	0.68	0.58	<MDL (0.13)	0.67	0.42	0.46
Chromium	260	270	42.4	31.6	38.4	42.5	16.8	36.3	37.1	41.6	44.4	8.5	35.5	46.7	13.3	44.2	55.1	58.8
Copper	390	390	70.2	29.8	48.6	41.1	17.9	34.2	42.8	67.4	56.8	13.6	43.1	53.3	11.2	61.7	48.5	57.6
Lead	450	530	103	36.0	73.3	33.4	17.9	27.0	47.8	73.2	62.8	4.5	63.0	47.9	10.1	82.3	42.1	42.0
Mercury	0.41	0.59	0.771	0.267	0.583	0.287	0.0867	0.166	0.468	0.418	0.620	0.025	0.686	0.429	0.0631	0.564	0.334	0.566
Silver	6.1	6.1	3.23	0.33	2.73	<MDL (0.35)	<MDL (0.26)	<MDL (0.37)	1.1	3.08	1.7	<MDL (0.24)	2.09	1.6	<MDL (0.27)	3.32	1.1	1.2
Zinc	410	960	134	70.2	105	84.3	56.6	76.4	81.0	122	103	25.9	106	96.9	34.7	109	98.5	103
Polychlorinated Biphenyls (PCBs) (mg/kg OC)																		
Total Aroclors	12	65	8.10	11.7	28.4	12.0	9.71	5.81	16.9	14.3	12.4	<MDL (5.6)	22.8	6.34	14.4	25.0	25.3	11.8
Polycyclic Aromatic Hydrocarbons (PAHs) (mg/kg OC)																		
2-Methylnaphthalene	38	64	1.15	1.1	0.97	1.42	1.3	0.66	0.73	0.83	0.53	<MDL (1.7)	0.74	<MDL (0.29)	<MDL (0.80)	1.30	0.87	0.45
Acenaphthene	16	57	2.03	2.10	1.97	1.12	2.01	0.49	1.05	1.26	0.86	<MDL (1.7)	3.79	0.49	<MDL (0.80)	1.99	0.90	0.54
Acenaphthylene	66	66	7.78	2.36	1.91	1.72	3.37	0.65	1.52	1.01	1.05	<MDL (1.7)	0.71	0.53	0.84	1.93	1.28	0.61
Anthracene	220	1200	31.1	9.98	8.10	5.89	12.2	2.64	4.91	4.45	3.43	7.81	3.39	1.80	4.23	7.67	4.34	2.39
Benz(a)anthracene	110	270	78.9	25.2	16.7	13.6	45.8	6.7	11.5	9.54	8.62	16.5	6.53	4.95	14.5	20.3	12.6	5.98
Benzo(a)pyrene	99	210	149	29.9	24.2	19.3	60.2	10.0	18.2	14.7	11.3	17.4	8.68	7.15	16.6	26.3	17.4	8.41
Benzo(b,j,k)fluoranthene	n/a[1]	n/a[1]	357	83.5	51.9	41.4	177	22.9	37.4	28.6	24.1	47.9	17.4	19.3	38.7	57.7	40.6	18.5
Benzo(g,h,i)perylene	31	78	38.3	8.19	14.7	13.4	13.4	4.45	11.0	7.70	7.31	4.74	5.44	1.93	7.5	11.5	7.87	3.74
Chrysene	110	460	159	42.5	22.5	20.6	91.8	10.6	18.4	13.4	11.3	28.0	8.37	7.32	20.6	25.5	17.6	8.86
Dibenz(a,h)anthracene	12	33	15.8	2.95	3.86	4.35	4.0	1.31	3.4	2.52	<MDL (1.6)	1.7	1.7	0.41	<MDL (0.80)	3.58	2.51	1.15
Fluoranthene	160	1200	44.4	39.1	28.0	22.7	72.0	11.4	17.2	17.2	14.0	25.0	12.2	7.20	31.2	34.8	21.3	10.1
Fluorene	23	79	4.85	3.37	2.59	1.97	3.75	0.71	1.25	1.82	1.11	1.9	3.05	0.62	1.3	2.50	1.29	0.84
Indeno(1,2,3-c,d)Pyrene	34	88	56.0	11.6	17.1	15.9	17.5	5.57	12.3	8.49	7.51	6.42	6.43	2.33	8.08	14.6	9.01	4.38
Naphthalene	99	170	1.72	1.3	1.25	1.29	1.2	0.64	0.98	0.68	0.79	<MDL (1.7)	0.95	<MDL (0.29)	<MDL (0.80)	1.49	0.99	0.69
Phenanthrene	100	480	29.6	25	16.5	12.1	23.4	4.82	8.72	12.5	7.57	11.8	9.30	3.87	9.76	18.9	9.21	5.49
Pyrene	1000	1400	102	44.3	38.7	27.8	69.0	12.6	22.6	24.1	17.5	22.0	16.7	8.31	35.8	48.3	23.9	11.1
Total benzofluoranthenes	230	450	357	83.5	51.9	41.9	177	22.9	37.4	28.6	24.1	47.9	17.4	19.3	38.7	57.7	40.6	18.5
Total HPAHs (calc.)	960	5300	999	287	218	180	551	85.5	152	118	102	170	83.4	58.9	173	242	153	72.2
Total LPAHs (calc.)	370	780	78.3	45.2	33.3	25.5	47.3	10.6	19.1	22.5	15.3	21.5	21.9	7.32	16.1	35.8	18.9	11.0
Phthalates (mg/kg OC)																		
Benzyl Butyl phthalate	4.9	64	3.80	1.94	<MDL (0.51)	<MDL (0.70)	7.51	1.04	<MDL (0.61)	1.74	<MDL (0.47)	<MDL (2.5)	<MDL (0.47)	0.63	<MDL (1.2)	25.5	4.17	<MDL (0.48)
Bis(2-Ethylhexyl)phthalate	47	78	13.7	20.7	61.7	12.9	22.2	8.46	24.7	28.5	19.5	16.2	39.3	10.2	12.2	42.0	32.1	12.5
Diethyl phthalate	61	110	0.30	<MDL (1.3)	<MDL (0.69)	<MDL (0.93)	<MDL (1.4)	<MDL (0.86)	<MDL (0.82)	<MDL (0.48)	0.86	<MDL (3.4)	<MDL (0.63)	0.97	<MDL (1.6)	<MDL (0.67)	<MDL (1.0)	0.69
Dimethyl phthalate	53	53	<MDL (0.27)	<MDL (1.3)	<MDL (0.69)	<MDL (0.93)	<MDL (1.4)	<MDL (0.86)	<MDL (0.82)	<MDL (0.48)	<MDL (0.63)	<MDL (3.4)	<MDL (0.63)	<MDL (0.59)	<MDL (1.6)	<MDL (0.67)	<MDL (1.0)	<MDL (0.64)
Di-n-butyl phthalate	220	1700	<MDL (0.27)	2.3	<MDL (0.69)	<MDL (0.93)	<MDL (1.4)	1.4	<MDL (0.82)	<MDL (0.48)	1.81	<MDL (3.4)	1.34	1.0	<MDL (1.6)	11.1	<MDL (1.0)	0.96
Di-n-octyl phthalate	58	4500	<MDL (1.4)	<MDL (1.3)	<MDL (3.4)	<MDL (4.7)	<MDL (1.4)	<MDL (0.86)	<MDL (4.1)	<MDL (2.4)	<MDL (3.1)	<MDL (3.4)	<MDL (3.2)	<MDL (0.59)	<MDL (8.1)	<MDL (3.3)	<MDL (1.0)	<MDL (0.64)
OC-normalized Organic Chemicals (mg/kg OC)																		
1,2,4-Trichlorobenzene	0.81	1.8	<MDL (0.014)	<MDL (0.063)	<MDL (0.034)	<MDL (0.046)	<MDL (0.069)	<MDL (0.042)	<MDL (0.040)	<MDL (0.024)	<MDL (0.031)	<MDL (0.17)	<MDL (0.031)	<MDL (0.029)	<MDL (0.080)	0.055	<MDL (0.051)	<MDL (0.032)
1,2-Dichlorobenzene	2.3	2.3	<MDL (0.14)	<MDL (0.63)	<MDL (0.34)	<MDL (0.47)	<MDL (0.70)	<MDL (0.43)	<MDL (0.41)	<MDL (0.24)	<MDL (0.31)	<MDL (1.7)	<MDL (0.32)	<MDL (0.29)	<MDL (0.80)	<MDL (0.33)	<MDL (0.52)	<MDL (0.32)
1,4-Dichlorobenzene	3.1	9	<MDL (0.20)	<MDL (0.95)	<MDL (0.51)	<MDL (0.70)	<MDL (1.0)	<MDL (0.64)	<MDL (0.61)	<MDL (0.36)	<MDL (0.47)	<MDL (2.5)	<MDL (0.47)	<MDL (0.44)	<MDL (1.2)	<MDL (0.50)	<MDL (0.78)	<MDL (0.48)
Dibenzofuran	15	58	1.21	1.28	1.19	0.81	1.3	<MDL (1.1)	0.76	0.69	0.50	<MDL (1.7)	2.33	0.31	<MDL (0.80)	1.24	0.74	0.32
Hexachlorobenzene	0.38	2.3	<MDL (0.014)	<MDL (0.063)	<MDL (0.034)	<MDL (0.046)	<MDL (0.069)	<MDL (0.042)	<MDL (0.040)	<MDL (0.024)	<MDL (0.031)	<MDL (0.17)	<MDL (0.031)	<MDL (0.029)	<MDL (0.080)	<MDL (0.033)	<MDL (0.051)	<MDL (0.032)
Hexachlorobutadiene	3.9	6.2	<MDL (0.068)	<MDL (0.31)	<MDL (0.17)	<MDL (0.23)	<MDL (0.34)	<MDL (0.21)	<MDL (0.20)	<MDL (0.12)	<MDL (0.16)	<MDL (0.84)	<MDL (0.16)	<MDL (0.15)	<MDL (0.40)	<MDL (0.17)	<MDL (0.26)	<MDL (0.16)
N-nitrosodiphenylamine	11	11	<MDL (0.34)	<MDL (1.6)	<MDL (0.86)	<MDL (1.2)	<MDL (1.7)	<MDL (16)	<MDL (1.0)	<MDL (0.60)	<MDL (0.78)	<MDL (4.2)	<MDL (0.79)	<MDL (0.73)	<MDL (2.0)	<MDL (2.0)	<MDL (1.3)	<MDL (0.80)
Pentachlorophenol	360	690	<MDL (2.0)	<MDL (9.5)	<MDL (5.1)	<MDL (7.0)	<MDL (10)	<MDL (6.4)	<MDL (6.1)	<MDL (3.6)	<MDL (4.7)	<MDL (25)	<MDL (4.7)	<MDL (4.4)	<MDL (12)	<MDL (5.0)	<MDL (7.8)	<MDL (4.8)
Other Organic Chemicals (µg/kg dw)																		
2,4-Dimethylphenol	29	29	29.6	<MDL (5.5)	<MDL (7.0)	<MDL (6.3)	<MDL (4.7)	<MDL (6.3)	<MDL (6.5)	<MDL (7.5)	<MDL (9.3)	<MDL (4.3)	<MDL (7.0)	<MDL (14)	<MDL (4.7)	<MDL (4.7)	<MDL (6.1)	<MDL (7.3)
2-Methylphenol	63	63	13	<MDL (5.5)	<MDL (7.0)	<MDL (6.3)	<MDL (4.7)	<MDL (6.3)	<MDL (6.5)	<MDL (7.5)	<MDL (9.3)	<MDL (4.3)	<MDL (7.0)	<MDL (14)	<MDL (4.7)	<MDL (4.7)	<MDL (6.1)	<MDL (7.3)
3-,4-Methylphenol	670	670	<MDL (44)	<MDL (27)	<MDL (35)	<MDL (31)	<MDL (24)	<MDL (32)	<MDL (32)	<MDL (38)	<MDL (47)	<MDL (22)	<MDL (35)	<MDL (69)	<MDL (23)	<MDL (23)	<MDL (30)	<MDL (36)
Benzoic acid	650	650	183	<MDL (110)	<MDL (141)	<MDL (130)	250	<MDL (130)	<MDL (130)	<MDL (150)	<MDL (190)	112	<MDL (140)	<MDL (280)	290	187	<MDL (120)	<MDL (150)
Benzyl alcohol	57	73	<MDL (22)	<MDL (14)	<MDL (18)	<MDL (16)	<MDL (12)	<MDL (16)	<MDL (16)	<MDL (19)	<MDL (23)	<MDL (11)	<MDL (18)	<MDL (35)	<MDL (12)	<MDL (12)	<MDL (15)	<MDL (18)
Phenol	420	1200	<MDL (44)	<MDL (27)	<MDL (35)	<MDL (31)	<MDL (24)	<MDL (32)	<MDL (32)	<MDL (38)	<MDL (47)	<MDL (22)	<MDL (35)	<MDL (69)	<MDL (23)	<MDL (23)	<MDL (30)	<MDL (36)

SMS = Sediment Management Standards
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
SQS = Sediment Quality Standards from Table I of Washington Administrative Code (WAC) 173-204-320
CSL = Cleanup Screening Level from Table III of WAC 173-204-562
mg/kg dw = Milligrams per kilogram dry weight
µg/kg dw = Micrograms per kilogram dry weight
mg/kg OC = Milligrams per kilogram normalized to organic carbon (OC)
(yellow) = Greater than SMS Marine SQS
(orange) = Greater than SMS Marine CSL
(lavender) = Greater than Marine Sediment LAET (dry weight equivalent of SQS) due to percent TOC <0.5 or >3.5
(salmon) = Greater than Marine Sediment 2LAET (dry weight equivalent of CSL) due to percent TOC <0.5 or >3.5
(red border) = Red border indicates an exceedance of the SMS Marine SQS or benthic CSL since these apply to the 0-10 cm depth stratum, which is the biologically active zone and point of compliance.

[1] The sum of the benzo(b)fluoranthene, benzo(j)fluoranthene, and benzo(k)fluoranthene concentrations is compared to the total benzofluoranthenes SMS Marine standard.
See Appendix B for lab reports with data qualifiers and dry weight concentrations for OC-normalized compounds

Table 7b: Sediment Chemistry Results Compared to DMMP Chemical Guidelines - 2015

Locator	DMMP Marine Guidelines		DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)			0 -10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10
Lab Sample ID	SL	ML	L62484-1	L62484-2	L62484-3	L62484-4	L62484-5	L62484-6	L62484-7	L62484-8	L62484-9	L62484-10	L62484-11	L62484-12	L62484-13	L62484-14	L62484-15	L62484-16
Pesticides (µg/kg dw)																		
4,4'-DDD	16[1]	---	11.5	2.43	10.9	2.3	1.3	<MDL (1.4)	5.56	13.2	8.81	<MDL (0.96)	12.9	4.2	<MDL (1.0)	13.4	5.61	3.84
4,4'-DDE	9[1]	---	5.07	<MDL (1.2)	5.14	<MDL (1.4)	<MDL (1.1)	<MDL (1.4)	1.8	4.46	3.4	<MDL (0.96)	4.33	<MDL (3.1)	<MDL (1.0)	4.70	2.2	2.0
4,4'-DDT	12[1]	---	8.77	2.84	<MDL (7.4)	3.08	1.4	1.9	4.30	6.09	<MDL (5.9)	<MDL (0.96)	<MDL (5.8)	5.8	<MDL (2.0)	8.33	<MDL (4.4)	<MDL (4.4)
Sum of 4,4'-DDD, 4,4'DDE, and 4,4'-DDT	---	69	25.3	5.27	16.0	5.35	2.7	1.9	11.6	23.7	12.2	<MDL (0.96)	17.3	10	<MDL (2.0)	26.4	7.80	5.86

DMMP = Dredge Material Management Program
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
SL = Screening Level
ML = Maximum level
mg/kg dw = Milligrams per kilogram dry weight
µg/kg dw = Micrograms per kilogram dry weight
(yellow) = Greater than DMMP Marine Guideline SL
See Appendix B for lab reports with data qualifiers
[1] ACOE 2013; per the Biological Opinion the most current guidance at the time the data was collected is used.

Table 7c: Physical and Conventional Parameter Characteristics - 2015

Parameter	DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Depth Stratum (cm)	0 -10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10
Lab Sample ID	L62484-1	L62484-2	L62484-3	L62484-4	L62484-5	L62484-6	L62484-7	L62484-8	L62484-9	L62484-10	L62484-11	L62484-12	L62484-13	L62484-14	L62484-15	L62484-16
Percent Fines (Clay plus Silt)	61.7	38.1	64	52.9	8.3	47.6	51.8	56.1	75.9	3.7	38	82.3	7.3	72.2	63.9	77.1
Percent Clay	11.9	10.7	14.1	12.4	5.1	11.4	10	13.5	13.7	2.1	13.4	29.9	4.3	16	22.7	34.6
Percent Silt	49.8	27.4	49.9	40.6	3.2	36.2	41.8	42.6	62.3	1.6	24.6	52.3	3	56.2	41.2	42.6
Percent Sand	25.5	60.7	34.7	37.2	54.6	56.1	45.9	46.2	25.2	46.7	58.4	17.4	70.3	26.1	27.6	19.7
Percent Gravel	10.8	5.6	9.2	7.7	39	3.0	2.0	5.8	1.6	50.4	1.1	<MDL (0.5)	24.9	1.9	4.5	1.8
Total Organic Carbon (percent dw)	6.55	0.88	2.05	1.37	0.69	1.50	1.60	3.18	3.00	0.26	2.24	4.79	0.59	2.22	1.18	2.30
Ammonia (mg/kg dw)	3.62	2.45	1.55	1.56	6.68	1.11	1.42	2.07	1.87	1.95	2.03	2.73	3.90	2.55	1.79	1.62
Sulfide (mg/kg dw)	419	<MDL (0.76)	14.7	234	42.2	18.9	19.4	127	55.3	43.1	212	183	25.0	314	89.9	83.6

mg/kg dw = Milligrams per kilogram dry weight
MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)

Table 8. Benthic Community Analysis - April 2006

Locator	DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Water Depth (-ft MLLW)	**35**	**41**	**56**	**81**	**13**	**66**	**96**	**81**	**95**	**20**	**68**	**90**	**18**	**42**	**72**	**82**
Benthic Community Indices [1]																
Total Richness (# of taxa/0.1 m^2)	**64**	**90**	**69**	**75**	**61**	**83**	**62**	**74**	**61**	**50**	**96**	**53**	**63**	**75**	**65**	**59**
Annelida Richness	34	44	33	36	27	42	28	38	31	20	49	29	26	45	31	28
Polychaeta Richness[2]	33	44	33	36	26	42	28	37	30	19	49	29	25	45	31	28
Crustacea Richness	16	15	10	9	19	10	8	10	8	17	17	6	20	14	8	8
Mollusca Richness	9	21	21	23	11	22	22	21	18	11	21	14	14	12	20	19
Miscellaneous Taxa Richness	6	10	6	7	3	9	4	6	4	2	9	4	3	4	6	4
Total Abundance (# of individuals/0.1 m^2)	**467**	**852**	**794**	**721**	**1,196**	**903**	**1,208**	**1,139**	**1,335**	**445**	**1,140**	**830**	**688**	**579**	**707**	**581**
Annelida Abundance	221	271	137	191	712	214	164	369	241	213	355	235	375	279	128	114
Polychaeta Abundance[2]	196	271	137	191	552	214	164	367	240	150	354	235	303	278	128	114
Crustacea Abundance	16	15	10	99	19	10	8	10	8	17	17	6	20	14	8	8
Mollusca Abundance	187	452	570	415	316	563	930	716	1,023	133	622	536	184	265	472	375
Miscellaneous Abundance	8	23	11	17	12	19	7	14	10	2	22	13	5	6	10	9
Total Biomass (g/0.1 m^2)	**14.91**	**14.66**	**12.37**	**6.34**	**11.40**	**29.93**	**11.25**	**15.17**	**17.12**	**3.79**	**16.88**	**18.06**	**7.16**	**17.37**	**5.94**	**7.86**
Annelida Biomass	3.67	8.11	1.20	1.27	5.00	1.24	2.10	1.87	1.63	1.31	3.02	0.87	3.85	7.69	0.97	1.52
Crustacea Biomass	2.03	0.57	0.83	0.52	1.15	0.28	0.22	0.17	0.10	0.80	0.49	0.08	1.13	0.19	0.19	0.17
Mollusca Biomass	6.52	5.28	10.13	4.40	5.24	6.79	8.88	11.22	15.24	1.47	7.71	17.04	2.17	9.48	4.45	5.89
Miscellaneous Biomass	2.68	0.70	0.22	0.15	0.01	21.62	0.05	1.91	0.15	0.21	5.66	0.06	0.01	0.01	0.33	0.28
Shannon-Wiener Diversity Index (log base 2)	**4.58**	**4.84**	**3.52**	**4.42**	**4.30**	**4.17**	**3.20**	**3.73**	**3.04**	**4.62**	**4.40**	**3.50**	**4.83**	**4.55**	**3.98**	**4.22**
Shannon-Wiener Diversity Index (log base 10)[2]	**1.38**	**1.46**	**1.06**	**1.33**	**1.29**	**1.26**	**0.96**	**1.12**	**0.91**	**1.39**	**1.32**	**1.05**	**1.45**	**1.37**	**1.20**	**1.27**
Pielou's Evenness Index	**0.76**	**0.74**	**0.58**	**0.71**	**0.73**	**0.66**	**0.54**	**0.60**	**0.51**	**0.82**	**0.67**	**0.61**	**0.81**	**0.73**	**0.66**	**0.72**
Swartz's Dominance Index	**12**	**18**	**6**	**11**	**10**	**9**	**5**	**6**	**4**	**12**	**13**	**6**	**14**	**12**	**8**	**10**
Physical Characteristics [3]																
Chemistry Sample Depth Stratum (cm)	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
Percent Fines (Clay plus Silt)	53.7	30.1	44.1	52.5	2.8	28.1	36.3	43.1	63.2	8.4	36.3	75.9	1.1	62.3	47.1	51.5
Percent Clay	13.4	7.1	9.9	16.3	0.7	6.6	7.1	8.4	10.5	3.6	8.5	12.0	1.1	14.6	15.4	15.3
Percent Silt	40.3	23	34.2	36.2	2.1	21.5	29.2	34.7	52.6	4.8	27.7	63.9	<MDL (0.5)	47.8	31.7	36.3
Percent Sand	32.9	51.1	44.4	42.2	33.3	67.2	48.6	45.4	27.5	90.9	61.0	20.8	67.7	32.6	30.3	24.5
Percent Gravel	7.4	8.3	4.6	10.8	62.5	1.2	8.1	5.8	2.5	1.5	2.0	0.6	26.9	0.8	13.1	19.9
Total Organic Carbon (percent dry weight)	3.50	1.13	1.47	0.892	0.850	1.36	0.951	2.16	2.47	0.786	1.94	2.55	0.395	1.99	1.09	1.27

Benthic community indices are defined in Section 4.0 of the report.
Benthic samples collected from the top 10 cm.
Benthic results were compared to Ecology's Reference Value Ranges (Ecology 2003), which include both a lower reference threshold (10th percentile) and an upper reference threshold (90th percentile). Highlighted values are considered potentially impacted sites because the metric is below the lower reference threshold, or for Polychaeta abundance above the upper reference threshold. More detail provided in Section 4.7 of the report: < lower ref. threshold > upper ref. threshold (Polychaeta abundance only)

[1] Benthic community indices calculated based on an average of three replicate samples. See Appendix D for full set of benthic data results.

[2] Polychaeta data (based on Annelida minus Oligachaeta data) provided for comparison to Reference Value Ranges, not presented as a separate analysis in the report; see Section 4.7.

[3] See Appendix B for lab reports with data qualifiers for physical characteristics.

MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
-ft MLLW = Depth in feet referenced to mean lower low water.

Table 9. Benthic Community Analysis - May 2007

Locator	DWMP-01	DWMP-02	DWMP-03	DWMP-04	DWMP-05	DWMP-06	DWMP-07	DWMP-08	DWMP-09	DWMP-10	DWMP-11	DWMP-12	DWMP-13	DWMP-14	DWMP-15	DWMP-16
Water Depth (-ft MLLW)	35	41	56	81	13	66	96	81	95	20	68	90	18	42	72	82
Benthic Community Indices [1]																
Total Richness (# of taxa/0.1 m^2)	**94**	**105**	**77**	**90**	**76**	**91**	**67**	**71**	**63**	**80**	**100**	**59**	**70**	**88**	**76**	**68**
Annelida Richness	55	55	39	50	38	46	33	42	35	38	58	34	35	55	38	35
Polychaeta Richness[2]	54	55	39	50	37	46	33	42	35	37	57	34	34	54	38	35
Crustacea Richness	18	16	9	10	19	11	8	9	6	17	14	6	19	9	9	8
Mollusca Richness	15	23	21	23	13	22	21	15	19	18	19	15	13	18	22	20
Miscellaneous Taxa Richness	6	11	8	7	6	12	5	5	3	7	9	4	3	6	7	5
Total Abundance (# of individuals/0.1 m^2)	**693**	**1,054**	**868**	**926**	**1,228**	**1,005**	**1,239**	**1,150**	**1,612**	**640**	**1,380**	**932**	**842**	**876**	**771**	**787**
Annelida Abundance	382	326	175	270	793	244	157	395	218	344	490	183	429	384	247	202
Polychaeta Abundance[2]	354	326	175	270	651	244	157	395	218	318	488	183	252	380	245	202
Crustacea Abundance	93	144	86	132	144	122	120	61	141	46	187	73	134	92	121	104
Mollusca Abundance	207	556	590	504	244	609	954	686	1,242	237	682	667	245	387	389	466
Miscellaneous Abundance	12	27	18	20	46	29	8	9	11	13	21	9	35	12	14	14
Total Biomass (g/0.1 m^2)	**11.33**	**12.01**	**8.20**	**7.38**	**12.45**	**12.24**	**12.97**	**24.08**	**17.74**	**5.56**	**10.37**	**16.46**	**5.66**	**12.60**	**7.82**	**7.52**
Annelida Biomass	4.64	4.70	1.40	1.67	5.89	2.76	1.37	3.32	1.43	3.34	3.06	1.33	2.77	5.72	2.67	2.03
Crustacea Biomass	0.49	0.22	0.18	0.18	1.04	0.19	0.15	0.05	0.20	0.55	0.19	0.10	0.89	0.16	0.16	0.15
Mollusca Biomass	6.15	6.19	6.30	5.46	4.82	8.85	10.01	20.54	15.19	1.51	6.79	14.94	1.94	4.57	4.71	5.09
Miscellaneous Biomass	0.06	0.90	0.32	0.07	0.71	0.43	1.44	0.17	0.91	0.16	0.33	0.08	0.07	2.15	0.28	0.25
Shannon-Wiener Diversity Index (log base 2)	**5.00**	**4.82**	**3.82**	**4.62**	**4.76**	**4.21**	**3.31**	**3.87**	**3.18**	**4.83**	**4.50**	**3.36**	**4.51**	**4.83**	**4.53**	**4.32**
Shannon-Wiener Diversity Index (log base 10)[2]	**1.50**	**1.45**	**1.15**	**1.39**	**1.43**	**1.27**	**1.00**	**1.16**	**0.96**	**1.45**	**1.35**	**1.01**	**1.36**	**1.46**	**1.36**	**1.30**
Pielou's Evenness Index	**0.76**	**0.72**	**0.61**	**0.71**	**0.76**	**0.65**	**0.55**	**0.63**	**0.53**	**0.77**	**0.68**	**0.57**	**0.73**	**0.75**	**0.73**	**0.71**
Swartz's Dominance Index	**18**	**17**	**7**	**12**	**11**	**9**	**5**	**6**	**4**	**18**	**11**	**5**	**12**	**17**	**12**	**10**
Physical Characteristics [3]																
Chemistry Sample Depth Stratum (cm)	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
Percent Fines (Clay plus Silt)	57.7	39.4	59.2	49.3	8.5	33.7	45.0	45.9	61.2	4.6	31.1	75.9	3.2	54.3	44.1	65.5
Percent Clay	17.7	12.0	15.6	12.8	4.9	10.3	13.1	13.4	14.6	2.6	10.0	16.5	1.3	12.6	13.4	29.0
Percent Silt	40.0	27.4	43.6	36.5	3.6	23.4	31.9	32.5	46.6	2.0	21.1	59.4	1.9	41.7	30.7	36.5
Percent Sand	28.8	53.5	33.7	39.4	30.9	62.6	46.9	42.8	28.5	91.7	64.6	19.6	67.8	35.2	36.7	21.8
Percent Gravel	5.7	3.4	1.2	5.5	61.6	1.8	2.6	9.2	2.2	1.9	2.5	0.7	29.5	0.6	10.1	6.2
Total Organic Carbon (percent dry weight)	3.70	1.47	2.03	1.48	1.42	1.82	1.58	2.27	2.95	0.873	2.22	3.73	0.382	2.26	1.33	1.16

Benthic community indices are defined in Section 4.0 of the report.
Benthic samples collected from the top 10 cm.
Benthic results were compared to Ecology's Reference Value Ranges (Ecology 2003), which include both a lower reference threshold (10th percentile) and an upper reference threshold (90th percentile). Highlighted values are considered potentially impacted sites because the metric is below the lower reference threshold, or for Polychaeta abundance above the upper reference threshold. More detail provided in Section 4.7 of the report: [yellow] < lower ref. threshold [orange] > upper ref. threshold (Polychaeta abundance only)

[1] Benthic community indices calculated based on an average of three replicate samples. See Appendix D for full set of benthic data results.

[2] Polychaeta data (based on Annelida minus Oligachaeta data) provided for comparison to Reference Value Ranges, not presented as a separate analysis in the report; see Section 4.7.

[3] See Appendix B for lab reports with data qualifiers for physical characteristics.

-ft MLLW = Depth in feet referenced to mean lower low water.

Table 10. Benthic Community Analysis - March 2008

Locator	DWMP-01	DWMP-03	DWMP-05	DWMP-08	DWMP-09	DWMP-10	DWMP-14	DWMP-15
Water Depth (-ft MLLW)	**35**	**56**	**13**	**81**	**95**	**20**	**42**	**72**
Benthic Community Indices [1]								
Total Richness (# of taxa/0.1 m^2)	**75**	**69**	**44**	**64**	**56**	**n/a**	**72**	**65**
Annelida Richness	51	31	24	39	29	n/a	44	26
Polychaeta Richness[2]	50	31	23	38	29	n/a	43	26
Crustacea Richness	11	11	10	7	9	n/a	10	13
Mollusca Richness	9	20	8	16	15	n/a	13	21
Miscellaneous Taxa Richness	4	7	2	3	3	n/a	4	6
Total Abundance (# of individuals/0.1 m^2)	**661**	**986**	**711**	**1,204**	**998**	**n/a**	**594**	**762**
Annelida Abundance	415	131	453	409	189	n/a	301	142
Polychaeta Abundance[2]	401	131	365	409	189	n/a	298	142
Crustacea Abundance	35	125	70	52	96	n/a	71	138
Mollusca Abundance	203	712	151	736	704	n/a	213	470
Miscellaneous Abundance	8	17	37	7	9	n/a	9	12
Total Biomass (g/0.1 m^2)	**10.70**	**17.28**	**5.45**	**37.92**	**15.84**	**n/a**	**12.65**	**6.81**
Annelida Biomass	5.07	0.80	3.00	3.57	2.00	n/a	6.98	1.52
Crustacea Biomass	0.65	0.30	0.09	0.10	0.27	n/a	2.14	0.25
Mollusca Biomass	4.75	12.90	2.37	34.14	13.41	n/a	3.36	4.56
Miscellaneous Biomass	0.24	3.28	0.07	0.11	0.16	n/a	0.25	0.48
Shannon-Wiener Diversity Index (log base 2)	**4.67**	**3.34**	**4.52**	**3.58**	**3.23**	**n/a**	**4.90**	**4.09**
Shannon-Wiener Diversity Index (log base 10)[2]	**1.41**	**1.01**	**1.36**	**1.08**	**0.97**	**n/a**	**1.47**	**1.23**
Pielou's Evenness Index	**0.75**	**0.55**	**0.83**	**0.60**	**0.56**	**n/a**	**0.79**	**0.68**
Swartz's Dominance Index	**23**	**7**	**15**	**8**	**5**	**n/a**	**21**	**9**
Physical Characteristics [3]								
Chemistry Sample Depth Stratum (cm)	0 -10	0 - 10	n/a	0 - 10	0 - 2	n/a	0 - 10	0 - 10
Percent Fines (Clay plus Silt)	61.2	59.7	n/a	40.7	65.1	n/a	55.8	48.4
Percent Clay	15.6	14.9	n/a	13.0	18.0	n/a	14.4	18.0
Percent Silt	45.7	44.8	n/a	27.8	47.1	n/a	41.4	30.3
Percent Sand	26.7	32	n/a	51.2	29.4	n/a	35.4	32.7
Percent Gravel	4.0	3.2	n/a	9.4	0.8	n/a	3.2	13.4
Total Organic Carbon (percent dry weight)	3.37	2.30	n/a	2.44	3.13	n/a	2.64	1.15

n/a = No results due to inability to collect sample (chemistry at DWMP-05, benthic and chemistry at DWMP-10)
Sample material was predominantly rock and gravel so no chemistry or particle size distribution analysis performed for DWMP-05 or DWMP-10.
No benthic or chemistry sample was collected at DWMP-10 due to recent completion of remediation there in February 2008. Refer to Section 2.1 in the report as well as the 2008 QA1 report in Appendix A for more detail.
Benthic community indices are defined in Section 4.0 of the report.
Benthic samples collected from the top 10 cm.
Benthic results were compared to Ecology's Reference Value Ranges (Ecology 2003), which include both a lower reference threshold (10th percentile) and an upper reference threshold (90th percentile). Highlighted values are considered potentially impacted sites because the metric is below the lower reference threshold, or for Polychaeta abundance above the upper reference threshold. More detail provided in Section 4.7 of the report: < lower ref. threshold > upper ref. threshold (Polychaeta abundance only)

[1] Benthic community indices calculated based on an average of three replicate samples. See Appendix D for full set of benthic data results.

[2] Polychaeta data (based on Annelida minus Oligachaeta data) provided for comparison to Reference Value Ranges, not presented as a separate analysis in the report; see Section 4.7.

[3] See Appendix B for lab reports with data qualifiers for physical characteristics.

-ft MLLW = Depth in feet referenced to mean lower low water.

Table 11. Benthic Community Analysis - May 2009

Locator	DWMP-01	DWMP-03	DWMP-05	DWMP-08	DWMP-09	DWMP-10	DWMP-14	DWMP-15
Water Depth (-ft MLLW)	**35**	**56**	**13**	**81**	**95**	**20**	**42**	**72**
Benthic Community Indices [1]								
Total Richness (# of taxa/0.1 m^2)	**84**	**80**	**78**	**65**	**67**	**76**	**76**	**74**
Annelida Richness	51	41	38	36	39	40	49	40
Polychaeta Richness[2]	50	41	37	36	39	39	48	40
Crustacea Richness	18	9	23	10	8	8	11	9
Mollusca Richness	12	21	13	12	16	22	13	20
Miscellaneous Taxa Richness	4	8	5	6	5	7	4	4
Total Abundance (# of individuals/0.1 m^2)	**698**	**1,246**	**1,951**	**968**	**1,059**	**762**	**973**	**780**
Annelida Abundance	430	214	1,186	294	223	431	386	197
Polychaeta Abundance[2]	423	214	1,030	294	223	431	383	197
Crustacea Abundance	111	168	234	43	54	15	182	113
Mollusca Abundance	152	842	514	623	774	240	399	461
Miscellaneous Abundance	6	22	16	8	8	76	5	9
Total Biomass (g/0.1 m^2)	**17.09**	**11.28**	**21.30**	**36.03**	**13.13**	**8.11**	**9.70**	**7.90**
Annelida Biomass	7.25	0.92	7.11	1.96	0.89	5.70	2.98	1.50
Crustacea Biomass	3.07	0.28	2.13	0.11	0.09	0.03	0.29	0.19
Mollusca Biomass	4.31	9.95	11.58	32.95	12.07	1.83	4.84	4.67
Miscellaneous Biomass	2.46	0.14	0.72	1.58	0.12	0.55	2.39	4.60
Shannon-Wiener Diversity Index (log base 2)	**4.98**	**3.46**	**4.42**	**3.95**	**3.19**	**5.73**	**4.47**	**4.20**
Shannon-Wiener Diversity Index (log base 10)[2]	**1.50**	**1.04**	**1.33**	**1.19**	**0.96**	**1.73**	**1.34**	**1.26**
Pielou's Evenness Index	**0.78**	**0.55**	**0.70**	**0.54**	**0.53**	**0.80**	**0.71**	**0.68**
Swartz's Dominance Index	**24**	**8**	**10**	**8**	**6**	**20**	**17**	**16**
Physical Characteristics [3]								
Chemistry Sample Depth Stratum (cm)	0 -10	0 - 10	0 - 10	0 - 10	0 - 2	0 - 10	0 - 10	0 - 10
Percent Fines (Clay plus Silt)	61.7	56.2	7.4	49.8	62.9	1.6	58.5	53.3
Percent Clay	14.1	13.5	3.7	13.2	16.0	1.1	12.9	17.2
Percent Silt	47.7	42.7	3.7	36.7	46.9	0.55	45.6	36.1
Percent Sand	27.6	33.9	36.4	40.4	27.8	72.4	30.6	29.5
Percent Gravel	8.0	1.6	53.5	8.0	1.9	27.2	0.5	10.9
Total Organic Carbon (percent dry weight)	2.75	2.02	1.54	2.01	1.88	<MDL (0.0485)	1.78	0.925

Benthic community indices are defined in Section 4.0 of the report.
Benthic samples collected from the top 10 cm.
Benthic results were compared to Ecology's Reference Value Ranges (Ecology 2003), which include both a lower reference threshold (10th percentile) and an upper reference threshold (90th percentile). Highlighted values are considered potentially impacted sites because the metric is below the lower reference threshold, or for Polychaeta abundance above the upper reference threshold. More detail provided in Section 4.7 of the report: [yellow] < lower ref. threshold [orange] > upper ref. threshold (Polychaeta abundance only)

[1] Benthic community indices calculated based on an average of three replicate samples. See Appendix D for full set of benthic data results.

[2] Polychaeta data (based on Annelida minus Oligachaeta data) provided for comparison to Reference Value Ranges, not presented as a separate analysis in the report; see Section 4.7.

[3] See Appendix B for lab reports with data qualifiers for physical characteristics.

MDL = Method Detection Limit (value in parentheses equals sample-specific MDL)
-ft MLLW = Depth in feet referenced to mean lower low water.

Table 12. Benthic Community Analysis - April 2010

Locator	DWMP-01	DWMP-03	DWMP-05	DWMP-08	DWMP-09	DWMP-10	DWMP-14	DWMP-15
Water Depth (-ft MLLW)	**35**	**56**	**13**	**81**	**95**	**20**	**42**	**72**
Benthic Community Indices [1]								
Total Richness (# of taxa/0.1 m^2)	**57**	**87**	**76**	**87**	**62**	**54**	**87**	**81**
Annelida Richness	33	44	33	47	30	29	49	39
Polychaeta Richness[2]	32	44	32	47	30	29	48	39
Crustacea Richness	12	11	22	16	10	10	16	14
Mollusca Richness	9	22	18	16	17	11	16	21
Miscellaneous Taxa Richness	3	10	2	8	5	4	6	8
Total Abundance (# of individuals/0.1 m^2)	**730**	**979**	**993**	**1,309**	**1,204**	**489**	**671**	**725**
Annelida Abundance	464	171	549	300	190	307	304	166
Polychaeta Abundance[2]	403	171	506	300	190	307	301	166
Crustacea Abundance	119	148	152	89	60	44	50	135
Mollusca Abundance	143	627	289	906	945	125	301	403
Miscellaneous Abundance	4	33	3	14	10	13	16	21
Total Biomass (g/0.1 m^2)	**8.24**	**9.66**	**9.18**	**22.17**	**14.01**	**4.65**	**10.27**	**9.33**
Annelida Biomass	3.42	1.43	2.90	2.88	1.54	2.25	4.36	2.16
Crustacea Biomass	1.06	0.34	2.01	0.08	0.12	0.72	0.21	2.75
Mollusca Biomass	3.18	7.16	4.26	18.53	12.24	1.56	5.25	4.33
Miscellaneous Biomass	0.58	0.73	0.02	0.68	0.11	0.37	0.45	0.09
Shannon-Wiener Diversity Index (log base 2)	**4.17**	**3.94**	**4.77**	**3.84**	**2.93**	**4.61**	**5.03**	**4.48**
Shannon-Wiener Diversity Index (log base 10)[2]	**1.25**	**1.19**	**1.44**	**1.16**	**0.88**	**1.39**	**1.52**	**1.35**
Pielou's Evenness Index	**0.71**	**0.61**	**0.76**	**0.60**	**0.49**	**0.80**	**0.78**	**0.71**
Swartz's Dominance Index	**9**	**15**	**17**	**9**	**4**	**19**	**30**	**20**
Physical Characteristics [3]								
Chemistry Sample Depth Stratum (cm)	0 -10	0 - 10	0 - 10	0 - 10	0 - 2	0 - 10	0 - 10	0 - 10
Percent Fines (Clay plus Silt)	51.2	63.9	5.3	43.1	91.7	1.2	45.8	47.5
Percent Clay	4.7	12.0	1.5	8.6	34.4	0.6	1.9	18.7
Percent Silt	46.5	51.9	3.8	34.5	57.3	0.6	43.8	28.9
Percent Sand	34.4	40.8	67.9	44.5	50.6	57.3	42.7	31.2
Percent Gravel	13.0	4.3	27.4	11.9	4.8	41.1	1.6	20.9
Total Organic Carbon (percent dry weight)	6.59	1.97	0.846	2.00	3.08	0.142	2.27	1.01

Benthic community indices are defined in Section 4.0 of the report.
Benthic samples collected from the top 10 cm.
Benthic results were compared to Ecology's Reference Value Ranges (Ecology 2003), which include both a lower reference threshold (10th percentile) and an upper reference threshold (90th percentile). Highlighted values are considered potentially impacted sites because the metric is below the lower reference threshold, or for Polychaeta abundance above the upper reference threshold. More detail provided in Section 4.7 of the report: [yellow] < lower ref. threshold [orange] > upper ref. threshold (Polychaeta abundance only)

[1] Benthic community indices calculated based on an average of three replicate samples. See Appendix D for full set of benthic data results.

[2] Polychaeta data (based on Annelida minus Oligachaeta data) provided for comparison to Reference Value Ranges, not presented as a separate analysis in the report; see Section 4.7.

[3] See Appendix B for lab reports with data qualifiers for physical characteristics.

-ft MLLW = Depth in feet referenced to mean lower low water.

Table 13. Benthic Community Analysis - April 2015

Locator	DWMP-01	DWMP-03	DWMP-05	DWMP-08	DWMP-09	DWMP-10	DWMP-14	DWMP-15
Water Depth (-ft MLLW)	35	56	13	81	95	20	42	72
Benthic Community Indices [1]								
Total Richness (# of taxa/0.1 m^2)	**69**	**73**	**60**	**75**	**66**	**55**	**72**	**78**
Annelida Richness	46	44	26	46	37	28	43	41
Polychaeta Richness[2]	45	44	25	45	37	27	43	41
Crustacea Richness	8	8	18	10	11	13	10	11
Mollusca Richness	10	14	13	12	14	11	12	20
Miscellaneous Taxa Richness	5	7	3	7	4	3	6	7
Total Abundance (# of individuals/0.1 m^2)	**461**	**735**	**1,580**	**1,468**	**1,618**	**1,090**	**765**	**796**
Annelida Abundance	231	222	1,060	376	168	838	253	227
Polychaeta Abundance[2]	214	222	1,022	375	168	837	253	227
Crustacea Abundance	49	90	188	87	99	89	23	136
Mollusca Abundance	170	410	327	994	1,343	159	476	423
Miscellaneous Abundance	11	14	5	12	8	4	13	11
Total Biomass (g/0.1 m^2)	**11.48**	**8.29**	**11.40**	**23.98**	**18.99**	**12.03**	**14.68**	**13.26**
Annelida Biomass	3.29	2.93	5.88	6.17	1.10	4.25	3.39	2.83
Crustacea Biomass	2.72	0.21	1.06	0.21	0.24	2.29	0.09	0.33
Mollusca Biomass	3.75	4.69	4.44	16.40	17.56	5.43	10.80	9.86
Miscellaneous Biomass	1.71	0.46	0.04	1.20	0.09	0.10	0.40	0.23
Shannon-Wiener Diversity Index (log base 2)	**4.83**	**4.10**	**3.14**	**3.19**	**3.38**	**2.95**	**3.76**	**6.17**
Shannon-Wiener Diversity Index (log base 10)[2]	**1.45**	**1.23**	**0.94**	**0.96**	**1.02**	**0.89**	**1.13**	**1.86**
Pielou's Evenness Index	**0.79**	**0.66**	**0.53**	**0.51**	**0.43**	**0.51**	**0.61**	**0.67**
Swartz's Dominance Index	**25**	**19**	**6**	**6**	**3**	**5**	**13**	**15**
Physical Characteristics [3]								
Chemistry Sample Depth Stratum (cm)	0 -10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10	0 - 10
Percent Fines (Clay plus Silt)	61.7	64.0	8.3	56.1	75.9	3.7	72.2	63.9
Percent Clay	11.9	14.1	5.1	13.5	13.7	2.1	16	22.7
Percent Silt	49.8	49.9	3.2	42.6	62.3	1.6	56.2	41.2
Percent Sand	25.5	34.7	54.6	46.2	25.2	46.7	26.1	27.6
Percent Gravel	10.8	9.2	39	5.8	1.6	50.4	1.9	4.5
Total Organic Carbon (percent dry weight)	6.55	2.05	0.687	3.18	3.00	0.259	2.22	1.18

Benthic community indices are defined in Section 4.0 of the report.
Benthic samples collected from the top 10 cm.
Benthic results were compared to Ecology's Reference Value Ranges (Ecology 2003), which include both a lower reference threshold (10th percentile) and an upper reference threshold (90th percentile). Highlighted values are considered potentially impacted sites because the metric is below the lower reference threshold, or for Polychaeta abundance above the upper reference threshold. More detail provided in Section 4.7 of the report: [yellow] < lower ref. threshold [orange] > upper ref. threshold (Polychaeta abundance only)

[1] Benthic community indices calculated based on an average of three replicate samples. See Appendix D for full set of benthic data results.

[2] Polychaeta data (based on Annelida minus Oligachaeta data) provided for comparison to Reference Value Ranges, not presented as a separate analysis in the report; see Section 4.7.

[3] See Appendix B for lab reports with data qualifiers for physical characteristics.

-ft MLLW = Depth in feet referenced to mean lower low water.

Table 14. Benthic Community Dominant Species Based on Swartz's Dominance Index - May 2006

DWMP-01 (SDI = 12)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	84	17.9
Mediomastus californiensis	Annelida	72	15.5
Alvania compacta	Mollusca	65	13.9
Oligochaeta	Annelida	25	5.3
Macoma carlottensis	Mollusca	20	4.4
Spiochaetopterus pottsi	Annelida	17	3.6
Lumbrineris californiensis	Annelida	15	3.3
Prionospio steenstrupi	Annelida	15	3.1
Axinopsida serricata	Mollusca	11	2.4
Foxiphalus similis	Crustacea	11	2.4
Spiophanes berkeleyorum	Annelida	9	2.0
Nephtys ferruginea	Annelida	8	1.6

DWMP-02 (SDI = 18)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	207	24.2
Axinopsida serricata	Mollusca	113	13.2
Euphilomedes carcharodonta	Crustacea	60	7.0
Alvania compacta	Mollusca	38	4.5
Prionospio steenstrupi	Annelida	28	3.3
Scoletoma luti	Annelida	27	3.1
Mediomastus californiensis	Annelida	23	2.7
Notomastus hemipodus	Annelida	20	2.3
Lumbrineris californiensis	Annelida	19	2.2
Clymenura gracilis	Annelida	15	1.7
Pholoides asperus	Annelida	14	1.6
Rochefortia tumida	Mollusca	13	1.6
Glycera nana	Annelida	12	1.4
Nephtys ferruginea	Annelida	12	1.4
Typosyllis cornuta	Annelida	12	1.4
Euphilomedes producta	Crustacea	12	1.4
Macoma elimata	Mollusca	11	1.3
Macoma carlottensis	Mollusca	11	1.3

DWMP-03 (SDI = 6)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	333	42.0
Axinopsida serricata	Mollusca	148	18.6
Euphilomedes carcharodonta	Crustacea	38	4.8
Prionospio steenstrupi	Annelida	37	4.7
Levinsenia gracilis	Annelida	27	3.4
Euphilomedes producta	Crustacea	27	3.4

DWMP-04 (SDI = 11)	Group	Number	Percent
Axinopsida serricata	Mollusca	199	27.5
Parvilucina tenuisculpta	Mollusca	98	13.6
Euphilomedes carcharodonta	Crustacea	55	7.7
Prionospio steenstrupi	Annelida	39	5.4
Macoma carlottensis	Mollusca	39	5.4
Levinsenia gracilis	Annelida	32	4.5
Euphilomedes producta	Crustacea	31	4.3
Myriochele olgae	Annelida	21	2.9
Lirobittium eschrichtii	Mollusca	15	2.1
Alvania rosana	Mollusca	11	1.5
Glycera nana	Annelida	8	1.1

DWMP-05 (SDI = 10)	Group	Number	Percent
Prionospio steenstrupi	Annelida	247	20.7
Oligochaeta	Annelida	160	13.4
Parvilucina tenuisculpta	Mollusca	133	11.1
Rochefortia tumida	Mollusca	104	8.7
Mediomastus californiensis	Annelida	77	6.4
Desdimelita desdichada	Crustacea	57	4.8
Protodorvillea gracilis	Annelida	41	3.4
Micropodarke dubia	Annelida	39	3.2
Macoma sp. juv.	Mollusca	34	2.8
Foxiphalus similis	Crustacea	29	2.4

DWMP-06 (SDI = 9)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	247	27.3
Axinopsida serricata	Mollusca	199	22.0
Prionospio steenstrupi	Annelida	65	7.2
Euphilomedes carcharodonta	Crustacea	56	6.2
Euphilomedes producta	Crustacea	33	3.7
Levinsenia gracilis	Annelida	28	3.1
Macoma carlottensis	Mollusca	26	2.9
Lirobittium eschrichtii	Mollusca	20	2.2
Lucinoma annulatum	Mollusca	10	1.1

DWMP-07 (SDI = 5)	Group	Number	Percent
Axinopsida serricata	Mollusca	564	46.7
Parvilucina tenuisculpta	Mollusca	204	16.9
Macoma carlottensis	Mollusca	52	4.3
Euphilomedes carcharodonta	Crustacea	51	4.2
Euphilomedes producta	Crustacea	47	3.9

DWMP-08 (SDI = 6)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	328	28.8
Axinopsida serricata	Mollusca	287	25.2
Prionospio steenstrupi	Annelida	104	9.1
Levinsenia gracilis	Annelida	91	8.0
Capitella capitata Complex	Annelida	37	3.2
Aricidea lopezi	Annelida	22	2.0

DWMP-09 (SDI = 4)	Group	Number	Percent
Axinopsida serricata	Mollusca	547	40.9
Parvilucina tenuisculpta	Mollusca	368	27.6
Levinsenia gracilis	Annelida	84	6.3
Prionospio steenstrupi	Annelida	41	3.1

DWMP-10 (SDI = 12)	Group	Number	Percent
Oligochaeta	Annelida	63	14.1
Capitella capitata Complex	Annelida	54	12.1
Alvania compacta	Mollusca	40	9.0
Parvilucina tenuisculpta	Mollusca	36	8.0
Prionospio steenstrupi	Annelida	33	7.3
Aoroides inermis	Crustacea	29	6.4
Macoma sp. juv.	Mollusca	21	4.7
Prionospio multibranchiata	Annelida	17	3.9
Foxiphalus similis	Crustacea	15	3.4
Rochefortia tumida	Mollusca	13	2.9
Scoloplos acmeceps	Annelida	11	2.5
Leitoscoloplos pugettensis	Annelida	10	2.2

DWMP-11 (SDI = 13)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	343	30.0
Axinopsida serricata	Mollusca	159	13.9
Prionospio steenstrupi	Annelida	105	9.2
Euphilomedes carcharodonta	Crustacea	62	5.4
Euphilomedes producta	Crustacea	38	3.4
Monticellina serratiseta	Annelida	34	3.0
Levinsenia gracilis	Annelida	29	2.6
Macoma carlottensis	Mollusca	28	2.5
Lucinoma annulatum	Mollusca	15	1.3
Nephtys cornuta	Annelida	15	1.3
Paraprionospio pinnata	Annelida	13	1.2
Notomastus hemipodus	Annelida	12	1.1
Turbonilla sp. #1	Annelida	12	1.1

DWMP-12 (SDI = 6)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	258	31.0
Axinopsida serricata	Mollusca	219	26.4
Levinsenia gracilis	Annelida	63	7.6
Aricidea lopezi	Annelida	41	5.0
Dipolydora caulleryi	Annelida	31	3.8
Prionospio steenstrupi	Annelida	29	3.5

DWMP-13 (SDI = 14)	Group	Number	Percent
Prionospio steenstrupi	Annelida	81	11.8
Oligochaeta	Annelida	72	10.4
Mediomastus californiensis	Annelida	71	10.3
Rochefortia tumida	Mollusca	56	8.1
Parvilucina tenuisculpta	Mollusca	55	7.9
Macoma sp. juv.	Mollusca	35	5.1
Foxiphalus similis	Crustacea	29	4.2
Leitoscoloplos pugettensis	Annelida	25	3.6
Scoloplos acmeceps	Annelida	19	2.8
Desdimelita desdichada	Crustacea	17	2.4
Prionospio multibranchiata	Annelida	15	2.2
Micropodarke dubia	Annelida	15	2.2
Cauleriella pacifica	Annelida	15	2.2
Megamoera subtener	Crustacea	15	2.2

DWMP-14 (SDI = 12)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	133	23.0
Axinopsida serricata	Mollusca	84	14.5
Diopatra ornata	Annelida	68	11.7
Mediomastus californiensis	Annelida	34	5.8
Scoletoma luti	Annelida	23	4.0
Notomastus hemipodus	Annelida	22	3.8
Alvania compacta	Mollusca	20	3.5
Lumbrineris californiensis	Annelida	14	2.4
Prionospio steenstrupi	Annelida	11	1.9
Paraprionospio pinnata	Annelida	10	1.7
Macoma carlottensis	Mollusca	9	1.6
Nephtys ferruginea	Annelida	7	1.2

DWMP-15 (SDI = 8)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	194	27.4
Axinopsida serricata	Mollusca	170	24.1
Euphilomedes carcharodonta	Crustacea	51	7.3
Euphilomedes producta	Crustacea	37	5.2
Prionospio steenstrupi	Annelida	24	3.4
Macoma carlottensis	Mollusca	24	3.4
Levinsenia gracilis	Annelida	22	3.1
Lirobittium eschrichtii	Mollusca	14	2.0

DWMP-16 (SDI = 10)	Group	Number	Percent
Axinopsida serricata	Mollusca	142	24.4
Parvilucina tenuisculpta	Mollusca	120	20.6
Euphilomedes carcharodonta	Crustacea	44	7.6
Macoma carlottensis	Mollusca	34	5.9
Euphilomedes producta	Crustacea	28	4.8
Levinsenia gracilis	Annelida	23	4.0
Prionospio steenstrupi	Annelida	17	2.9
Lirobittium eschrichtii	Mollusca	16	2.7
Ennucula tenuis	Mollusca	11	1.9
Alvania rosana	Mollusca	11	1.8

Notes

1. The species listed for each sampling station are the most dominant species that comprise 75% of the total abundance number of individuals) as indicated by the Swartz's Dominance Index (SDI) number in Table 8.
2. The **number** listed for each species is the average number of species' individuals found in three replicate samples at each station.
3. The **percent** listed for each species is calculated by dividing the number of species' individuals by the total number of organisms in each sample (averaged over three replicate samples).
4. The most dominant species at each sampling station have been color-coded to provide a quick comparative tool for assessing benthic community assemblages.

Annelida
Crustacea
Mollusca

Table 15. Benthic Community Dominant Species Based on Swartz's Dominance Index - April 2007

DWMP-01 (SDI = 18)	Group	Number	Percent
Prionospio steenstrupi	Annelida	120	17.3
Parvilucina tenuisculpta	Mollusca	120	17.3
Mediomastus californiensis	Annelida	44	6.4
Axinopsida serricata	Mollusca	37	5.3
Foxiphalus similis	Crustacea	35	5.0
Oligochaeta	Annelida	28	4.0
Lumbrineris californiensis	Annelida	21	3.1
Alvania compacta	Mollusca	17	2.4
Aphelochaeta glandaria	Annelida	16	2.3
Macoma carlottensis	Mollusca	15	2.2
Prionospio multibranchiata	Annelida	14	2.1
Dipolydora brachycephala	Annelida	9	1.3
Spiochaetopterus pottsi	Annelida	9	1.3
Spiophanes berkeleyorum	Annelida	9	1.3
Eudorella pacifica	Crustacea	8	1.2
Heterophoxus conlanae	Crustacea	8	1.1
Scoletoma luti	Annelida	7	1.1
Heterophoxus sp.	Crustacea	7	1.0

DWMP-02 (SDI = 17)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	236	22.4
Axinopsida serricata	Mollusca	190	18.0
Prionospio steenstrupi	Annelida	65	6.2
Euphilomedes carcharodonta	Crustacea	60	5.7
Euphilomedes producta	Crustacea	32	3.1
Eudorella pacifica	Crustacea	24	2.3
Apistobranchus tullbergi	Annelida	23	2.2
Scoletoma luti	Annelida	22	2.1
Mediomastus californiensis	Annelida	21	2.0
Notomastus hemipodus	Annelida	19	1.8
Nutricola lordi	Mollusca	19	1.8
Macoma carlottensis	Mollusca	17	1.6
Macoma yoldiformis	Mollusca	14	1.4
Lyonsia californica	Mollusca	14	1.3
Solamen columbianum	Mollusca	13	1.2
Clymenura gracilis	Annelida	11	1.1
Dipolydora socialis	Annelida	11	1.0

DWMP-03 (SDI = 7)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	343	39.5
Axinopsida serricata	Mollusca	144	16.6
Prionospio steenstrupi	Annelida	43	4.9
Euphilomedes producta	Crustacea	35	4.0
Euphilomedes carcharodonta	Crustacea	32	3.6
Macoma carlottensis	Mollusca	31	3.5
Levinsenia gracilis	Annelida	29	3.4

DWMP-04 (SDI = 12)	Group	Number	Percent
Axinopsida serricata	Mollusca	219	23.6
Parvilucina tenuisculpta	Mollusca	127	13.7
Euphilomedes carcharodonta	Crustacea	60	6.5
Prionospio steenstrupi	Annelida	57	6.1
Euphilomedes producta	Crustacea	54	5.9
Macoma carlottensis	Mollusca	53	5.8
Myriochele olgae	Annelida	41	4.4
Levinsenia gracilis	Annelida	31	3.3
Pholoides asperus	Annelida	16	1.7
Lirobittium eschrichtii	Mollusca	15	1.7
Alvania rosana	Mollusca	14	1.5
Capitella capitata Complex	Annelida	13	1.4

DWMP-05 (SDI = 11)	Group	Number	Percent
Oligochaeta	Annelida	143	11.6
Mediomastus californiensis	Annelida	134	10.9
Parvilucina tenuisculpta	Mollusca	125	10.2
Prionospio steenstrupi	Annelida	109	8.9
Prionospio multibranchiata	Annelida	86	7.0
Protodorvillea gracilis	Annelida	73	6.0
Rochefortia tumida	Mollusca	73	6.0
Foxiphalus similis	Crustacea	69	5.6
Armandia brevis	Annelida	48	3.9
Leptoplanidae spp. indet.	Platyhelm.	39	3.2
Dipolydora cardalia	Annelida	24	2.0

DWMP-06 (SDI = 9)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	291	29.0
Axinopsida serricata	Mollusca	183	18.2
Euphilomedes carcharodonta	Crustacea	66	6.6
Capitella capitata Complex	Annelida	57	5.7
Prionospio steenstrupi	Annelida	53	5.2
Macoma carlottensis	Mollusca	40	4.0
Euphilomedes producta	Crustacea	39	3.9
Solamen columbianum	Mollusca	22	2.2
Lirobittium eschrichtii	Mollusca	15	1.5

DWMP-07 (SDI = 5)	Group	Number	Percent
Axinopsida serricata	Mollusca	558	45.0
Parvilucina tenuisculpta	Mollusca	214	17.3
Macoma carlottensis	Mollusca	70	5.7
Euphilomedes producta	Crustacea	56	4.5
Euphilomedes carcharodonta	Crustacea	52	4.2

DWMP-08 (SDI = 6)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	336	29.2
Macoma carlottensis	Mollusca	203	17.6
Prionospio steenstrupi	Annelida	115	10.0
Capitella capitata Complex	Annelida	89	7.7
Axinopsida serricata	Mollusca	82	7.2
Levinsenia gracilis	Annelida	45	3.9

DWMP-09 (SDI = 4)	Group	Number	Percent
Axinopsida serricata	Mollusca	510	31.7
Parvilucina tenuisculpta	Mollusca	488	30.3
Macoma carlottensis	Mollusca	168	10.4
Euphilomedes producta	Crustacea	76	4.7

DWMP-10 (SDI = 17)	Group	Number	Percent
Capitella capitata Complex	Annelida	143	22.4
Parvilucina tenuisculpta	Mollusca	91	14.3
Alvania compacta	Mollusca	52	8.2
Macoma yoldiformis	Mollusca	26	4.0
Oligochaeta	Annelida	25	4.0
Mediomastus californiensis	Annelida	23	3.5
Prionospio steenstrupi	Annelida	18	2.8
Macoma sp. juv.	Mollusca	17	2.7
Goniada maculata	Annelida	14	2.2
Rochefortia tumida	Mollusca	13	2.0
Scoloplos acmeceps	Annelida	13	2.0
Platynereis bicanaliculata	Annelida	10	1.6
Glycera nana	Annelida	10	1.5
Foxiphalus similis	Crustacea	8	1.3
Eualus subtilis	Crustacea	8	1.2
Glycinde armigera	Annelida	7	1.1
Harmothoe extenuata	Annelida	6	1.0

DWMP-11 (SDI = 11)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	351	25.4
Axinopsida serricata	Mollusca	165	12.0
Prionospio steenstrupi	Annelida	137	9.9
Capitella capitata Complex	Annelida	90	6.5
Macoma carlottensis	Mollusca	90	6.5
Euphilomedes carcharodonta	Crustacea	65	4.7
Euphilomedes producta	Crustacea	61	4.4
Levinsenia gracilis	Annelida	26	1.9
Leptochelia savignyi	Crustacea	23	1.7
Lucinoma annulatum	Mollusca	16	1.2
Lirobittium eschrichtii	Mollusca	15	1.1

DWMP-12 (SDI = 5)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	321	34.5
Axinopsida serricata	Mollusca	237	25.4
Macoma carlottensis	Mollusca	66	7.0
Levinsenia gracilis	Annelida	56	6.0
Euphilomedes producta	Crustacea	37	4.0

DWMP-13 (SDI = 12)	Group	Number	Percent
Oligochaeta	Annelida	177	21.0
Rochefortia tumida	Mollusca	117	13.9
Parvilucina tenuisculpta	Mollusca	79	9.4
Foxiphalus similis	Crustacea	47	5.6
Armandia brevis	Annelida	44	5.2
Prionospio steenstrupi	Annelida	42	4.9
Prionospio multibranchiata	Annelida	37	4.4
Leptoplanidae spp. indet.	Platyhelm.	30	3.6
Desdimelita desdichada	Crustacea	19	2.3
Leitoscoloplos pugettensis	Annelida	16	1.9
Mediomastus californiensis	Annelida	15	1.7
Alvania compacta	Mollusca	15	1.7

DWMP-14 (SDI = 17)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	179	20.4
Axinopsida serricata	Mollusca	143	16.3
Aphelochaeta glandaria	Annelida	53	6.0
Prionospio steenstrupi	Annelida	51	5.8
Euphilomedes carcharodonta	Crustacea	45	5.2
Eudorella pacifica	Crustacea	26	3.0
Mediomastus californiensis	Annelida	24	2.7
Scoletoma luti	Annelida	23	2.6
Dipolydora socialis	Annelida	19	2.2
Macoma carlottensis	Mollusca	16	1.8
Apistobranchus tullbergi	Annelida	15	1.8
Notomastus hemipodus	Annelida	15	1.7
Levinsenia gracilis	Annelida	12	1.4
Euphilomedes producta	Crustacea	12	1.3
Phyllodoce hartmanae	Annelida	10	1.2
Macoma sp. juv.	Mollusca	10	1.1
Dipolydora brachycephala	Annelida	9	1.0

DWMP-15 (SDI = 12)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	158	20.5
Axinopsida serricata	Mollusca	146	18.9
Prionospio steenstrupi	Annelida	63	8.2
Euphilomedes carcharodonta	Crustacea	52	6.7
Euphilomedes producta	Crustacea	46	6.0
Macoma carlottensis	Mollusca	31	4.0
Pholoides asperus	Annelida	19	2.5
Levinsenia gracilis	Annelida	19	2.4
Chaetozone nr setosa	Annelida	14	1.9
Aphelochaeta glandaria	Annelida	13	1.7
Scoletoma luti	Annelida	12	1.6
Notomastus hemipodus	Annelida	9	1.1

DWMP-16 (SDI = 10)	Group	Number	Percent
Axinopsida serricata	Mollusca	182	23.1
Parvilucina tenuisculpta	Mollusca	125	15.9
Macoma carlottensis	Mollusca	87	11.1
Euphilomedes carcharodonta	Crustacea	48	6.1
Euphilomedes producta	Crustacea	46	5.8
Capitella capitata Complex	Annelida	36	4.6
Prionospio steenstrupi	Annelida	29	3.7
Levinsenia gracilis	Annelida	19	2.4
Lirobittium eschrichtii	Mollusca	17	2.2
Pholoides asperus	Annelida	15	1.9

Notes

1. The species listed for each sampling station are the most dominant species that comprise 75% of the total abundance number of individuals) as indicated by the Swartz's Dominance Index (SDI) number in Table 9.
2. The **number** listed for each species is the average number of species' individuals found in three replicate samples at each station.
3. The **percent** listed for each species is calculated by dividing the number of species' individuals by the total number of organisms in each sample (averaged over three replicate samples).
4. The most dominant species at each sampling station have been color-coded to provide a quick comparative tool for assessing benthic community assemblages.

Annelida
Mollusca
Crustacea

Table 16. Benthic Community Dominant Species Based on Swartz's Dominance Index - March 2008

DWMP-01 (SDI = 23)	Group	Number	Percent
Aphelochaeta glandaria (=Aphelochaeta sp N1)	Annelida	122	15.9%
Parvilucina tenuisculpta	Mollusca	122	15.9%
Mediomastus californiensis	Annelida	47	6.1%
Prionospio steenstrupi	Annelida	44	5.7%
Alvania compacta	Mollusca	40	5.2%
Lumbrineris californiensis	Annelida	34	4.5%
Axinopsida serricata	Mollusca	19	2.4%
Spiochaetopterus pottsi (=Spiochaetopterus costarum)	Annelida	18	2.3%
Oligochaeta	Annelida	14	1.9%
Heterophoxus conlanae	Crustacea	13	1.7%
Spiophanes berkeleyorum	Annelida	11	1.4%
Eualus sp.	Crustacea	10	1.3%
Macoma carlottensis	Mollusca	9	1.2%
Dipolydora brachycephala (=Dipolydora caulleryi)	Annelida	8	1.1%
Scoletoma luti	Annelida	8	1.1%
Nephtys ferruginea	Annelida	8	1.0%
Prionospio multibranchiata	Annelida	8	1.0%
Dipolydora socialis	Annelida	7	1.0%
Leitoscoloplos pugettensis	Annelida	7	0.9%
Magelona longicornis	Annelida	7	0.9%
Turbonilla sp. 1	Mollusca	7	0.9%
Notomastus hemipodus	Annelida	7	0.9%
Eualus subtilis	Annelida	7	0.8%

DWMP-03 (SDI = 7)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	471	42.4%
Axinopsida serricata	Mollusca	152	13.6%
Euphilomedes carcharodonta	Crustacea	98	8.8%
Euphilomedes producta	Crustacea	40	3.6%
Prionospio steenstrupi	Annelida	39	3.5%
Macoma carlottensis	Mollusca	22	1.9%
Levinsenia gracilis	Annelida	20	1.8%

DWMP-05 (SDI = 15)	Group	Number	Percent
Prionospio steenstrupi	Annelida	146	14.2%
Macoma inquinata	Mollusca	101	9.8%
Oligochaeta	Annelida	88	8.6%
Rochefortia tumida	Mollusca	82	8.0%
Paleonemertea spp. indet.	Miscellaneous	49	4.7%
Euphilomedes carcharodonta	Crustacea	44	4.3%
Parvilucina tenuisculpta	Mollusca	41	3.9%
Capitella capitata Complex	Annelida	36	3.5%
Euphilomedes producta	Crustacea	28	2.7%
Prionospio multibranchiata	Annelida	27	2.7%
Mediomastus californiensis	Annelida	24	2.4%
Chaetozone acuta	Annelida	22	2.1%
Protodorvillea gracilis	Annelida	21	2.0%
Micropodarke dubia	Annelida	20	1.9%
Dorvillea annulata	Annelida	17	1.7%
Macoma sp. juv.	Mollusca	17	1.7%
Nutricola lordi	Mollusca	17	1.7%

DWMP-08 (SDI = 8)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	493	38.5%
Capitella capitata Complex	Annelida	129	10.1%
Prionospio steenstrupi	Annelida	117	9.1%
Macoma carlottensis	Mollusca	72	5.6%
Axinopsida serricata	Mollusca	49	3.8%
Levinsenia gracilis	Annelida	48	3.7%
Euphilomedes carcharodonta	Crustacea	41	3.2%
Macoma sp. juv.	Mollusca	37	2.9%

DWMP-09 (SDI = 5)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	385	36.1%
Axinopsida serricata	Mollusca	246	23.1%
Levinsenia gracilis	Annelida	87	8.1%
Euphilomedes carcharodonta	Crustacea	56	5.3%
Euphilomedes producta	Crustacea	28	2.6%

DWMP-14 (SDI = 21)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	115	17.5%
Prionospio steenstrupi	Annelida	53	8.1%
Axinopsida serricata	Mollusca	53	8.1%
Euphilomedes carcharodonta	Crustacea	37	5.6%
Mediomastus californiensis	Annelida	25	3.8%
Scoletoma luti	Annelida	24	3.6%
Glycera nana	Annelida	19	2.9%
Notomastus hemipodus	Annelida	17	2.6%
Nephtys sp	Annelida	15	2.3%
Magelona longicornis	Annelida	15	2.2%
Eudorella pacifica	Crustacea	15	2.2%
Alvania compacta	Mollusca	13	2.0%
Macoma carlottensis	Mollusca	13	1.9%
Apistobranchus tullbergi (=Apistobranchus ornatus)	Annelida	12	1.9%
Aphelochaeta monilaris	Annelida	12	1.8%
Diopatra ornata	Annelida	12	1.8%
Lumbrineris californiensis	Annelida	11	1.7%
Levinsenia gracilis	Annelida	9	1.4%
Lumbrineridae juvenile	Annelida	8	1.3%
Macoma sp. juv.	Mollusca	8	1.3%
Euphilomedes producta	Crustacea	8	1.2%

DWMP-15 (SDI = 9)	Group	Number	Percent
Ophiura sp. indet.	Miscellaneous	203	16.6%
Parvilucina tenuisculpta	Mollusca	185	15.1%
Axinopsida serricata	Mollusca	161	13.1%
Ophiura luetkenii	Miscellaneous	104	8.5%
Pentamera sp. indet.	Miscellaneous	91	7.4%
Euphilomedes carcharodonta	Crustacea	82	6.7%
Prionospio steenstrupi	Annelida	38	3.1%
Macoma carlottensis	Mollusca	33	2.7%
Astyris gausapata	Mollusca	25	2.0%

Notes

1. The species listed for each sampling station are the most dominant species that comprise 75% of the total abundance number of individuals) as indicated by the Swartz's Dominance Index (SDI) number in Table 10.
2. The **number** listed for each species is the average number of species' individuals found in three replicate samples at each station.
3. The **percent** listed for each species is calculated by dividing the number of species' individuals by the total number of organisms in each sample (averaged over three replicate samples).
4. The most dominant species at each sampling station have been color-coded to provide a quick comparative tool for assessing benthic community assemblages.

Annelida
Mollusca
Crustacea
Miscellaneous

Table 17. Benthic Community Dominant Species Based on Swartz's Dominance Index - May 2009

DWMP-01 (SDI = 24)	Group	Number	Percent
Lumbrineris californiensis	Annelida	113.00	14.7%
Parvilucina tenuisculpta	Mollusca	85.67	11.1%
Aphelochaeta glandaria Cmplx (=Aphelochaeta sp N1)	Annelida	57.33	7.4%
Prionospio steenstrupi	Annelida	57.00	7.4%
Alvania compacta	Mollusca	30.00	3.9%
Foxiphalus similis	Crustacea	28.67	3.7%
Heterophoxus conlanae	Crustacea	28.67	3.7%
Mediomastus californiensis	Annelida	27.00	3.5%
Spiophanes berkeleyorum	Annelida	17.00	2.2%
Pista wui	Annelida	16.67	2.2%
Axinopsida serricata	Mollusca	15.33	2.0%
Eualus subtilis	Crustacea	12.33	1.6%
Prionospio multibranchiata	Annelida	12.00	1.6%
Dipolydora brachycephala (=Dipolydora caulleryi)	Annelida	8.67	1.1%
Eudorella pacifica	Crustacea	8.33	1.1%
Harmothoe imbricata	Annelida	7.67	1.0%
Laonice pugettensis	Annelida	7.50	1.0%
Oligochaeta	Annelida	7.00	0.9%
Parametaphoxus quaylei	Crustacea	7.00	0.9%
Notomastus hemipodus	Annelida	6.67	0.9%
Macoma carlottensis	Mollusca	6.67	0.9%
Nephtys ferruginea	Annelida	6.00	0.8%
Spiochaetopterus pottsi (=Spiochaetopterus costarum)	Annelida	6.00	0.8%
Chaetozone acuta	Annelida	5.00	0.6%
Macoma elimata	Mollusca	5.00	0.6%

DWMP-03 (SDI = 8)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	597.33	45.0%
Axinopsida serricata	Mollusca	147.67	11.1%
Euphilomedes carcharodonta	Crustacea	102.33	7.7%
Levinsenia gracilis	Annelida	43.33	3.3%
Euphilomedes producta	Crustacea	43.00	3.2%
Prionospio steenstrupi	Annelida	29.33	2.2%
Mediomastus californiensis	Annelida	20.00	1.5%
Ennucula tenuis		18.67	1.4%

DWMP-05 (SDI = 10)	Group	Number	Percent
Rochefortia tumida	Mollusca	250.00	12.4%
Parvilucina tenuisculpta	Mollusca	226.00	11.2%
Prionospio steenstrupi	Annelida	216.33	10.7%
Micropodarke dubia	Annelida	167.00	8.3%
Oligochaeta	Annelida	156.00	7.7%
Mediomastus californiensis	Annelida	150.67	7.5%
Dorvillea annulata	Annelida	123.00	6.1%
Prionospio multibranchiata	Annelida	122.67	6.1%
Aoroides excilis	Crustacea	76.67	3.8%
Foxiphalus similis	Crustacea	57.33	2.8%

DWMP-08 (SDI = 8)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	518.33	50.0%
Prionospio steenstrupi	Annelida	86.00	8.3%
Levinsenia gracilis	Annelida	52.33	5.0%
Macoma carlottensis	Mollusca	38.33	3.7%
Axinopsida serricata	Mollusca	31.33	3.0%
Capitella capitata Complex	Annelida	27.33	2.6%
Euphilomedes carcharodonta	Crustacea	15.67	1.5%
Lucinoma annulatum	Mollusca	15.00	1.4%

DWMP-09 (SDI = 6)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	494.00	43.8%
Axinopsida serricata	Mollusca	200.00	17.7%
Levinsenia gracilis	Annelida	82.67	7.3%
Prionospio steenstrupi	Annelida	31.00	2.7%
Macoma carlottensis	Mollusca	26.33	2.3%
Euphilomedes producta	Crustacea	22.33	2.0%

DWMP-10 (SDI = 20)	Group	Number	Percent
Platynereis bicanaliculata	Annelida	84.67	10.4%
Lyonsia californica	Mollusca	83.67	10.3%
Axiothella rubrocincta	Annelida	69.67	8.6%
Leptosynapta transgressor	Miscellaneous	61.67	7.6%
Alvania compacta	Mollusca	49.33	6.1%
Micropodarke dubia	Annelida	40.00	4.9%
Leitoscoloplos pugettensis	Annelida	29.67	3.6%
Boccardia pugettensis	Annelida	27.33	3.4%
Malmgreniella macginitiei	Annelida	22.67	2.8%
Rochefortia tumida	Mollusca	17.67	2.2%
Typosyllis cornuta (=Typosyllis harti)	Annelida	16.67	2.0%
Prionospio steenstrupi	Annelida	15.33	1.9%
Macoma sp. juv.	Mollusca	14.33	1.8%
Glycera nana	Annelida	13.67	1.7%
Lasaea adansoni	Mollusca	13.33	1.6%
Tellina modesta	Mollusca	12.67	1.6%
Macoma yoldiformis	Mollusca	10.67	1.3%
Chaetozone acuta	Annelida	10.33	1.3%
Nereis procera	Annelida	10.00	1.2%
Macoma golikovi	Mollusca	9.67	1.2%

DWMP-14 (SDI = 17)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	261.33	24.8%
Euphilomedes carcharodonta	Crustacea	112.33	10.7%
Axinopsida serricata	Mollusca	98.33	9.3%
Prionospio steenstrupi	Annelida	71.67	6.8%
Eudorella pacifica	Crustacea	37.67	3.6%
Scoletoma luti	Annelida	30.67	2.9%
Leptochelia savignyi	Crustacea	20.00	1.9%
Dipolydora socialis	Annelida	19.00	1.8%
Nephtys cornuta	Annelida	18.67	1.8%
Aphelochaeta glandaria Cmplx (=Aphelochaeta sp N1)	Annelida	17.67	1.7%
Aphelochaeta sp N5	Annelida	17.33	1.6%
Apistobranchus tullbergi (=Apistobranchus ornatus)	Annelida	16.67	1.6%
Nephtys ferruginea	Annelida	16.67	1.6%
Mediomastus californiensis	Annelida	16.00	1.5%
Magelona longicornis	Annelida	14.33	1.4%
Boccardiella hamata	Annelida	12.33	1.2%
Levinsenia gracilis	Annelida	11.00	1.0%

DWMP-15 (SDI = 16)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	202.00	23.5%
Axinopsida serricata	Mollusca	171.33	20.0%
Euphilomedes carcharodonta	Crustacea	76.33	8.9%
Prionospio steenstrupi	Annelida	35.33	4.1%
Macoma carlottensis	Mollusca	25.67	3.0%
Euphilomedes producta	Crustacea	20.33	2.4%
Boccardiella hamata	Annelida	15.50	1.8%
Levinsenia gracilis	Annelida	14.00	1.6%
Ennucula tenuis	Mollusca	14.00	1.6%
Pholoides asperus	Annelida	11.67	1.4%
Chaetozone nr setosa	Annelida	11.00	1.3%
Exogone lourei	Annelida	10.67	1.2%
Paraprionospio alata (=Paraprionospio pinnata)	Annelida	10.00	1.2%
Magelona longicornis	Annelida	9.50	1.1%
Monticellina serratiseta	Annelida	9.33	1.1%
Lirobittium eschrichtii	Mollusca	9.33	1.1%

Notes

1. The species listed for each sampling station are the most dominant species that comprise 75% of the total abundance number of individuals) as indicated by the Swartz's Dominance Index (SDI) number in Table 11.
2. The **number** listed for each species is the average number of species' individuals found in three replicate samples at each station.
3. The **percent** listed for each species is calculated by dividing the number of species' individuals by the total number of organisms in each sample (averaged over three replicate samples).
4. The most dominant species at each sampling station have been color-coded to provide a quick comparative tool for assessing benthic community assemblages.

Annelida
Mollusca
Crustacea

Table 18. Benthic Community Dominant Species Based on Swartz's Dominance Index - April 2010

DWMP-01 (SDI = 9)	Group	Number	Percent
Prionospio multibranchiata	Annelida	225.00	25.9%
Prionospio steenstrupi	Annelida	89.33	10.3%
Foxiphalus similis	Crustacea	80.33	9.2%
Parvilucina tenuisculpta	Mollusca	80.00	9.2%
Oligochaeta	Annelida	60.33	6.9%
Mediomastus californiensis	Annelida	48.33	5.6%
Lumbrineris californiensis	Annelida	26.00	3.0%
Axinopsida serricata	Mollusca	22.33	2.6%
Heterophoxus conlanae	Crustacea	20.00	2.3%

DWMP-03 (SDI = 15)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	403.67	38.0%
Axinopsida serricata	Mollusca	102.67	9.7%
Euphilomedes carcharodonta	Crustacea	89.67	8.4%
Macoma carlottensis	Mollusca	48.33	4.5%
Euphilomedes producta	Crustacea	37.67	3.5%
Levinsenia gracilis	Annelida	23.33	2.2%
Prionospio steenstrupi	Annelida	18.67	1.8%
Lirobittium munitum	Mollusca	13.33	1.3%
Trochochaeta multisetosa	Annelida	11.00	1.0%
Ophiurida spp. indet.	Miscellaneous	10.67	1.0%
Nephtys ferruginea	Annelida	9.67	0.9%
Scoletoma luti	Annelida	9.00	0.8%
Ennucula tenuis	Mollusca	9.00	0.8%
Pectinaria granulata	Annelida	8.00	0.8%
Pholoides asperus	Annelida	8.00	0.8%

DWMP-05 (SDI = 17)	Group	Number	Percent
Prionospio steenstrupi	Annelida	206.33	19.7%
Parvilucina tenuisculpta	Mollusca	86.00	8.2%
Leitoscoloplos pugettensis	Annelida	64.33	6.2%
Rochefortia tumida	Annelida	57.67	5.5%
Mediomastus californiensis	Mollusca	53.67	5.1%
Oligochaeta	Annelida	42.33	4.0%
Foxiphalus similis	Crustacea	42.33	4.0%
Alvania compacta	Mollusca	40.33	3.9%
Macoma golikovi	Mollusca	36.00	3.4%
Chaetozone sp N1	Mollusca	34.00	3.3%
Owenia fusiformis	Annelida	24.00	2.3%
Aoroides inermis	Crustacea	24.00	2.3%
Aoroides exilis	Crustacea	16.67	1.6%
Macoma sp. juv.	Mollusca	15.33	1.5%
Glycinde picta (=Glycinde polygnatha)	Annelida	15.00	1.4%
Tellina modesta	Mollusca	14.67	1.4%
Pleusymtes sp.	Crustacea	14.33	1.4%

DWMP-08 (SDI = 9)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	389.67	27.9%
Axinopsida serricata	Mollusca	234.33	16.8%
Macoma carlottensis	Mollusca	222.33	15.9%
Prionospio steenstrupi	Annelida	68.33	4.9%
Capitella capitata Complex	Annelida	37.33	2.7%
Levinsenia gracilis	Annelida	35.33	2.5%
Euphilomedes carcharodonta	Crustacea	31.33	2.2%
Euphilomedes producta	Crustacea	24.67	1.8%
Lucinoma annulatum	Mollusca	16.33	1.2%

DWMP-09 (SDI = 4)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	482.00	38.1%
Axinopsida serricata	Mollusca	356.33	28.2%
Levinsenia gracilis	Annelida	101.67	8.0%
Macoma carlottensis	Mollusca	55.33	4.4%

DWMP-10 (SDI = 19)	Group	Number	Percent
Prionospio steenstrupi	Annelida	89.67	15.9%
Parvilucina tenuisculpta	Mollusca	58.33	10.3%
Chaetozone acuta	Annelida	52.67	9.3%
Protodorvillea gracilis	Annelida	33.67	6.0%
Lumbrineris californiensis	Annelida	26.00	4.6%
Macoma sp. juv.	Mollusca	23.00	4.1%
Aoroides inermis	Crustacea	19.00	3.4%
Rochefortia tumida	Mollusca	17.00	3.0%
Owenia fusiformis	Annelida	16.00	2.8%
Cauleriella pacifica	Annelida	12.67	2.2%
Foxiphalus similis	Crustacea	11.00	1.9%
Leitoscoloplos pugettensis	Annelida	10.33	1.8%
Glycera nana	Annelida	9.00	1.6%
Ampithoe lacertosa	Crustacea	9.00	1.6%
Typosyllis cornuta (=Typosyllis harti)	Annelida	8.67	1.5%
Macoma golikovi	Mollusca	8.67	1.5%
Aoroides exilis	Crustacea	8.00	1.4%
Thysanocardia nigra	Miscellaneous	7.00	1.2%
Nereis procera	Annelida	6.33	1.1%

DWMP-14 (SDI = 30)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	152.00	19.5%
Axinopsida serricata	Mollusca	71.67	9.2%
Scoletoma luti	Annelida	36.33	4.7%
Alvania compacta	Mollusca	32.67	4.2%
Apistobranchus tullbergi (=Apistobranchus ornatus)	Annelida	26.00	3.3%
Mediomastus californiensis	Annelida	23.67	3.0%
Prionospio steenstrupi	Annelida	22.67	2.9%
Macoma carlottensis	Mollusca	21.67	2.8%
Nephtys ferruginea	Annelida	19.67	2.5%
Aphelochaeta sp N5	Annelida	17.00	2.2%
Levinsenia gracilis	Annelida	16.00	2.1%
Euphilomedes carcharodonta	Crustacea	15.00	1.9%
Dipolydora brachycephala (=Dipolydora caulleryi)	Annelida	13.00	1.7%
Magelona longicornis	Annelida	12.33	1.6%
Lumbrineris californiensis	Annelida	10.33	1.3%
Notomastus hemipodus	Annelida	9.67	1.2%
Eudorella pacifica	Crustacea	9.50	1.2%
Podarkeopsis glabrus	Annelida	8.00	1.0%
Diopatra ornata	Annelida	7.67	1.0%
Dipolydora socialis	Annelida	7.00	0.9%
Aoroides inermis	Crustacea	6.33	0.8%
Eualus sp.	Crustacea	6.00	0.8%
Lineidae spp. indet.	Miscellaneous	6.00	0.8%
Nephtys cornuta	Annelida	5.50	0.7%
Spiophanes berkeleyorum	Annelida	5.33	0.7%
Macoma sp. juv.	Mollusca	5.33	0.7%
Glycera nana	Annelida	5.00	0.6%
Pholoides asperus	Annelida	5.00	0.6%
Polycirrus sp	Annelida	5.00	0.6%
Byblis millsi	Crustacea	5.00	0.6%

DWMP-15 (SDI = 20)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	159.67	20.0%
Axinopsida serricata	Mollusca	115.33	14.4%
Euphilomedes carcharodonta	Crustacea	92.00	11.5%
Macoma carlottensis	Mollusca	68.33	8.6%
Pholoides asperus	Annelida	29.00	3.6%
Trochochaeta multisetosa	Annelida	16.00	2.0%
Levinsenia gracilis	Annelida	13.33	1.7%
Euphilomedes producta	Crustacea	13.00	1.6%
Rutiderma lomae	Crustacea	11.50	1.4%
Prionospio steenstrupi	Annelida	10.33	1.3%
Ophiurida spp. indet.	Miscellaneous	10.00	1.3%
Alvania compacta	Mollusca	9.67	1.2%
Glycera nana	Annelida	7.67	1.0%
Aphelochaeta sp N5	Annelida	7.33	0.9%
Lumbrineris californiensis	Annelida	6.67	0.8%
Pectinaria granulata	Annelida	6.33	0.8%
Lirobittium munitum	Mollusca	6.33	0.8%
Scoletoma luti	Annelida	5.67	0.7%
Odostomia sp.	Mollusca	5.67	0.7%
Magelona longicornis	Annelida	5.33	0.7%

Notes

1. The species listed for each sampling station are the most dominant species that comprise 75% of the total abundance number of individuals) as indicated by the Swartz's Dominance Index (SDI) number in Table 12.
2. The **number** listed for each species is the average number of species' individuals found in three replicate samples at each station.
3. The **percent** listed for each species is calculated by dividing the number of species' individuals by the total number of organisms in each sample (averaged over three replicate samples).
4. The most dominant species at each sampling station have been color-coded to provide a quick comparative tool for assessing benthic community assemblages.

Annelida
Mollusca
Crustacea

Table 19. Benthic Community Dominant Species Based on Swartz's Dominance Index - April 2015

DWMP-01 (SDI = 25)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	123.33	22.9%
Mediomastus californiensis	Annelida	33.00	6.1%
Foxiphalus similis	Crustacea	27.00	5.0%
Lumbrineris californiensis	Annelida	24.67	4.6%
Spiochaetopterus costarum pottsi	Annelida	19.67	3.7%
Axinopsida serricata	Mollusca	18.00	3.3%
Oligochaeta sp.	Annelida	17.00	3.2%
Prionospio steenstrupi	Annelida	16.00	3.0%
Prionospio lighti	Annelida	11.33	2.1%
Heterophoxus conlanae	Crustacea	11.00	2.0%
Dipolydora cardalia	Annelida	10.67	2.0%
Macoma carlottensis	Mollusca	9.33	1.7%
Spiophanes berkeleyorum	Annelida	9.00	1.7%
Notomastus hemipodus	Annelida	8.33	1.5%
Scoletoma luti	Annelida	8.33	1.5%
Eualus subtilis	Crustacea	8.00	1.5%
Nephtys ferruginea	Annelida	7.00	1.3%
Heterophoxus sp.	Crustacea	6.50	1.2%
Macoma sp. Juv.	Mollusca	6.33	1.2%
Eualus sp.	Crustacea	6.00	1.1%
Alvania compacta	Mollusca	6.00	1.1%
Leitoscoloplos pugettensis	Annelida	5.33	1.0%
Tubulanus polymorphus	Miscellaneous	5.33	1.0%
Magelona longicornis	Annelida	5.00	0.9%
Ianiropsis analoga	Crustacea	5.00	0.9%

DWMP-03 (SDI = 19)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	283.33	34.3%
Axinopsida serricata	Mollusca	77.33	9.4%
Euphilomedes carcharodonta	Crustacea	59.33	7.2%
Paraprionospio alata	Annelida	30.00	3.6%
Prionospio steenstrupi	Annelida	30.00	3.6%
Euphilomedes producta	Crustacea	17.33	2.1%
Lucinoma annulatum	Mollusca	16.00	1.9%
Scoletoma luti	Annelida	15.67	1.9%
Levinsenia gracilis	Annelida	14.67	1.8%
Mediomastus californiensis	Annelida	10.50	1.3%
Spiochaetopterus costarum pottsi	Annelida	9.67	1.2%
Malmgreniella sp	Annelida	9.00	1.1%
Glycera nana	Annelida	8.00	1.0%
Astyris gausapata	Mollusca	8.00	1.0%
Macoma carlottensis	Mollusca	8.00	1.0%
Amphiuridae sp. juv	Miscellaneou	7.00	0.8%
Aphelochaeta N5	Annelida	6.67	0.8%
Magelona longicornis	Annelida	6.67	0.8%
Nephtys ferruginea	Annelida	6.67	0.8%

DWMP-05 (SDI = 6)	Group	Number	Percent
Prionospio steenstrupi	Annelida	774.67	47.0%
Parvilucina tenuisculpta	Mollusca	216.00	13.1%
Mediomastus californiensis	Annelida	78.00	4.7%
Micropodarke dubia	Annelida	65.00	3.9%
Aoroides exilis	Crustacea	59.00	3.6%
Foxiphalus similis	Crustacea	58.33	3.5%

DWMP-08 (SDI = 6)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	769.00	50.1%
Axinopsida serricata	Mollusca	129.00	8.4%
Prionospio steenstrupi	Annelida	121.00	7.9%
Macoma carlottensis	Mollusca	56.33	3.7%
Euphilomedes carcharodonta	Crustacea	40.33	2.6%
Paraprionospio alata	Annelida	39.67	2.6%

DWMP-09 (SDI = 3)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	746.33	44.5%
Axinopsida serricata	Mollusca	501.33	29.9%
Euphilomedes carcharodonta	Crustacea	66.00	3.9%

DWMP-10 (SDI = 5)	Group	Number	Percent
Prionospio steenstrupi	Annelida	619.00	54.3%
Parvilucina tenuisculpta	Mollusca	111.00	9.7%
Mediomastus californiensis	Annelida	59.00	5.2%
Prionospio multibranchiata	Annelida	54.67	4.8%
Eualus subtilis	Crustacea	25.67	2.3%

DWMP-14 (SDI = 13)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	350.33	41.6%
Axinopsida serricata	Mollusca	81.67	9.7%
Scoletoma luti	Annelida	36.00	4.3%
Prionospio steenstrupi	Annelida	22.50	2.7%
Mediomastus californiensis	Annelida	22.33	2.7%
Lumbrineris californiensis	Annelida	20.67	2.5%
Prionospio multibranchiata	Annelida	17.50	2.1%
Paraprionospio alata	Annelida	17.00	2.0%
Alvania compacta	Mollusca	17.00	2.0%
Nephtys ferruginea	Annelida	14.67	1.7%
Apistobranchus sp.	Annelida	12.33	1.5%
Macoma carlottensis	Mollusca	11.67	1.4%
Magelona longicornis	Annelida	9.67	1.1%

DWMP-15 (SDI = 15)	Group	Number	Percent
Parvilucina tenuisculpta	Mollusca	250.33	28.5%
Euphilomedes carcharodonta	Crustacea	101.67	11.6%
Axinopsida serricata	Mollusca	94.00	10.7%
Prionospio steenstrupi	Annelida	52.00	5.9%
Macoma carlottensis	Mollusca	35.67	4.1%
Pholoides asperus	Annelida	25.50	2.9%
Paraprionospio alata	Annelida	18.67	2.1%
Euphilomedes producta	Crustacea	15.33	1.7%
Levinsenia gracilis	Annelida	10.67	1.2%
Glycera nana	Annelida	10.33	1.2%
Magelona longicornis	Annelida	10.33	1.2%
Scoletoma luti	Annelida	10.33	1.2%
Rutiderma lomae	Crustacea	9.00	1.0%
Rochefortia tumida	Mollusca	9.00	1.0%
Nephtys ferruginea	Annelida	8.50	1.0%

Notes

1. The species listed for each sampling station are the most dominant species that comprise 75% of the total abundance number of individuals) as indicated by the Swartz's Dominance Index (SDI) number in Table 13.
2. The **number** listed for each species is the average number of species' individuals found in three replicate samples at each station.
3. The **percent** listed for each species is calculated by dividing the number of species' individuals by the total number of organisms in each sample (averaged over three replicate samples).
4. The most dominant species at each sampling station have been color-coded to provide a quick comparative tool for assessing benthic community assemblages.

Annelida
Mollusca
Crustacea

Table 20. Ecology's Benthic Community 10th and 90th Percentile Reference Value Ranges (RVRs) for Puget Sound Habitats

Benthic Endpoint	N	0-20% Fines	N	20-50% Fines	N	50-80% Fines	N	80-100% Fines
Total Abundance	57	278.1-764.9	19	334.1-726.8	22	120.3-736.3	30	171.6-511.6
Crustacea Abundance	57	40.1-286.0	19	26.9-221.6	22	6.9-268.5	30	12.8-216.2
Mollusca Abundance	57	38.3-195.7	19	50.7-277.9	22	37.1-277.4	30	17.0-136.7
Polychaeta Abundance	57	65.2-418.8	19	145.1-479.5	22	54.2-280.8	30	32.8-173.9
Total Richness	57	44.5-98.0	19	51.5-87.4		22.5-66.6	30	22.5-51.2
Crustacea Richness	57	7.8-21.2	19	6.7-17.8	22	3.4-12.2	30	3.2-7.2
Mollusca Richness	57	11.2-21.4	19	9.9-17.8	22	5.9-18.0	30	5.3-14.1
Polychaeta Richness	57	19.6-54.5	19	26.5-53.1	22	11.9-35.4	30	9.2-28.3
Shannon-Wiener Diversity[1]	57	1.0-1.6	19	1.1-1.5	22	1.0-1.5	28	0.8-1.2
Pielou's Evenness	57	0.6-0.8	19	0.6-0.8	22	0.6-0.9	28	0.6-0.8
Swartz's Dominance Index	57	5.2-24.5	19	7.8-19.3	22	5.6-18.7	28	3.9-10.1

Source: Ecology 2003

Habitat category <150 ft.

N references the number of stations used to develop the RVRs for that percent fines category.

All Ecology benthic reference data collected prior to 1999.

The two values shown in each cell represents the 10th and 90th percentile of the reference data.

[1] Ecology's Shannon-Wiener Diversity RVR values are in log base 10 (Striplin personal communication 2017), whereas Denny Way data have been calculated in log base 2. Denny Way data values were converted to log base 10 before comparing to the RVRs (see Tables 8 - 13 for RVR comparison outcomes).

Table 21. Denny Way Benthic Sample Categories Based on Reference Value Range (RVR) Percent Fines Categories

Locator	0-20% Fines	20-50% Fines	50-80% Fines	80-100% Fines
DWMP-01			All years	
DWMP-03		2006	2007-2010, 2015	
DWMP-05	All years			
DWMP-08		2006-2010	2015	
DWMP-09			2006-2009, 2015	2010
DWMP-10	All years			
DWMP-14		2010	2006-2009, 2015	
DWMP-15		2006-2008, 2010	2009, 2015	

Table 22. Percent of Samples Above SMS Marine Sediment Quality Standards of Select Contaminants

Depth Strata	0 - 2 cm								0 - 10 cm				
Year Sampled	**2001**	**2003**	**2004**	**2006**	**2007**	**2008**	**2009**	**2010**	**2004**	**2008**	**2009**	**2010**	**2015**
Number of Samples (n)	**16**	**16**	**5**	**16**	**16**	**6**	**6**	**6**	**5**	**8**	**11**	**11**	**16**
Mercury	56.3	50.0	80.0	50.0	50.0	50.0	33.3	33.3	80.0	50.0	45.5	36.4	56.3
PCBs	62.5	62.5	40.0	62.5	43.8	0.0	16.7	50.0	80.0	62.5	63.6	54.5	62.5
BEHP	43.8	25.0	20.0	43.8	25.0	0.0	33.3	16.7	0.0	0.0	27.3	36.4	6.25
BBP	56.3	6.25	0.0	68.8	18.8	0.0	0.0	0.0	0.0	12.5	18.2	36.4	18.8
Total HPAHs [1]	6.25	0.0	0.0	12.5	6.25	0.0	0.0	0.0	0.0	0.0	9.09	18.2	6.25

Depth Strata	All combined								
Year Sampled	**2001**	**2003**	**2004**	**2006**	**2007**	**2008**	**2009**	**2010**	**2015**
Number of Samples (n)	**16**	**16**	**10**	**16**	**16**	**14**	**17**	**17**	**16**
Mercury	56.3	50.0	80.0	50.0	50.0	50.0	41.2	35.3	56.3
PCBs	62.5	62.5	60.0	62.5	43.8	35.7	47.1	52.9	62.5
BEHP	43.8	25.0	10.0	43.8	25.0	0.0	29.4	29.4	6.25
BBP	56.3	6.25	0.0	68.8	18.8	7.14	11.8	23.5	18.8
Total HPAHs [1]	6.25	0.00	0.0	12.5	6.25	0.0	5.88	11.8	6.25

[1] Individual PAH compound concentrations in some years were above than the sediment quality standards, but once summed as total HPAHs were not.

Appendix A: KCEL Lab QA 1 Reports

This appendix available separately.

Appendix B: Chemistry Results

This appendix available separately

Appendix C: Method Blank Data Review

This appendix available separately.

Appendix D: Benthic Community Data

This appendix available separately.