Final Clam Tissue Collection and Characterization Report

Wyckoff/Eagle Harbor Superfund Site

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1.0 Background and Purpose

Collection and analysis of clam tissue occurred in 2016 at the Eagle Harbor East Harbor Operating Unit (OU) at the Wyckoff/Eagle Harbor Superfund Site located on Bainbridge Island, Washington. The purpose of this effort is to gather information necessary to evaluate whether remedial actions to date and natural recovery have resulted in a decrease of carcinogenic polycyclic aromatic hydrocarbon (PAH) concentrations in horse clam tissue over time.

The targeted species, *Tresus*[1] *capax,* is a suspension/filter feeder eating diatoms, flagellates, dinoflagellates, and detritus. They are mature at three years with a shell length of approximately seven centimeters. Their shells are oval and white or yellow with patches of brown on the shell. The shells are flared around the siphon and do not completely close. They are normally buried 12-16 inches in the substrate and are found in the lower intertidal zones as deep as 60 feet, and prefer sand, mud and gravel substrate. The *T. capax* has a typical life span of about 20 years. Another horse clam species, *Tresus nuttallii*, is very similar in appearance to the *T. capax*. *T. nuttallii* prefer the same type of substrate and are found in similar areas and elevations as the *T.capax*. The main difference between the two species is that the *T. nuttallii* shells are longer compared to their height than the *T. capax*, and *T. nuttallii* normally have larger siphonal plates. *T. nuttallii* have a typical life span of about 17 years.

Clam tissue samples from East Beach and North Shoal sediments were first collected in 2003 for the 2002 OMMP Addendum (Integral Consulting, Inc. 2004); clam tissue samples for the Intertidal Cap and West Beach locations were added in the 2011 and 2014 sampling events, respectively. Clam tissue samples from the West Beach, Intertidal Cap, North Shoal and East Beach were collected in the 2016 event. Additional sampling was performed in 2016 at Point No Point Park to determine background PAH concentrations in clam tissue.

2.0 Field Methods

2.1 Sampling Event

Clam tissue sampling was conducted in July 2016, in accordance with the amended quality assurance project plan (QAPP) specific to the 2016 clam tissue collection. Clams were collected within a later time window (July) than the 2003, 2011 and 2014 monitoring events (May). The tidal elevation during the 2016 event was -2.77 (ft. mean lower low water (MLLW). The tidal elevation during the 2014 event was – 2.4 ft MLLW. Sediment at the West Beach is predominantly fish mix gravels compared to sediments found at the other sampling locations. Eagle Harbor clams were collected on 5 July 2016, attempting three separate locations within the Intertidal Cap, North Shoal, West Beach and East Beach locations. For a specific description of the sampling event, and deviations from QAPP, see the Shellfish Sampling Field Report in Appendix C. The species identification was confirmed in the field by Debbie Kay, a biologist with the Suquamish Tribe.

[1] http://wdfw.wa.gov/fishing/shellfish/clams/horse_clams.html

2.2 Differences between the 2016 and Previous Sampling Events

Several differences between this sampling event and previous events are worth noting. The clams collected in 2011 and 2014 were *T. capax* (*T. nuttallii* collected in 2011 were not analyzed). In 2016, the majority of clams collected were *T. capax,* but some *T. nuttallii* were also collected and analyzed (see 2016 Shellfish Sampling Field Report). An attempt to revisit past sampling locations has proven difficult due to apparent changes in *T. capax* densities and locations between sampling events. In 2016, additional sampling was done at a separate location (Point No Point) to determine a background concentration for PAHs in horse clam tissue.

The 2011 samples included five clams in each composite sample. Following confirmation by the analytical laboratory that three clams would generate a sufficient volume of tissue for analysis, in 2014 and 2016, each composite sample consisted of three clams (when possible). Lowering the number of clams required in each composite from five to three made it easier to complete the sampling - it was not always possible to find five large clams within a reasonably small sampling area. No horse clams were found on West Beach in 2011. However, the 2014 sampling included horse clams from West Beach. The addition of West Beach brings a new area into the data set, where the substrate is largely fill material imported in 2008. The clams from West Beach are assumed to be no more than five years old, since they were not found in 2011. The age of the clams from the other beaches is unknown and it is possible that they are older than the clams collected from West Beach. In 2016, clams were collected from all four intertidal sampling areas – West Beach, Intertidal Cap, North Shoal and East Beach.

Additionally, varnish clams were also collected at the Wyckoff site in order to determine abundance and tissue weight per clam. No analytical analyses were done on the varnish clam tissue. This was done to draw conclusions about this clam species presence at the site for possible future sampling, if desired.

2.3 Laboratory Methods

Tissue samples were collected in accordance with the Puget Sound Protocols and Guidelines, (PSAT 1997). Collection of three separate composite samples were attempted at each of the four separate beach areas (a field duplicate represented the fourth composite sample) for a total of 12 sample locations, however not all samples were successfully taken (see Shellfish Sampling Field Report). Once removed from the sediment, the horse clams were rinsed in site seawater, measured, and placed in bags with a sample label. Whole clams were placed in a cooler with ice (cooled to 4^{o}C) and hand delivered to the laboratory. Upon arrival to the laboratory, the clams were rinsed and placed into the freezer until analysis occurred.

A minimum of 100 grams of clam tissue (whole body without shell) is desired in each tissue sample for analysis of PAH and lipids, although in some samples, the lab was able to accept less clam tissue. This was accomplished by compositing the three clams (if three clams were taken) from each sample location. The liquid inside the shell was not retained; and clams were not depurated prior to processing. The laboratory processing included resection of the entire clam tissue, removing the outer skin and hard tip from the neck, discarding the contents of the gutball (ie. empty the gutball and rinse with distilled water then retain the gutball tissue for analysis), homogenizing the composite samples, and freezing the samples in glass jars at -18ºC for subsequent analysis. The tissue sample preparation and homogenization procedure for PAH and lipid analysis was modified from the Washington Department of Health February 4, 2011 Technical Assistance SOP preparing geoduck tissue samples, in the following ways:

PAHs. The Manchester Environmental Laboratory limit of quantitation (LOQ) for the seven carcinogenic PAHs (cPAHs) ranged from 1 to 2 parts per billion (ppb). The tissue samples were extracted using EPA Method 3550-M modified (industrial blender), cleaned up using EPA Method 3660B, 3665A, and 3640A if needed, and analyzed for PAHs using EPA Method 8270D -SIM modified as necessary to achieve the required reporting limits (RL).

Lipids. The Manchester Environmental Laboratory Standard Operating Procedure was used for lipid content analysis. The laboratory reports the total weight for each homogenized sample which included skinned neck (hard tip removed), strap, and empty gutball.

3.0 Equivalency Factors

The EPA has proposed a clam tissue cleanup goal for cPAHs of 0.12 µg/kg benzo(a)pyrene (B[a]P)-equivalent concentration (USEPA, 2016). However, there are no established tissue-based PAH protectiveness goals in the current East Harbor Record of Decision (ROD). Instead, the ROD identifies a sediment-based human health objective of 1,200 µg/kg dry weight high-molecular weight polycyclic aromatic hydrocarbons (HPAH), which is based on the 90th percentile of background Puget Sound subtidal sediments. In addition, to better evaluate the human health risk associated with current concentrations on site, EPA uses potency equivalency factors (PEFs). The PEFs from these results can be used to facilitate a human health risk assessment. Using the PEF values provided from EPA guidance (EPA, 1993), a total PEF value (expressed as a B[a]P equivalency concentration) for each sample location was calculated. The EPA guidance assigns a specific PEF relative response equivalency factor values to each cPAH compound, and is used widely on Superfund sites to help assist in assessing human health risk. PEFs are calculated by using weighted values of seven cPAHs in a sample result. The compounds included in summing a total PEF value are: benzo(a)anthracene, benzo(a)pyrene (B[a]P), benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenzo[a,h]anthracene and indeno(1,2,3-cd)pyrene (highlighted in Tables 1 and 2). Each cPAH compound has its own specific B[a]P relative response equivalency factor. These factors, when multiplied by the concentration of the cPAH detected, are then summed to create a total PEF (expressed as a B[a]P equivalency concentration) for a given sample. These calculated values can assist in comparing how natural attenuation is affecting clam tissue carcinogenic PAH concentrations. The wet weight results were used for both the total cPAH values and for calculating PEF equivalents.

Washington State Department of Ecology created a similar cPAH human health toxicity value using toxicity equivalency factors (TEFs), in accordance with the Model Toxics Control Act (MTCA) rule (Washington State Department of Ecology, 2015). TEFs are calculated in the same way as PEFs, using the same cPAH constituents. However, the MTCA individual B[a]P relative response factors are different from the EPA B[a]P relative response factors. For the purposes of comparison, all of the Wyckoff samples (2011, 2014 and 2016) were summed using both the EPA PEF and the MTCA TEF methodologies (Tables 1 and 2).

To calculate total PEF or TEF for non-detected results, the reporting limit was multiplied by 0.5 to represent its value (called “ND = ½ * RL” approach). Because the concentration is below the reporting limit and is unknown, this provides a conservative approach to average that possible value.

For comparison purposes, total PEFs and TEFs were also calculated using non-detected results as 0.0 (called “ND = 0” approach).

4.0 Results

2016 sampling results

Table 1 presents the 2016 clam tissue sample results from all four sections of the beach and the background location. Table 2 presents data from 2011, 2014, and 2016 sampling events. In both Tables 1 and 2, chemicals used in the total PEF and TEF calculations are highlighted. Chemicals with relatively high concentrations at all locations in 2016 were fluoranthene, phenanthene, and pyrene. Total cPAHs for 2016 range from a high of 18.12 μg/kg-wet at East Beach to a low of 9.97 μg/kg-wet at Intertidal Cap. The background sample at Point No Point for total carcinogenic PAHs was 4.78 μg/kg-wet, with only indeno(1,2,3-cd)pyrene detected. In 2016, average (hereafter meaning arithmetic mean) concentrations for a given section of the beach for cPAHs were highest at North Shoal (16.94 μg/kg-wet), however this is based on one sample result compared to most beaches having 3 sample results. This concentration is higher than the concentrations at East Beach (average of 16.66 μg/kg-wet), West Beach (average of 14.13 μg/kg-wet), and the Intertidal Cap (average of 14.09 μg/kg-wet). 2016 cPAH PEF ranged from a low of 1.50 at Intertidal Cap to a high of 2.58 at East Beach.

Lipid content ranged from a low of 0.31 percent at East Beach and a high of 0.63 percent at West Beach.

The one sample retrieved from the background location at Point No Point park was non-detect for all PAHs except indeno(1,2,3-cd)pyrene. This resulted in a total cPAH concentration of 4.78 μg/kg-wet and a PEF of 1.09.

For the 60 varnish clams that were collected on site and sent to the lab for tissue weight analysis, the average tissue weight per varnish clam was 8.93 grams.

5.0 Discussion and Conclusion

As stated previously, there are no established tissue-based PAH protectiveness goals in the current Eagle Harbor East Beach OU Record of Decision. However, EPA is proposing a clam tissue cleanup goal of 0.12 μg/kg B[a]P-equivalent.

Although PEF values are separate from cPAH concentrations, since PEF calculations are based on the respective cPAH concentrations, they show a similar trend. Meaning, in general, lower cPAH concentrations have lower PEF values, and higher cPAH concentrations have higher PEF values. For the purposes of this discussion, PEF values are used because of its weighted value based on the specific toxicity for different cPAH compounds.

Table 1 shows the calculated PEFs from the 2016 sampling event, and Figure 2 displays the calculated PEFs for each specific sample location for all 3 sampling events. In general, PEFs calculated from the data of this sampling event were lower than those in 2011, but higher than 2014. The 2016 PEFs were higher than the 2014 PEFs at all sampling locations where samples were retrieved (no samples for North Shoal 1 or North Shoal 2 were retrieved in the 2016 event).

In general, PEF values at the site do not have a definitive trend. Total PEFs have varied throughout the 2011, 2014 and 2016 sampling events, at all locations on the beach (West Beach, Intertidal Cap, North Shoal and East Beach). Each specific sampling location (i.e "East Beach 1") is not a clam taken from the same exact location for each sampling event over the years, however, the average (mean) PEF of all samples from a section of the beach (i.e "East Beach 1, 2 and 3) for one sampling event in a given year, has also varied over the years (Figure 6).

In general, EPA PEFs create a more conservative value with respect to human health risk, as the EPA PEF value for most samples is higher than the MTCA TEF value. This is mainly due in part to the EPA B[a]P PEF for dibenzo[a,h]anthracene value of 1.0, compared to the MTCA TEF value of 0.1. The specific differences in B[a]P values can be seen in Tables 1 and 2. In 2016, every PEF value was higher than its respective TEF value except the one sample retrieved at Point No Point. For every figure created to represent PEF data, a figure representing the same data calculated in TEF methodology was also created and can be seen in Appendix B.

The effect of calculating non-detects as 0.0 as opposed to 0.5 times the reporting limit has a varying effect and is very sample dependent. This is due to the different B[a]P–equivalent PEF/TEF values, and varying cPAH concentrations for a given sample. For example, having a non-detect result for benzo(a)pyrene in a sample will result in a large difference between the calculations because of its relatively large B[a]P equivalency value.

With respect to the sampling results as a whole, the trends are generally the same when comparing each calculation approach (Figures 2 and 3). The most notable difference is in 2014; many of the PEF values are significantly lower in the ND = 0 approach. This is because many of the samples in the 2014 sampling event had a significant amount of non-detect results (Table 2). Additionally, a bigger difference in value between the two calculation methodologies for the PEF values is noted, as opposed to the MTCA values (Table 2), because the EPA PEFs are more conservative. Figures displaying PEFs and TEFs using both the ND = ½ * RL and ND = 0 methodologies can be seen in Appendix B.

In addition, a statistical comparison was also performed using EPA's ProUCL software with data from the 2011, 2014 and 2016 sampling events. A multiple box plots chart was created (Figure

10) to show the average for all PEFs over time at the site, independent of sampling location. This chart displays the distribution of the PEFs calculated for all samples during a given sampling event. Figure 10 also shows how North Shoal with one PEF value (from 2014) greatly affects the mean average, and is listed as an outlier of this data set. From this figure, the sum of PEFs generally decreased over time. However, PEFs still varied greatly between specific sections of the beach over the years, which can be seen in the data tables (Tables 1 and 2). A multiple box plots chart was also created to show the PEF data for each beach over time at the Site (Figure 11).

The following are notable examples of how the data vary at each section of the beach:

- PEF values for East Beach in 2016 were higher on average than 2011 and 2014. In contrast, North Shoal PEF values show a decrease on average each year; but there was only one sample taken in 2016 so it is not representative of that whole section of the beach.
- Although in general the North Shoal PEFs decrease each year, the North Shoal also shows an increase in PEF at one specific part of the beach from 2011 to 2014 (North Shoal 3) and another point increase from 2014-2016 (North Shoal 1).
    - On the North Shoal, one large PEF value in 2014 highly influences the average at the beach location, giving the illustration that PEFs at the North Shoal have decreased each year, but this one data point doesn't give an accurate representation of the whole section of that part of the beach.
- In 2016, the Intertidal Cap PEF values increased from 2014 to levels slightly below the 2011 values.
- West Beach had higher concentrations on average in 2016 as compared to 2014, but this part of the beach wasn't sampled in 2011.

Although the total PEF values of samples for a given sampling event have shown a slight decrease since 2011 (Figure 10), overall, the data vary greatly from year to year at each location. Because of this variance, it cannot at this time be determined how natural recovery has affected clam tissue concentrations when comparing cPAH PEF μg/kg-wet 2011, 2014 and 2016 values.

Limited comparisons can be made from the 2016 Wyckoff horse clam PEFs to the Puget Sound horse clam background PEF collected from Point No Point due to the inability to successfully retrieve applicable and useful background samples and data in 2016 (see Appendix C). No conclusive decisions can be made in comparing clam tissue concentrations of PAHs at the Wyckoff site to background clams collected in this sampling event. The Lower Duwamish Waterway ROD (EPA, 2014) presents a background concentration of shellfish tissue in the Puget Sound region of 0.12 μg/kg B[a]P-equivalent, which is the proposed clam tissue goal for the Wyckoff site. As a whole, the PEFs at the Wyckoff site are elevated in comparison to this background concentration. The background data from the Lower Duwamish Waterway ROD, however, contains deficiencies in being able to create and draw statistical conclusions for comparison to the Wyckoff clam PEFs. For example, this background data is a makeup of multiple different clam species, which doesn’t include horse clams. Although the PEFs in clams at Wyckoff are elevated in comparison to these background PEF values, it is strongly recommended that additional horse clam background sampling occur, to collect more background data that is more suitable for comparison to the Wyckoff site.

Additionally, lipid analysis was performed to determine whether there is a correlation between lipid and cPAH content. In general, lipid percentages in clam tissue between the 2011 and 2016 sampling event were very similar, and lipid percentages in clam tissue in 2014 were greater than these two events. A comparison of the 2016 total cPAHs ug/kg (1/2*RL) to the lipid fraction (Figure 12) found no correlation (R value of 0.277). An R value shows correlation when its value approaches 1 and no correlation as the value approaches 0. Since cPAH concentrations in tissue are not related to lipid concentration, the time of year clams are collected does not seem to result in changes in the cPAH concentrations in the horse clam tissues. Data from the 2011 and 2014 sampling events also agree with this conclusion.

6.0 References

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Appendix A – Tables

Table 1. 2016 Clam Tissue PAHs Results and PEF/TEF Values

Sample Location:			EAST BEACH # 1				EAST BEACH # 2				EAST BEACH #3				East Beach #3 (FD)			
Compound	EPA[1] Benzo(a)pyrene Potency Equivalency Factor	MTCA[2] Benzo(a)pyrene Toxicity Equivalency Factor	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			2.30				2.70				3.40				2.70			
Acenaphthene			2.10				2.70				3.00				2.50			
Acenaphthylene			0.77	U			0.74	U			0.75	U			0.77	U		
Anthracene			3.00				3.10				4.20				3.30			
Benzo(a)anthracene	0.10	0.10	3.40		0.34	0.34	4.60	J	0.46	0.46	5.60	J	0.56	0.56	3.90		0.39	0.39
Benzo(a)pyrene	1.00	1.00	0.98		0.98	0.98	0.85		0.85	0.85	0.98		0.98	0.98	0.77	U	0.39	0.39
Benzo(g,h,i)perylene			1.30				0.74	U			0.75	U			0.77	U		
Benzo[b]Fluoranthene	0.10	0.10	3.40		0.34	0.34	3.30		0.33	0.33	4.80		0.48	0.48	3.00		0.30	0.30
Benzo[k]fluoranthene	0.01	0.10	1.00		0.0100	0.10	0.79		0.0079	0.08	0.99		0.0099	0.10	0.77	U	0.0039	0.04
Chrysene	0.001	0.01	3.50		0.0035	0.04	4.20		0.0042	0.04	5.00		0.0050	0.05	3.30	U	0.0033	0.03
Dibenzo[a,h]anthracene	1.00	0.10	0.77	U	0.39	0.04	0.74	U	0.37	0.04	0.75	U	0.38	0.04	0.77	U	0.39	0.04
Fluoranthene			17.00				22.00				22.00				17.00			
Indeno(1,2,3-cd)pyrene	0.10	0.10	5.20		0.52	0.52	1.20	J	0.12	0.12	0.75	U	0.04	0.04	4.00		0.40	0.40
Naphthalene			2.60	U			2.10	U			2.60	U			2.70	U		
Naphthalene, 1-methyl-			1.10				0.97				1.50				1.40			
Naphthalene, 2-methyl-			2.30	U			1.90	U			2.30	U			2.10	U		
Phenanthrene			12.00				18.00				16.00				15.00			
Pyrene			14.00				21.00				27.00				16.00			
Lipids%			0.49				0.53				0.56				0.31			
Total cPAH (ND = 0.5 *RL)			17.87				15.31				18.12				15.355			
Total cPAH (ND = 0)			17.48				14.94				17.37				14.20			
Total EPA PEF (ND = 0.5 * RL)					2.58				2.14				2.45				1.87	
Total EPA PEF (ND = 0)					2.19				1.77				2.03				1.09	
Total MTCA TEF (ND = 0.5 *RL)						2.35				1.92				2.24				1.59
Total MTCA TEF (ND = 0)						2.32				1.88				2.17				1.12

Sample Location:			INTERDIAL CAP #1				INTERTIDAL CAP # 2				INTERTIDAL CAP # 3				Intertidal Cap #2 (FD)			
Compound	EPA1 Benzo(a)pyrene Potency Equivalency Factor	MTCA2 Benzo(a)pyrene Toxicity Equivalency Factor	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			2.70				2.40				1.20				1.90			
Acenaphthene			2.30				2.00				0.98				1.70			
Acenaphthylene			0.76	U			0.75	U			0.78	U			0.78	U		
Anthracene			3.50				2.90				1.80				2.50			
Benzo(a)anthracene	0.10	0.10	3.50		0.35	0.35	3.30		0.33	0.33	1.70		0.17	0.17	2.60		0.26	0.26
Benzo(a)pyrene	1.00	1.00	0.76	U	0.38	0.38	0.75	U	0.38	0.38	0.78	U	0.39	0.39	0.78	U	0.39	0.39
Benzo(g,h,i)perylene			0.76	U			0.75	U			0.78	U			0.78	U		
Benzo[b]Fluoranthene	0.10	0.10	4.60		0.46	0.46	3.80		0.38	0.38	2.00		0.20	0.20	4.10		0.41	0.41
Benzo[k]fluoranthene	0.01	0.10	0.81		0.01	0.08	0.80		0.0080	0.08	0.78	U	0.0039	0.04	0.78	U	0.0039	0.04
Chrysene	0.001	0.01	3.70		0.00	0.04	3.20		0.0032	0.03	1.70		0.0017	0.02	2.70		0.0027	0.03
Dibenzo[a,h]anthracene	1.00	0.10	0.76	U	0.38	0.04	0.75	U	0.38	0.04	0.78	U	0.39	0.04	0.78	U	0.39	0.04
Fluoranthene			19.00				15.00				8.70				14.00			
Indeno(1,2,3-cd)pyrene	0.10	0.10	3.30		0.33	0.33	4.00		0.40	0.40	3.40		0.34	0.34	3.30		0.33	0.33
Naphthalene			2.40	U			2.50	U			1.70	U			2.30	U		
Naphthalene, 1-methyl-			0.86				0.87				0.78	U			0.78	U		
Naphthalene, 2-methyl-			2.00	U			1.80	U			1.20	U			1.70	U		
Phenanthrene			14.00				12.00				5.50				9.30			
Pyrene			15.00				12.00				6.90				11.00			
Lipids%			0.56				0.49				0.49				0.41			
Total cPAH (ND = 0.5 *RL)			16.67				15.85				9.97				13.87			
Total cPAH (ND = 0)			15.91				15.10				8.80				12.70			
Total EPA PEF (ND = 0.5 * RL)					1.91				1.87				1.50				1.79	
Total EPA PEF (ND = 0)					1.15				1.12				0.71				1.00	
Total MTCA TEF (ND = 0.5 *RL)						1.68				1.63				1.20				1.50
Total MTCA TEF (ND = 0)						1.26				1.22				0.73				1.03

Sample Location:			NORTH SHOAL # 1			
Compound	EPA1 Benzo(a)pyrene Potency Equivalency Factor	MTCA2 Benzo(a)pyrene Toxicity Equivalency Factor	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			3.70			
Acenaphthene			3.10			
Acenaphthylene			0.75	U		
Anthracene			3.40			
Benzo(a)anthracene	0.10	0.10	4.30		0.43	0.43
Benzo(a)pyrene	1.00	1.00	0.99		0.99	0.99
Benzo(g,h,i)perylene			0.75	U		
Benzo[b]Fluoranthene	0.10	0.10	4.90		0.49	0.49
Benzo[k]fluoranthene	0.01	0.10	1.00		0.0100	0.10
Chrysene	0.001	0.01	5.00		0.0050	0.05
Dibenzo[a,h]anthracene	1.00	0.10	0.75	U	0.38	0.08
Fluoranthene			26.00			
Indeno(1,2,3-cd)pyrene	0.10	0.10	0.75	U	0.04	0.08
Naphthalene			2.80	U		
Naphthalene, 1-methyl-			1.30			
Naphthalene, 2-methyl-			2.30	U		
Phenanthrene			20.00			
Pyrene			27.00			
Lipids%			0.57			
Total cPAH (ND = 0.5 *RL)			16.94			
Total cPAH (ND = 0)			16.19			
Total EPA PEF (ND = 0.5 * RL)					2.34	
Total EPA PEF (ND = 0)					1.93	
Total MTCA TEF (ND = 0.5 *RL)						2.21
Total MTCA TEF (ND = 0)						2.06

Sample Location:			West Beach #1				West Beach #2				West Beach #3			
Compound	EPA[1] Benzo(a)pyrene Potency Equivalency Factor	MTCA[2] Benzo(a)pyrene Toxicity Equivalency Factor	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			2.20				3.10				2.30			
Acenaphthene			1.90				3.30				1.90			
Acenaphthylene			0.77	U			0.76	U			0.77	U		
Anthracene			2.30				3.00				2.10			
Benzo(a)anthracene	0.10	0.10	2.70		0.27	0.27	2.80		0.28	0.28	2.40		0.24	0.24
Benzo(a)pyrene	1.00	1.00	0.77	U	0.39	0.39	0.76	U	0.38	0.38	0.77	U	0.39	0.39
Benzo(g,h,i)perylene			0.77	U			0.76	U			0.77	U		
Benzo[b]Fluoranthene	0.10	0.10	4.00		0.40	0.40	3.90		0.39	0.39	4.00		0.40	0.40
Benzo[k]fluoranthene	0.01	0.10	0.93		0.0093	0.09	0.76	U	0.0038	0.04	0.77	U	0.0039	0.04
Chrysene	0.001	0.01	2.50		0.0025	0.03	3.00		0.0030	0.03	2.60		0.0026	0.03
Dibenzo[a,h]anthracene	1.00	0.10	0.77	U	0.39	0.04	0.76	U	0.38	0.04	0.77	U	0.39	0.04
Fluoranthene			11.00				16.00				13.00			
Indeno(1,2,3-cd)pyrene	0.10	0.10	3.70		0.37	0.37	3.30		0.33	0.33	3.50		0.35	0.35
Naphthalene			2.40	U			2.80	U			2.60	U		
Naphthalene, 1-methyl-			0.80				1.20				0.83			
Naphthalene, 2-methyl-			1.90	U			2.40	U			2.00	U		
Phenanthrene			8.60				12.00				9.40			
Pyrene			9.70				12.00				11.00			
Lipids%			0.44				0.63				0.33			
Total cPAH (ND = 0.5 *RL)			14.6				14.14				13.655			
Total cPAH (ND = 0)			13.83				13.00				12.50			
Total EPA PEF (ND = 0.5 * RL)					1.82				1.77				1.77	
Total EPA PEF (ND = 0)					1.05				1.00				0.99	
Total MTCA TEF (ND = 0.5 *RL)						1.58				1.49				1.48
Total MTCA TEF (ND = 0)						1.16				1.03				1.02

Sample Location:			Point No Point #1			
Compound	EPA1 Benzo(a)pyrene Potency Equivalency Factor	MTCA2 Benzo(a)pyrene Toxicity Equivalency Factor	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			0.76	U		
Acenaphthene			0.76	U		
Acenaphthylene			0.76	U		
Anthracene			0.76	U		
Benzo(a)anthracene	0.10	0.10	0.76	U	0.04	0.076
Benzo(a)pyrene	1.00	1.00	0.76	U	0.38	0.76
Benzo(g,h,i)perylene			0.76	U		
Benzo[b]Fluoranthene	0.10	0.10	0.76	U	0.04	0.076
Benzo[k]fluoranthene	0.01	0.10	0.76	U	0.0038	0.076
Chrysene	0.001	0.01	0.76	U	0.0004	0.0076
Dibenzo[a,h]anthracene	1.00	0.10	0.76	U	0.38	0.076
Fluoranthene			0.76	U		
Indeno(1,2,3-cd)pyrene	0.10	0.10	2.50		0.25	0.25
Naphthalene			2.10	U		
Naphthalene, 1-methyl-			0.76	U		
Naphthalene, 2-methyl-			1.40	U		
Phenanthrene			0.76	U		
Pyrene			0.76	U		
Lipids%			0.38			
Total cPAH (ND = 0.5 *RL)			4.78			
Total cPAH (ND = 0)			2.50			
Total EPA PEF (ND = 0.5 * RL)					1.09	
Total EPA PEF (ND = 0)					0.25	
Total MTCA TEF (ND = 0.5 *RL)						1.3216
Total MTCA TEF (ND = 0)						0.25

Notes:

- How to read this table: An EPA/MTCA benzo(a)pyrene potency equivalency factor for a given cPAH is multiplied by its respective result to create an EPA/MTCA B[a]P – equivalent. The B[a]P equivalents for a given sample are then summed to create an EPA/MTCA total PEF/TEF, which can be seen at the bottom of the table, for the various calculations.

- Green highlight indicates chemical used in B[a]P – equivalent calculation.

- Blue highlight indicates EPA PEF (ND = 0.5 * RL method) value, which is used for the primary analysis of results.

- [1] Environmental Protection Agency 1993. *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*. July 1993.

- [2] Washington State Department of Ecology 2015. *Evaluating the Toxicity and Assessing the Carcinogenic Risk of Environmental Mixtures Using Toxicity Equivalency Factors.* April 2015.

- Q = Qualifier

- U = Non-detect

Table 2. 2011, 2014 and 2016 PAH Results and PEF/TEF Values

Sample Location:			EAST BEACH # 1												EAST BEACH # 2											
Compound	EPA[1] Benzo(a)pyrene Potency Equivalency Factor	MTCA[2] Benzo(a)pyrene Toxicity Equivalency Factor	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			0.93	U	0.82	U	2.30								1.6		1.2		2.70							
Acenaphthene			0.93	U	0.82	U	2.10								1.6		1.2		2.70							
Acenaphthylene			0.93	U	0.82	U	0.77	U							0.93	U	0.8	U	0.74	U						
Anthracene			4.50		0.82	U	3.00								4.3		0.8	U	3.10							
Benzo(a)anthracene	0.10	0.10	2.10		0.82	U	3.40		0.21	0.21	0.04	0.082	0.34	0.34	3		1		4.60	J	0.30	0.30	0.10	0.10	0.46	0.46
Benzo(a)pyrene	1.00	1.00	1.20		0.82	U	0.98		1.20	1.20	0.41	0.82	0.98	0.98	1.6		0.8	U	0.85		1.60	1.60	0.80	0.40	0.85	0.85
Benzo(g,h,i)perylene			5.70		0.82	U	1.30								5.1		0.8	U	0.74	U						
Benzo[b]Fluoranthene	0.10	0.10	0.93	U	1.10		3.400		0.05	0.0465	0.11	0.11	0.34	0.34	1.7		1.7		3.30		0.17	0.17	0.17	0.17	0.33	0.33
Benzo[k]fluoranthene	0.01	0.10	0.93	U	0.82	U	1.00		0.005	0.0465	0.004	0.082	0.010	0.10	0.93	U	0.82		0.79		0.005	0.05	0.01	0.08	0.01	0.08
Chrysene	0.001	0.01	1.90	U	1.40		3.50		0.001	0.0095	0.001	0.014	0.004	0.04	1.9	U	3.2		4.20		0.001	0.01	0.003	0.03	0.004	0.04
Dibenzo[a,h]anthracene	1.00	0.10	0.93	U	0.82	U	0.77	U	0.47	0.0465	0.41	0.082	0.39	0.04	0.93	U	0.8	U	0.74	U	0.47	0.05	0.80	0.04	0.37	0.04
Fluoranthene			3.90		3.70		17.00								7.6		6.7		22.00							
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.90	U	0.82	U	5.20		0.10	0.095	0.04	0.082	0.52	0.52	1.9	U	0.8	U	1.20	J	0.10	0.10	0.08	0.04	0.12	0.12
Naphthalene			1.10	U	0.82	U	2.60	U							1.4	U	2.6	U	2.10	U						
Naphthalene, 1-methyl-					3.90		1.10										3.3		0.97							
Naphthalene, 2-methyl-			14.00	U	9.00		2.30	U							13	U	7.1		1.90	U						
Phenanthrene			3.30		2.00		12.00								6.7		4.1		18.00							
Pyrene			4.80		5.00		14.00								11		15		21.00							
Lipids%			0.54		0.74		0.49								0.49		0.72		0.53							
Total cPAH (ND = 0.5 *RL)			9.89		6.60		17.87								11.96		9.12		15.31							
Total cPAH (ND = 0)			3.30		2.50		17.48								6.30		6.72		14.94							
Total EPA PEF (ND = 0.5 * RL)									2.02		1.02		2.58								2.64		1.96		2.14	
Total EPA PEF (ND = 0)									1.41		0.11		2.19								2.07		0.28		1.77	
Total MTCA TEF (ND = 0.5 *RL)										1.65		1.27		2.35								2.27		0.86		1.918
Total MTCA TEF (ND = 0)										1.41		0.124		2.32								2.07		0.38		1.881

Sample Location:			EAST BEACH #3											
Compound	EPA[1] Benzo(a)pyrene Potency Equivalency Factor	MTCA[2] Benzo(a)pyrene Toxicity Equivalency Factor	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			1.10		1.20		3.40							
Acenaphthene			1.00		0.88		3.00							
Acenaphthylene			0.95	U	0.84	U	0.75	U						
Anthracene			5.20		0.84	U	4.20							
Benzo(a)anthracene	0.10	0.10	2.90		0.84	U	5.60	J	0.29	0.29	0.04	0.04	0.56	0.56
Benzo(a)pyrene	1.00	1.00	1.90		0.84	U	0.98		1.90	1.90	0.42	0.42	0.98	0.98
Benzo(g,h,i)perylene			6.00		0.84	U	0.75	U						
Benzo[b]Fluoranthene	0.10	0.10	1.90		1.20		4.80		0.19	0.19	0.12	0.12	0.48	0.48
Benzo[k]fluoranthene	0.01	0.10	0.95	U	0.84	U	0.99		0.005	0.05	0.004	0.04	0.01	0.10
Chrysene	0.001	0.01	1.90	U	2.20		5.00		0.001	0.01	0.002	0.02	0.01	0.05
Dibenzo[a,h]anthracene	1.00	0.10	0.95	U	0.84	U	0.75	U	0.48	0.05	0.42	0.04	0.38	0.04
Fluoranthene			5.20		6.60		22.00							
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.90	U	0.84	U	0.75	U	0.10	0.10	0.04	0.04	0.04	0.04
Naphthalene			1.50	U	2.70	U	2.60	U						
Naphthalene, 1-methyl-			4.10		4.10		1.50							
Naphthalene, 2-methyl-			1.60	U	9.00		2.30	U						
Phenanthrene			4.70		4.00		16.00							
Pyrene			26.00		8.40		27.00							
Lipids%			0.40		1.10		0.56							
Total cPAH (ND = 0.5 *RL)			12.40		7.60		18.12							
Total cPAH (ND = 0)			6.70		3.40		17.37							
Total EPA PEF (ND = 0.5 * RL)									2.96		1.05		2.45	
Total EPA PEF (ND = 0)									2.38		0.12		2.03	
Total MTCA TEF (ND = 0.5 *RL)										2.58		0.73		2.244
Total MTCA TEF (ND = 0)										2.38		0.14		2.169

Sample Location:			INTERDIAL CAP #1												INTERTIDAL CAP # 2											
Compound	EPA1 Benzo(a)pyrene Potency Equivalency Factor	MTCA2 Benzo(a)pyrene Toxicity Equivalency Factor	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			1.20		1.60		2.70								1.20		0.91		2.40							
Acenaphthene			0.99		1.40		2.30								0.93	U	0.85	U	2.00							
Acenaphthylene			1.20		0.83	U	0.76	U							1.10		0.85	U	0.75	U						
Anthracene			9.60		0.83	U	3.50								10.00		0.85	U	2.90							
Benzo(a)anthracene	0.10	0.10	2.40		0.83	U	3.50		0.24	0.24	0.04	0.04	0.35	0.35	2.20		0.85	U	3.30		0.22	0.22	0.04	0.04	0.33	0.33
Benzo(a)pyrene	1.00	1.00	1.30		0.83	U	0.76	U	1.30	1.30	0.42	0.42	0.38	0.38	1.10		0.85	U	0.75	U	1.10	1.10	0.43	0.43	0.38	0.38
Benzo(g,h,i)perylene			5.10		0.83	U	0.76	U							6.80		0.85	U	0.75	U						
Benzo[b]Fluoranthene	0.10	0.10	2.20		1.40		4.60		0.22	0.22	0.14	0.14	0.46	0.46	1.80		1.10		3.80		0.18	0.18	0.11	0.11	0.38	0.38
Benzo[k]fluoranthene	0.01	0.10	0.92	U	0.83	U	0.81		0.005	0.05	0.004	0.04	0.01	0.08	0.93	U	0.85	U	0.80		0.005	0.05	0.004	0.04	0.008	0.08
Chrysene	0.001	0.01	1.80	U	3.50		3.70		0.001	0.01	0.004	0.04	0.004	0.04	1.90	U	2.40		3.20		0.001	0.01	0.002	0.02	0.003	0.03
Dibenzo[a,h]anthracene	1.00	0.10	0.92	U	0.83	U	0.76	U	0.46	0.05	0.42	0.04	0.38	0.04	0.93	U	0.85	U	0.75	U	0.47	0.05	0.43	0.04	0.38	0.04
Fluoranthene			7.30		9.60		19.00								7.30		6.50		15.00							
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.80	U	0.83	U	3.30		0.09	0.09	0.04	0.08	0.33	0.33	1.90	U	0.85	U	4.00		0.10	0.10	0.04	0.04	0.40	0.40
Naphthalene			1.10	U	2.70	U	2.40	U							0.93	U	2.70	U	2.50	U						
Naphthalene, 1-methyl-					1.70	U	0.86										1.10	U	0.87							
Naphthalene, 2-methyl-			1.50	U	3.50	U	2.00	U							13.00	U	2.00	U	1.80	U						
Phenanthrene			4.80		6.60		14.00								5.20		4.10		12.00							
Pyrene			11.00		13.00		15.00								7.10		8.50		12.00							
Lipids%			0.47		0.78		0.56								0.55		0.59		0.49							
Total cPAH (ND = 0.5 *RL)			11.34		9.05		16.67								10.76		7.75		15.85							
Total cPAH (ND = 0)			5.90		4.90		15.91								5.10		3.50		15.10							
Total EPA PEF (ND = 0.5 * RL)									2.59		1.06		1.91								2.07		1.05		1.87	
Total EPA PEF (ND = 0)									1.76		0.14		1.15								1.50		0.11		1.12	
Total MTCA TEF (ND = 0.5 *RL)										1.95		0.80		1.68								1.70		0.73		1.63
Total MTCA TEF (ND = 0)										1.76		0.18		1.26								1.50		0.13		1.22

Sample Location:			INTERTIDAL CAP # 3											
Compound	EPA1 Benzo(a)pyrene Potency Equivalency Factor	MTCA2 Benzo(a)pyrene Toxicity Equivalency Factor	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			1.40		0.81	U	1.20							
Acenaphthene			0.99		0.81	U	0.98							
Acenaphthylene			1.60		0.81	U	0.78	U						
Anthracene			17.00		0.81	U	1.80							
Benzo(a)anthracene	0.10	0.10	3.40		0.81	U	1.70		0.34	0.34	0.04	0.04	0.17	0.17
Benzo(a)pyrene	1.00	1.00	1.50		0.81	U	0.78	U	1.50	1.50	0.41	0.41	0.39	0.39
Benzo(g,h,i)perylene			6.20		0.81	U	0.78	U						
Benzo[b]Fluoranthene	0.10	0.10	2.60		1.10		2.00		0.26	0.26	0.11	0.11	0.20	0.20
Benzo[k]fluoranthene	0.01	0.10	0.95	U	0.81	U	0.78	U	0.005	0.05	0.004	0.04	0.004	0.04
Chrysene	0.001	0.01	1.90	U	1.60		1.70		0.001	0.01	0.002	0.02	0.002	0.02
Dibenzo[a,h]anthracene	1.00	0.10	0.95	U	0.81	U	0.78	U	0.48	0.05	0.41	0.04	0.39	0.04
Fluoranthene			7.30		2.70		8.70							
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.90	U	0.81	U	3.40		0.10	0.10	0.04	0.04	0.34	0.34
Naphthalene			1.30	U	2.60	U	1.70	U						
Naphthalene, 1-methyl-			1.90		1.20	U	0.78	U						
Naphthalene, 2-methyl-			1.70	U	2.80	U	1.20	U						
Phenanthrene			4.50		1.90		5.50							
Pyrene			9.70		4.40		6.90							
Lipids%			0.71		0.47		0.49							
Total cPAH (ND = 0.5 *RL)			13.20		6.75		9.97							
Total cPAH (ND = 0)			7.50		2.70		8.80							
Total EPA PEF (ND = 0.5 * RL)									2.68		1.01		1.50	
Total EPA PEF (ND = 0)									2.10		0.11		0.71	
Total MTCA TEF (ND = 0.5 *RL)										2.30		0.69		1.20
Total MTCA TEF (ND = 0)										2.10		0.13		0.73

Sample Location:			NORTH SHOAL # 1												NORTH SHOAL # 2							
Compound	EPA[1] Benzo(a)pyrene Potency Equivalency Factor	MTCA[2] Benzo(a)pyrene Toxicity Equivalency Factor	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			1.70		1.30		3.70								1.50		1.20					
Acenaphthene			1.20		1.20		3.10								1.40		0.92					
Acenaphthylene			1.40		0.85	U	0.75	U							1.20	U	0.82	U				
Anthracene			10.00		0.88		3.40								9.90	U	0.82	U				
Benzo(a)anthracene	0.10	0.10	2.80		0.96		4.30		0.28	0.28	0.10	0.10	0.43	0.43	3.50		0.97		0.35	0.35	0.10	0.10
Benzo(a)pyrene	1.00	1.00	3.40		0.85	U	0.99		3.40	3.40	0.43	0.43	0.99	0.99	3.00	U	0.82	U	1.50	1.50	0.41	0.41
Benzo(g,h,i)perylene			5.80		0.85	U	0.75	U							5.20	U	0.82	U				
Benzo[b]Fluoranthene	0.10	0.10	4.20		2.30		4.90		0.42	0.42	0.23	0.23	0.49	0.49	3.30		1.50		0.33	0.33	0.15	0.15
Benzo[k]fluoranthene	0.01	0.10	1.20		0.97		1.00		0.01	0.12	0.010	0.10	0.010	0.10	1.10		0.82		0.011	0.110	0.01	0.08
Chrysene	0.001	0.01	1.90	U	3.20		5.00		0.001	0.010	0.00	0.03	0.005	0.05	1.80		3.50		0.002	0.018	0.004	0.04
Dibenzo[a,h]anthracene	1.00	0.10	0.95	U	0.85	U	0.75	U	0.48	0.05	0.43	0.04	0.38	0.04	0.91	U	0.82	U	0.46	0.05	0.41	0.04
Fluoranthene			11.00		8.20		26.00								15.00		8.60					
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.90	U	0.85	U	0.75	U	0.10	0.10	0.04	0.04	0.04	0.04	1.80	U	0.82	U	0.09	0.09	0.04	0.04
Naphthalene			1.80	U	2.80	U	2.80	U							2.10	U	2.60	U				
Naphthalene, 1-methyl-					2.00	U	1.30									U	2.40	U				
Naphthalene, 2-methyl-			1.00	U	4.30		2.30	U							1.00		5.00					
Phenanthrene			6.40		5.90		20.00								6.70		6.50					
Pyrene			24.00		11.00		27.00								26.00		10.00					
Lipids%			0.56		0.68		0.57								0.53		0.67					
Total cPAH (ND = 0.5 *RL)			16.35		9.98		16.94								15.41		9.25					
Total cPAH (ND = 0)			11.60		7.43		16.19								9.70		6.79					
Total EPA PEF (ND = 0.5 * RL)									4.68		1.23		2.34						2.74		1.12	
Total EPA PEF (ND = 0)									4.11		0.34		1.93						0.69		0.26	
Total MTCA TEF (ND = 0.5 *RL)										4.37		0.97		2.14						2.44		0.86
Total MTCA TEF (ND = 0)										4.22		0.46		2.06						0.81		0.36

Sample Location:			NORTH SHOAL # 3							
Compound	EPA[1] Benzo(a)pyrene Potency Equivalency Factor	MTCA[2] Benzo(a)pyrene Toxicity Equivalency Factor	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			9.00		4.10					
Acenaphthene			1.50		5.90					
Acenaphthylene			1.30		0.85	U				
Anthracene			11.00		6.80					
Benzo(a)anthracene	0.10	0.10	2.60		8.70		0.26	0.26	0.87	0.87
Benzo(a)pyrene	1.00	1.00	2.30		3.70		2.30	2.30	3.70	3.70
Benzo(g,h,i)perylene			4.30		0.85	U				
Benzo[b]Fluoranthene	0.10	0.10	2.90		9.30		0.29	0.29	0.93	0.93
Benzo[k]fluoranthene	0.01	0.10	1.40		3.10		0.014	0.140	0.03	0.31
Chrysene	0.001	0.01	1.90	U	16.00		0.001	0.010	0.02	0.16
Dibenzo[a,h]anthracene	1.00	0.10	0.94	U	0.85	U	0.47	0.05	0.43	0.04
Fluoranthene			9.00		76.00					
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.90	U	1.10		0.10	0.10	0.11	0.11
Naphthalene			2.00	U	3.20	U				
Naphthalene, 1-methyl-					4.30					
Naphthalene, 2-methyl-			1.60	U	8.10					
Phenanthrene			7.00		16.00					
Pyrene			14.00		130.00					
Lipids%			0.48		0.80					
Total cPAH (ND = 0.5 *RL)			13.94		42.75					
Total cPAH (ND = 0)			9.20		41.90					
Total EPA PEF (ND = 0.5 * RL)							3.43		6.08	
Total EPA PEF (ND = 0)							2.86		5.66	
Total MTCA TEF (ND = 0.5 *RL)								3.14		6.12
Total MTCA TEF (ND = 0)								2.99		6.08

Sample Location:			West Beach #1								West Beach #2								West Beach #3							
Compound	EPA1 Benzo(a)pyrene Potency Equivalency Factor	MTCA2 Benzo(a)pyrene Toxicity Equivalency Factor	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			0.83	U	2.20						0.84	U	3.10						0.80	U	2.30					
Acenaphthene			0.83	U	1.90						0.84	U	3.30						0.80	U	1.90					
Acenaphthylene			0.83	U	0.77	U					0.84	U	0.76	U					0.80	U	0.77	U				
Anthracene			0.83	U	2.30						0.84	U	3.00						0.80	U	2.10					
Benzo(a)anthracene	0.10	0.10	0.83	U	2.70		0.04	0.04	0.27	0.27	0.84	U	2.80		0.04	0.04	0.28	0.28	0.80	U	2.40		0.04	0.04	0.24	0.24
Benzo(a)pyrene	1.00	1.00	0.83	U	0.77	U	0.42	0.42	0.39	0.385	0.84	U	0.76	U	0.42	0.42	0.38	0.38	0.80	U	0.77	U	0.40	0.40	0.39	0.385
Benzo(g,h,i)perylene			0.83	U	0.77	U					0.84	U	0.76	U					0.80	U	0.77	U				
Benzo[b]Fluoranthene	0.10	0.10	1.10		4.00		0.11	0.11	0.40	0.4	0.99		3.90		0.10	0.10	0.39	0.39	0.96		4.00		0.10	0.10	0.40	0.4
Benzo[k]fluoranthene	0.01	0.10	0.83	U	0.93		0.004	0.042	0.009	0.093	0.84	U	0.76	U	0.004	0.042	0.004	0.04	0.80	U	0.77	U	0.004	0.040	0.004	0.0385
Chrysene	0.001	0.01	1.70		2.50		0.002	0.017	0.003	0.025	1.80		3.00		0.002	0.018	0.003	0.03	1.80		2.60		0.002	0.018	0.003	0.026
Dibenzo[a,h]anthracene	1.00	0.10	0.83	U	0.77	U	0.42	0.04	0.39	0.0385	0.84	U	0.76	U	0.42	0.04	0.38	0.04	0.80	U	0.77	U	0.40	0.04	0.39	0.0385
Fluoranthene			4.90		11.00						3.30		16.00						3.90		13.00					
Indeno(1,2,3-cd)pyrene	0.10	0.10	0.83	U	3.70		0.04	0.04	0.37	0.37	0.84	U	3.30		0.04	0.04	0.33	0.33	0.80	U	3.50		0.04	0.04	0.35	0.35
Naphthalene			2.70	U	2.40	U					2.70	U	2.80	U					2.60	U	2.60	U				
Naphthalene, 1-methyl-			1.60	U	0.80						1.00	U	1.20						1.70	U	0.83					
Naphthalene, 2-methyl-			3.40	U	1.90	U					2.30	U	2.40	U					3.50	U	2.00	U				
Phenanthrene			3.00		8.60						2.20		12.00						2.60		9.40					
Pyrene			4.90		9.70						5.10		12.00						4.50		11.00					
Lipids%			0.36		0.44						0.42		0.63						0.44		0.33					
Total cPAH (ND = 0.5 *RL)			6.95		14.60						6.99		14.14						6.76		13.66					
Total cPAH (ND = 0)			2.80		13.83						2.79		13.00						2.76		12.50					
Total EPA PEF (ND = 0.5 * RL)							1.03		1.82						1.03		1.77						0.98		1.77	
Total EPA PEF (ND = 0)							0.11		1.05						0.10		1.00						0.10		0.99	
Total MTCA TEF (ND = 0.5 *RL)								0.71		1.5815						0.71		1.49						0.67		1.478
Total MTCA TEF (ND = 0)								0.13		1.158						0.12		1.03						0.11		1.016

Notes:

- How to read this table: An EPA/MTCA benzo(a)pyrene potency equivalency factor for a given cPAH is multiplied by its respective result to create an EPA/MTCA B[a]P – equivalent. The B[a]P equivalents for a given sample are then summed to create an EPA/MTCA total PEF/TEF, which can be seen at the bottom of the table, for the various calculations.

- Green highlight indicates chemical used in B[a]P – equivalent calculation.

- Blue highlight indicates EPA PEF (ND = 0.5 * RL method) value, which is used for the primary analysis of results.

- [1] Environmental Protection Agency 1993. *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*. July 1993.

- [2] Washington State Department of Ecology 2015. *Evaluating the Toxicity and Assessing the Carcinogenic Risk of Environmental Mixtures Using Toxicity Equivalency Factors.* April 2015.

- Q = Qualifier

- U = Non-detect

Appendix B – Figures

Figure 1. 2016 Clam Sample Locations

Figure 2. PEFs from 2011, 2014 and 2016 for Each Sampling Location

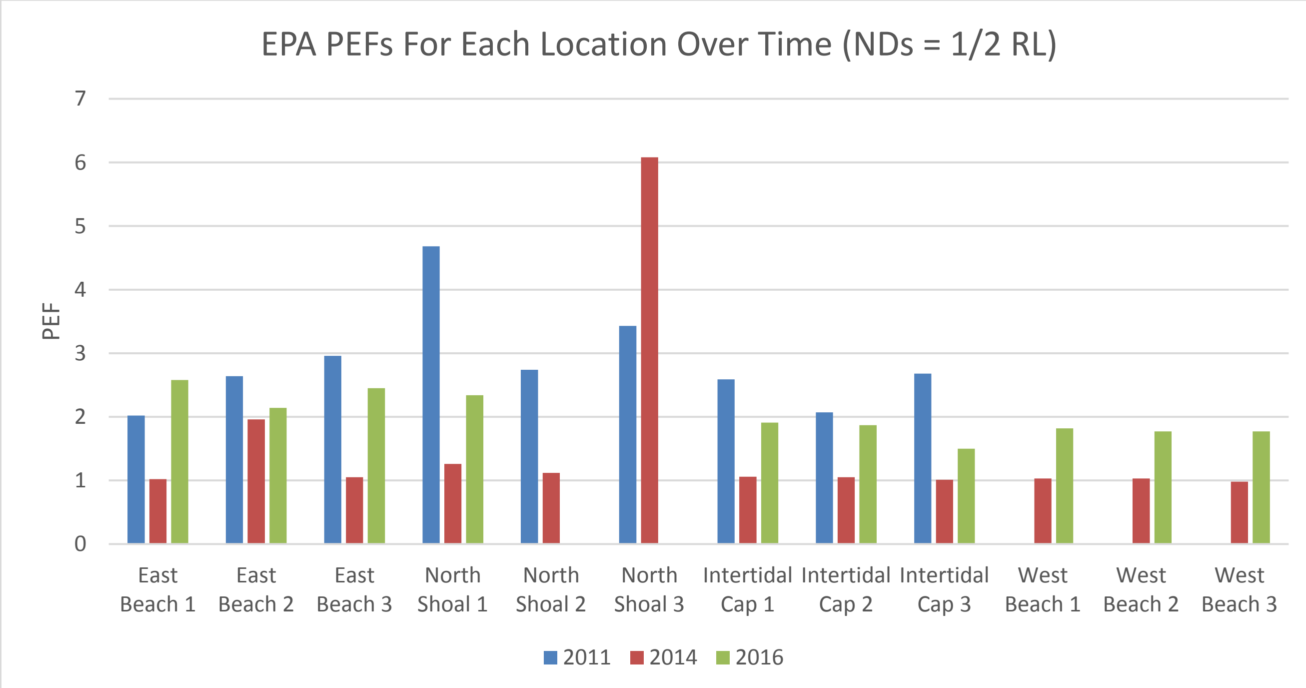


Figure 3. PEFs for Each Sampling Location over Time (using NDs equaling 0).

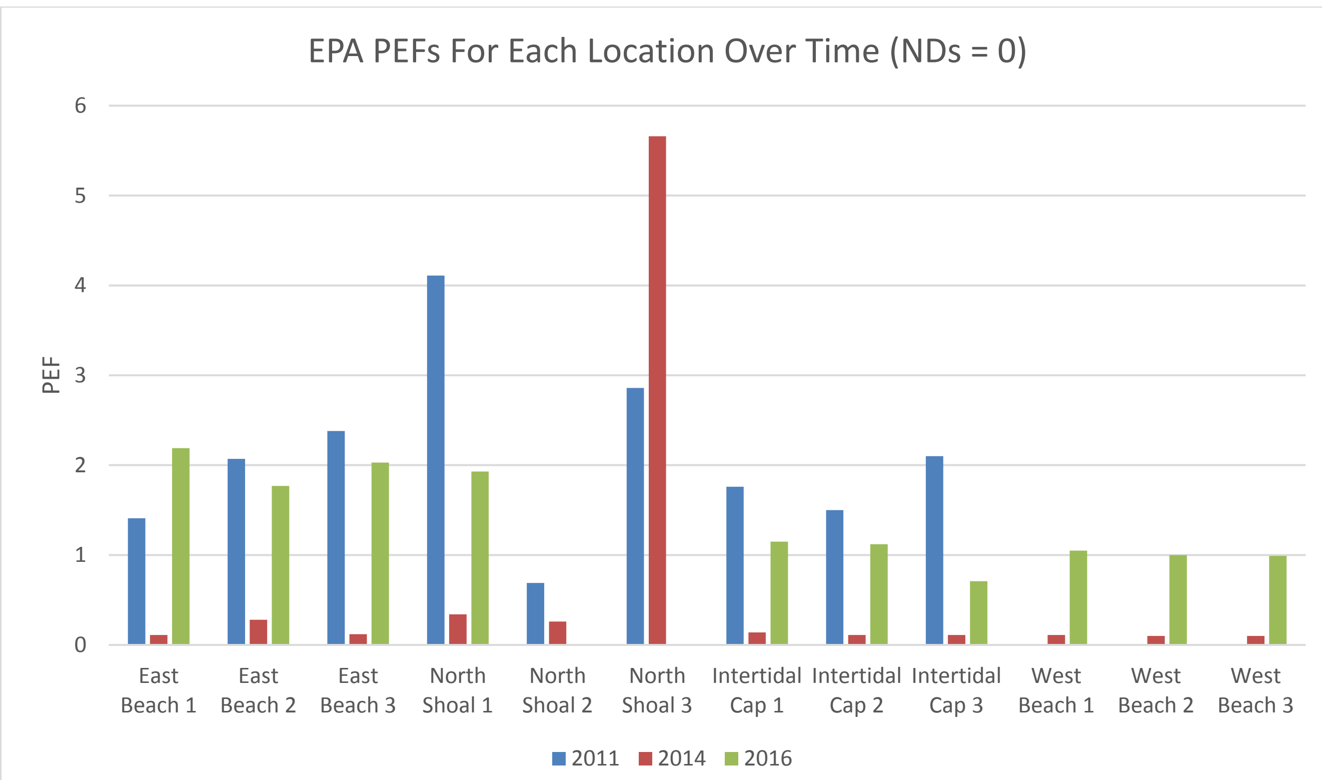


Figure 4. TEFs for Each Sampling Location over Time.

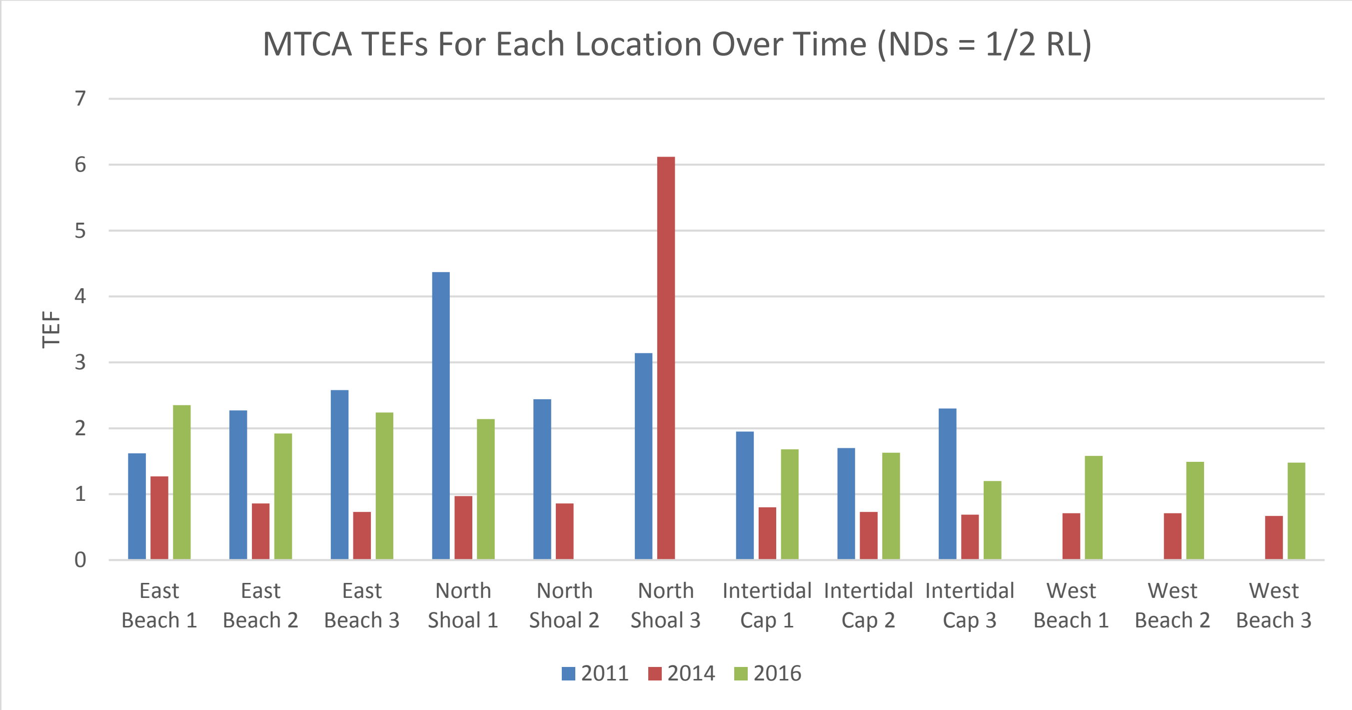


Figure 5. TEFs for Each Sampling Location over Time (using NDs equaling 0).

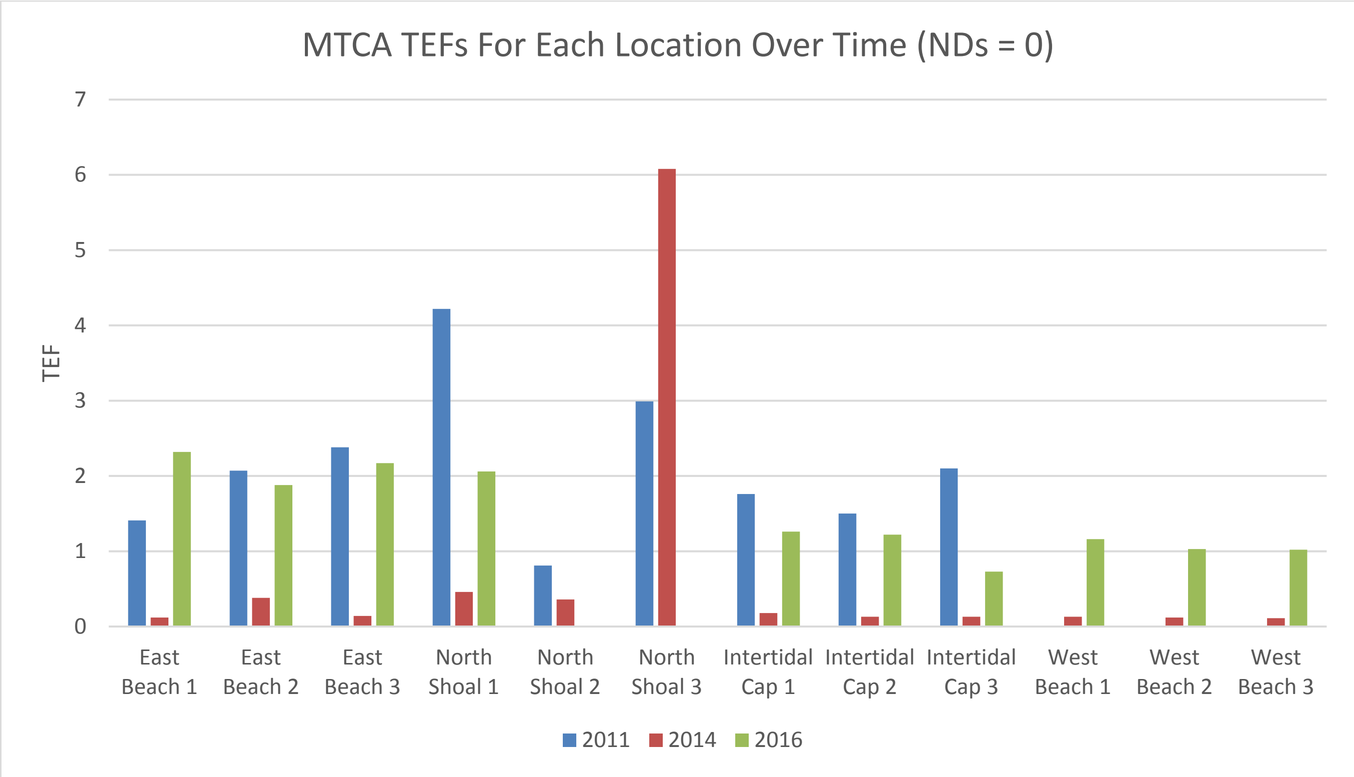


Figure 6. Average PEFs for Each Beach over Time.

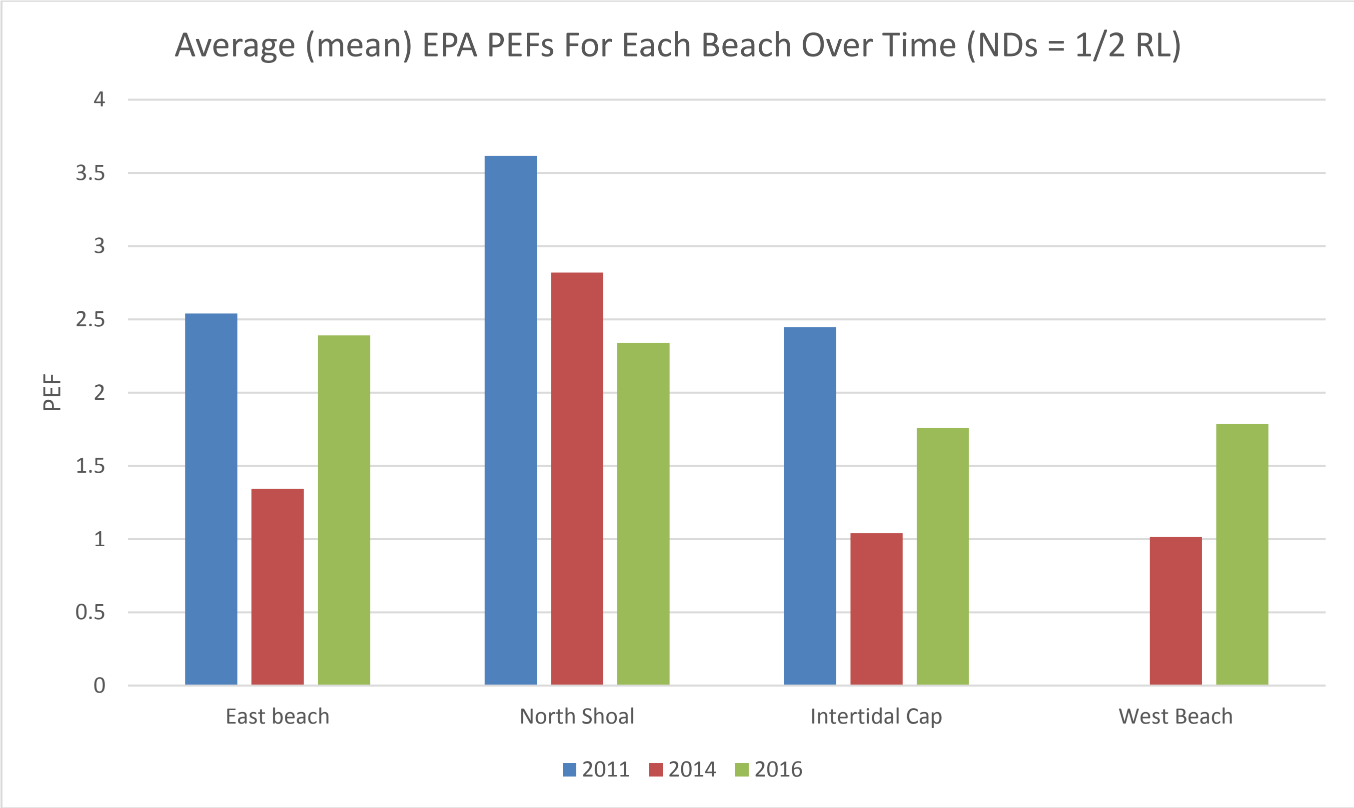


Figure 7. Average PEFs for Each Beach over Time (using NDs equaling 0).

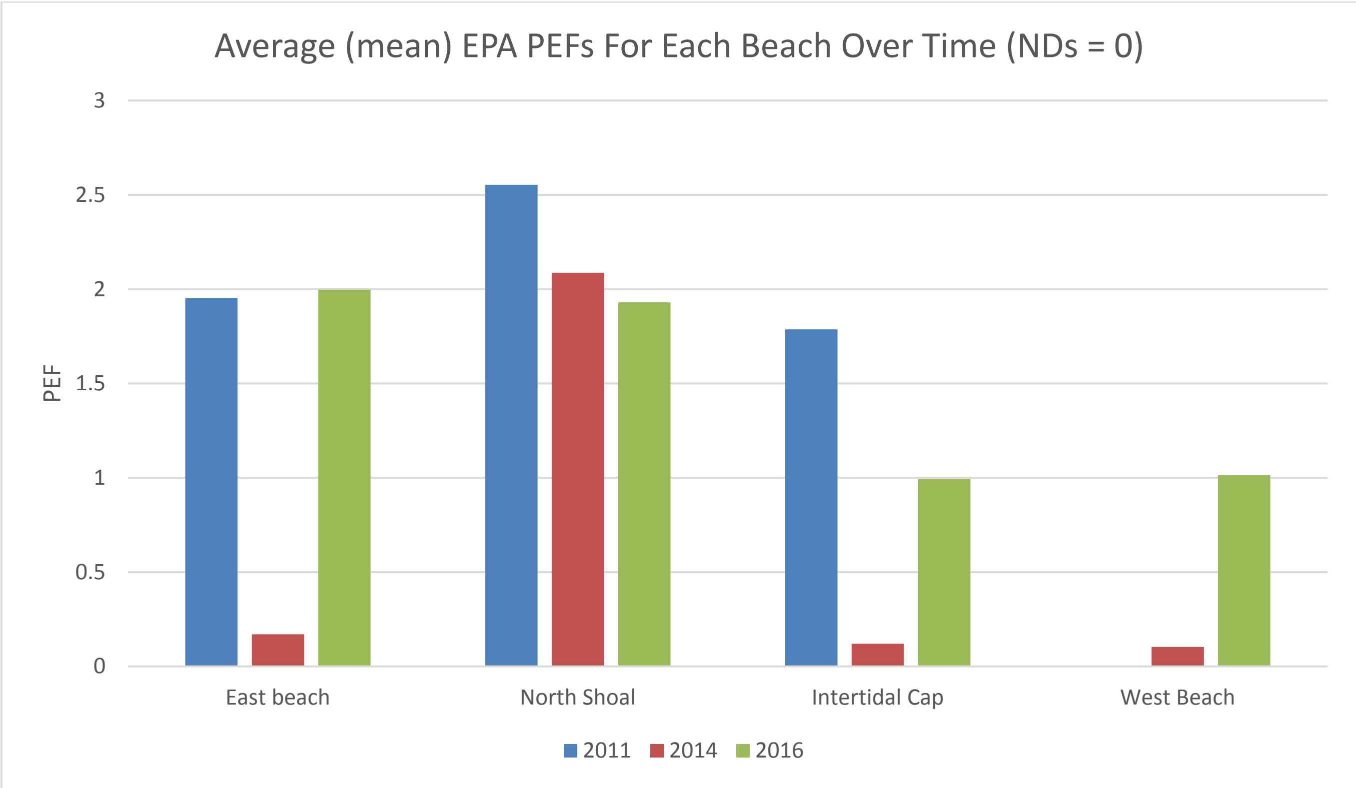


Figure 8. Average TEFs for Each Beach over Time.

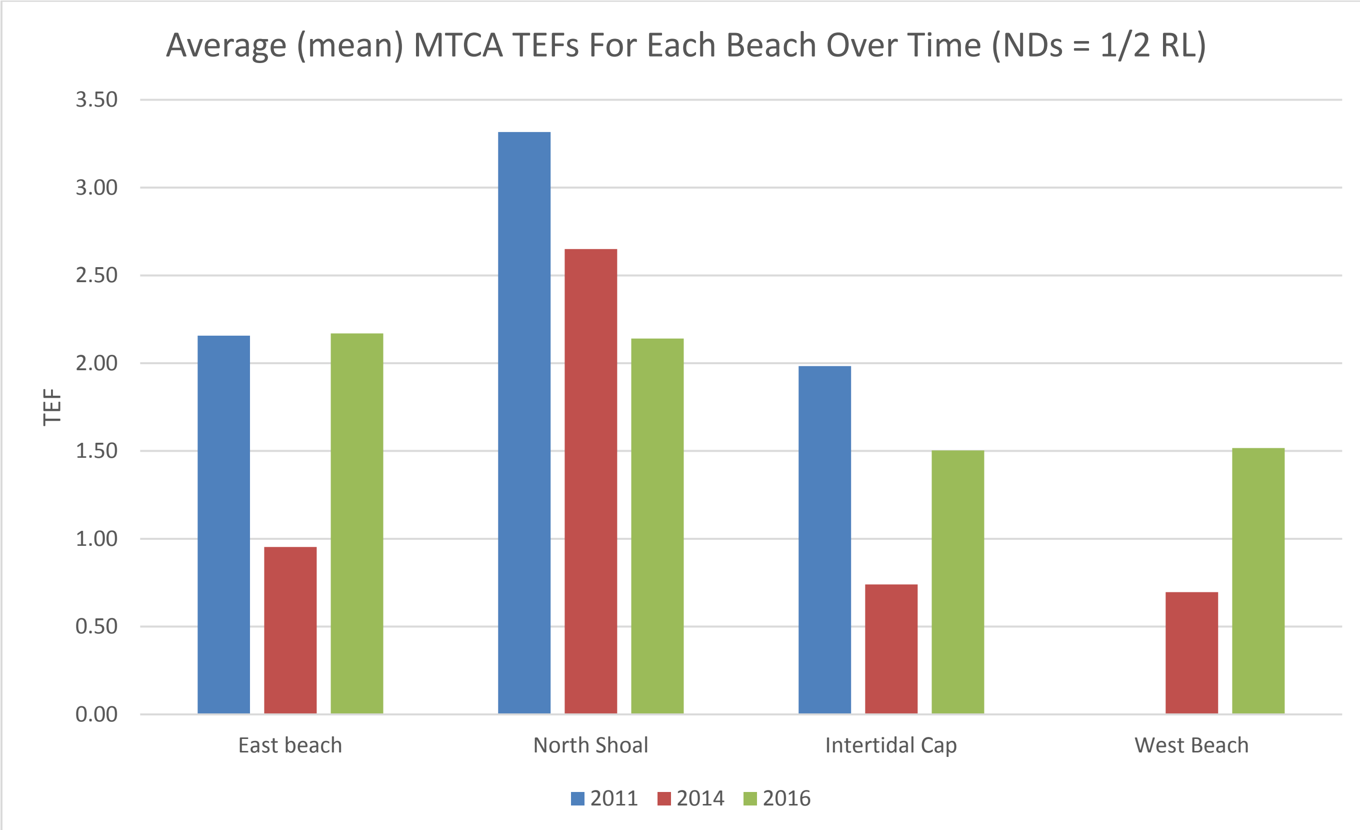


Figure 9. Average TEFs for Each Beach over Time (using NDs equaling 0).

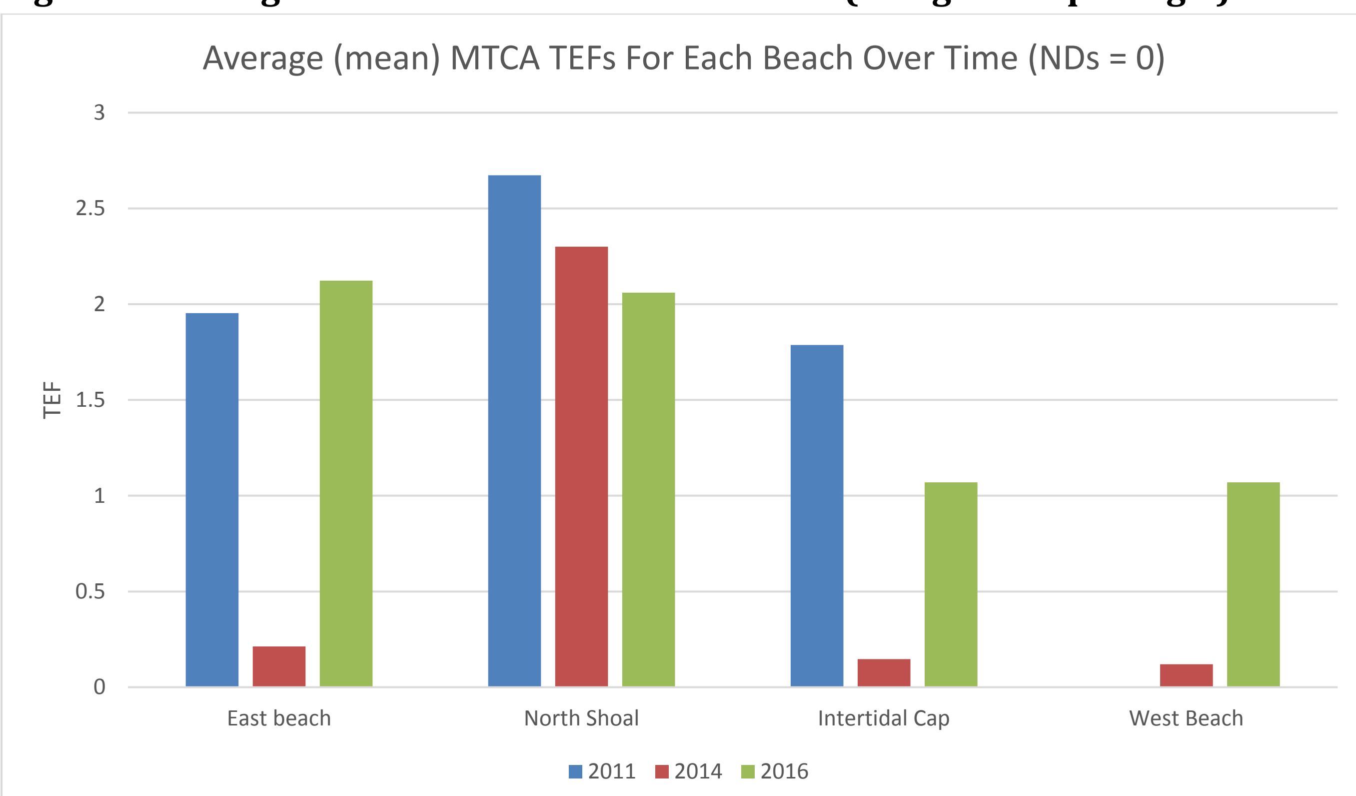
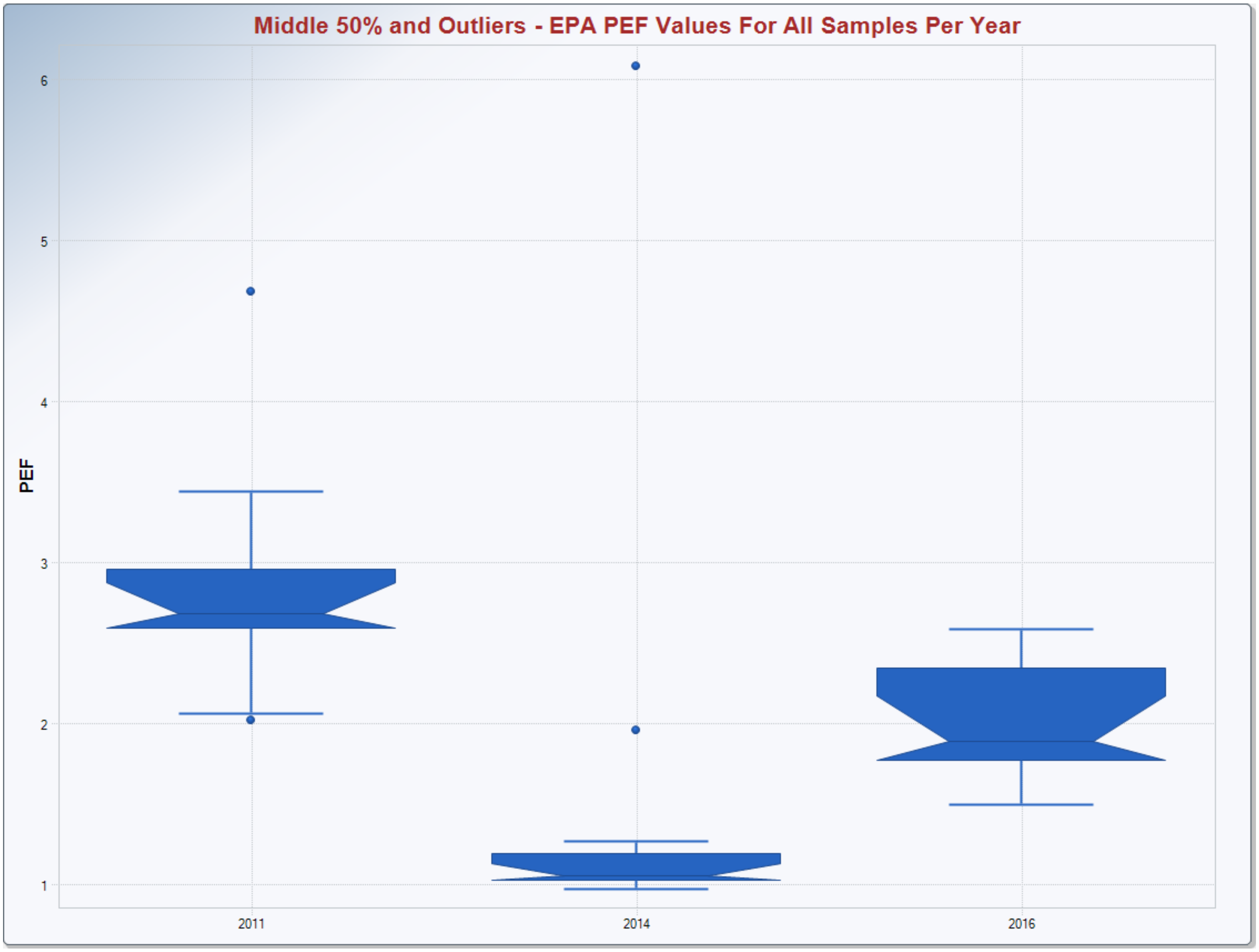
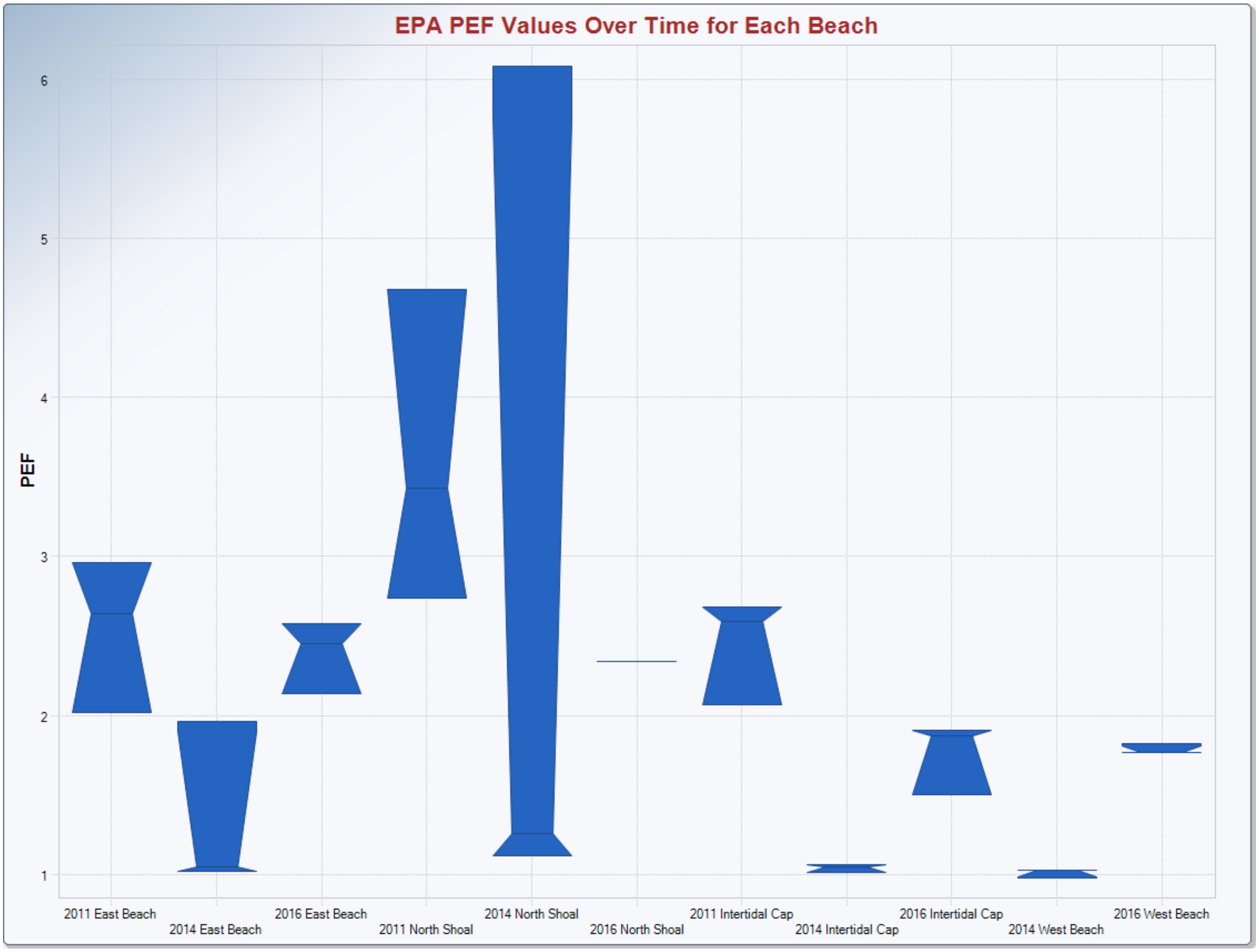


Figure 10. Multiple Box Plots Median Average and Outliers - PEF Values for total 2011, 2014 and 2016 Samples.



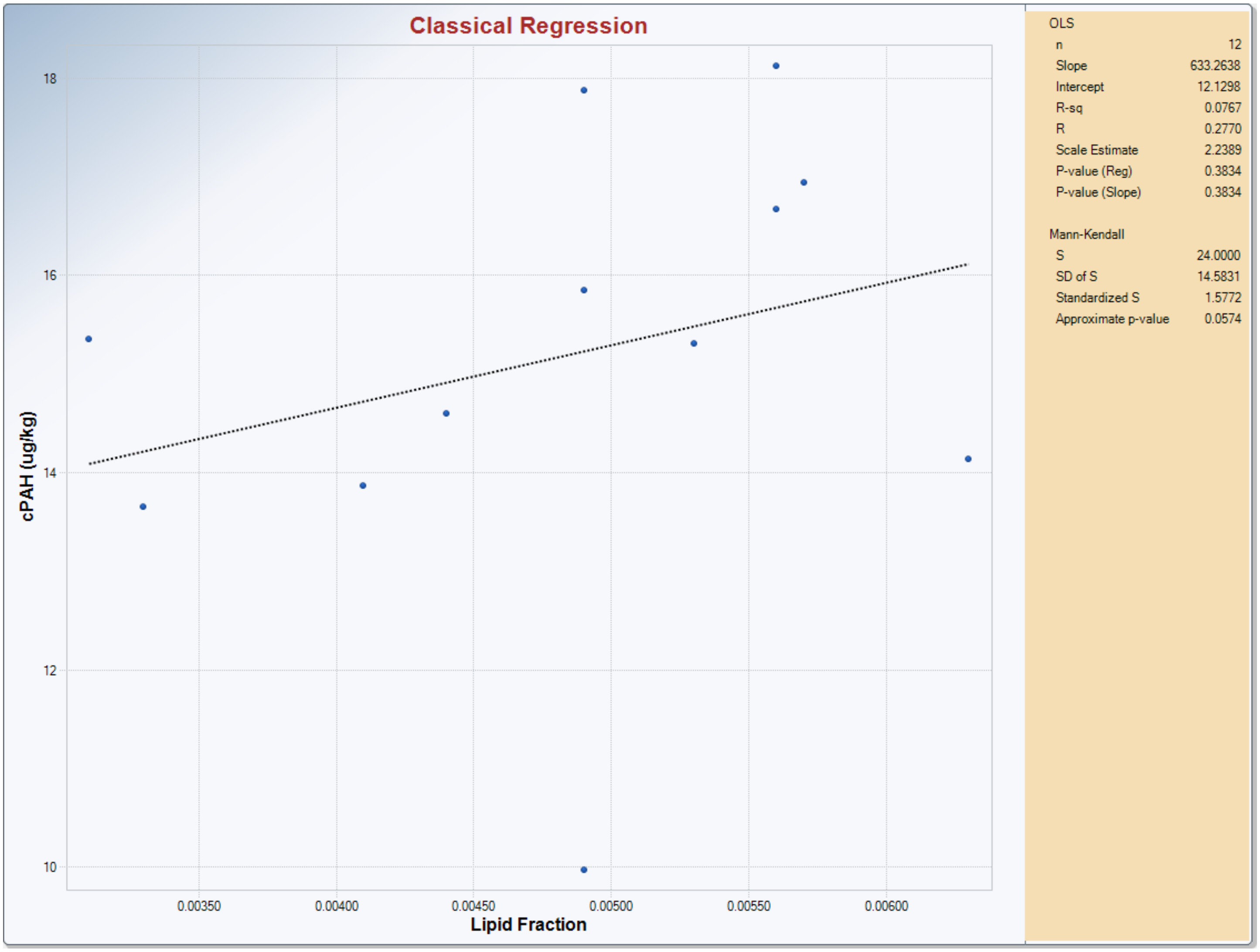
Note: This box plot reports in quartiles. The lowest line for each box plot represents the minimum value, and the highest line represents the maximum value (excluding outliers). The shaded blue box in-between represents the first through third quartile of value, and the line in the middle of the box represents the median. Circular blue points are outliers.

Figure 11. Multiple Box Plots Median Average - PEF Values for Each Beach Over Time (ND = ½ * RL).



Note: This box plot reports in quartiles. The lowest line for each box plot represents the minimum value, and the highest line represents the maximum value (excluding outliers). The shaded blue box in-between represents the first through third quartile of value, and the line in the middle of the box represents the median.

Figure 12. Ordinary Least Squares Regression of 2016 cPAH vs Lipid Fraction.



Appendix C – 2016 Clam Sampling Field Report

Wyckoff Shellfish Sampling Field Report

Wyckoff/Eagle Harbor Superfund Site

Bainbridge Island, WA

Sampling Performed: July 5-6, 2016

Prepared By:

Technical Services Branch

US Army Corps of Engineers®
Seattle District

1.0 Introduction

The U.S. Army Corps of Engineers (USACE) has been conducting shellfish sampling events to support the requirements of the Record of Decision (ROD) [USACE, 1994] at the Wyckoff Superfund Site, located in Bainbridge Island, Washington. This work was conducted in accordance with the 2016 Quality Assurance Project Plan (QAPP) [USACE, 2016]. This environmental sampling event was designed to obtain shellfish (clam) tissue analytical data as part of the existing monitoring for this site. Data from this sampling event will also be used in the next Five Year Review.

2.0 Project Background

The Wyckoff/Eagle Harbor Superfund site is located on the southern shoreline near the entrance to Eagle Harbor. A 40-acre wood-treating facility contributed to contaminated soil and groundwater, and contaminated sediments in adjacent Eagle Harbor. The Remedial Investigation conducted by EPA identified mercury and polycyclic aromatic hydrocarbons (PAHs) as the principal contaminants of concern in marine sediments. In addition, the ROD for the Wyckoff / Eagle Harbor Superfund site named PAHs and metals as the major risk drivers resulting from consumption of seafood near Eagle Harbor.

3.0 Project Objectives

The purposes of the work performed at the Wyckoff site for this field sampling event and identified in the QAPP are to:

- Obtain clam tissue for the analysis of contaminants of concern (CoCs) described in the ROD.
- Determine if clam tissue CoC levels have changed over time due to natural recovery.
- Collect site-specific background clam tissue for the analysis of CoCs described in the ROD.

Clam tissue PAH concentrations will be used in the next Five-Year Review, and will be used to update sampling locations and procedures as appropriate. The work was completed during low tides in early July 2016. Collection and analysis will assist EPA to assess success of remedial activities and the natural recovery process. The ROD states that monitoring is necessary to document natural recovery.

4.0 Summary of Field Activities

Eagle Harbor Sampling – July 5, 2016

The shellfish sampling team was comprised of personnel from USACE (Jake Williams (field lead), Kristen Kerns, Blair Kinser, Marlowe Laubach, Alex Meincke, Jayson Osborne, Aaron King, Zach Wilson, and Nancy Gleason), from EPA (Helen Bottcher and Kathryn Cerise), and from the Suquamish Tribe (Debbie Kay).

Horse clams (*Tresus capax*) were collected within four targeted intertidal areas: West Beach, Intertidal Cap, North Shoal, and East Beach. *Tresus nuttallii* were also collected in some locations as described later in this report. It was anticipated that a shellfish sample would be collected from three different locations within each intertidal area (with the addition of one field duplicate in each area). It was determined that a shellfish sample would include 3 horse clams of at least 5 inches in length to provide enough tissue sample for analysis. Sampling locations in each intertidal area were determined by the location of potential clam siphon holes on the sediment surface. Shellfish samples were collected for the following laboratory analyses: PAHs (method 8270D) and lipids (Bligh- Dyer method). GPS point locations of the clam locations were also taken. All samples were hand delivered in iced shipping coolers (by Jayson Osborne) under chain of custody to Manchester Environmental Laboratory (MEL), Port Orchard, Washington on 5 July 2016.

At the request of EPA, 60 varnish clams were also collected on July 5th. No sample analysis was performed on these clams. Rather, this clam sample was sent to the lab, shucked, and weighed, to determine the amount of clams needed to perform a tissue analysis in the future, should analysis for varnish clams tissue be required.

Point No Point Background Sampling – July 6, 2016

Part of the goal of this sampling effort was to retrieve background horse clam tissue data. In coordination with the Suquamish Tribe, it was determined that Point No Point Park, located on the northern end of Kitsap Peninsula, would provide an acceptable background level for clams in that region of the Puget Sound, including at the Wyckoff Site. On July 6th, 2016 USACE (Jake Williams, Marlowe Laubach and Alex Meincke), EPA (Helen Bottcher), and the Suquamish Tribe (Debbie Kay) went to Point No Point Park to collect 3 clam samples to provide background tissue data.

The clams at this location were buried deeper and were harder to retrieve compared to the Wyckoff site. The sampling team was able to retrieve one clam (*T. nuttallii*) 5 inches long for sample analysis. One clam does not provide the lab with the minimum amount of tissue needed to run the standard 8270D analysis for PAHs. USACE contacted the MEL and MEL indicated they could run 8270D analysis on whatever tissue was recovered, however MEL indicated that there may be a higher reporting limits associated with this sample, due to the lack of tissue mass recovered. The sample was hand delivered in an iced shipping cooler (by the field team) under chain of custody to MEL in Port Orchard, Washington on 6 July 2016.

5.0 Safety Briefing

All sampling activities were conducted under Worker Protection Level D. Personal protective equipment included Nitrile gloves, steel-toed rubber boots, safety glasses, and appropriate field work clothing. Prior to conducting fieldwork, all samplers reviewed the activity hazard analysis in the Health and Safety Plan. Prior to commencing work, a safety briefing was given by the field sampling lead in which general hazards were covered at the work site, and all field personnel, after having read the site-specific safety and health planned, signed the acknowledgement form. A copy of the signed acknowledgement form is included in Appendix B.

5.1 Sampling Activities

On July 5, 2016, USACE personnel arrived at the Wyckoff/Eagle Harbor site well in advance of a minus tide predicted for mid-day, which was a -2.7 ft. MLLW. The USACE field team mobilized to the beach, and split into two sub-teams of four persons each – with teams starting at West Beach (Figure 2). The sampling team familiarized themselves with the target shellfish species to be collected, the horse clam (*T. capax*), employing field guides.

Using clam rakes, buckets, shovels, and stainless steel spoons and bowls, the two sub-teams actively began clam sampling within the sampling areas as the field lead stayed at the van to process the clam samples as they were collected. Field work began at approximately 0930.

Sampling teams attempted to locate clams at approximately the same locations as previous sampling events, however this was difficult -- with clam densities/locations apparently changed from previous sampling events. The samplers used their clam shovels and rakes to gently remove material within about a one foot diameter circle area around an exposed siphon hole. A wooden dowel was simultaneously placed down the exposed siphon hole until the user felt it hit the clamshell. This was done to track the location of clam, while others were digging around and eventually under the exposed clam to retrieve it.

Once collected, the clam was measured to be sure it was of adequate size (5 inches), wrapped in foil and then placed in a Ziploc bag. Sand and other debris were removed from the clams prior to placing them in Ziploc® bags. Each bag was labeled with a unique sample ID number (cross- referenced in the field book and sample matrix) using indelible ink.

The two sampling sub-teams worked moving to sampling areas throughout the beach. It took approximately 3 hours for the teams to finish sampling in the first two sampling areas (West Beach and Intertidal Cap). Each team had one member dedicated to field notes, taking pictures, recording GPS points, and delivering samples to be processed. Shellfish sampling was completed by 1430 before the incoming tide inundated the targeted intertidal elevations, which were 50-60 feet.

In total, the sampling teams collected all proposed samples except for two primary samples and a field duplicate in the North Shoal area and a field duplicate in the West Beach location. This was because not enough horse clams in a similar area could be located for field duplicates. The field duplicate for the Intertidal Cap was taken at the “Intertidal Cap 2” location, and the field duplicate for the East Beach was taken at the “East Beach 3” location (Figure 2). In addition, it was difficult to locate the preferred horse clam (*T. Capax*). Because of this difficulty, some of the other species of horse clams (*T. nuttallii*) were collected as samples for the East Beach and North Shoal area. The specific clam composition for each sample is documented in the table below.

Sample Location	Number of Tresus nuttallii clams in sample	Number of Tresus capax clams in sample
West Beach 1	-	3
West Beach 2	-	2
West Beach 3	-	3
Intertidal Cap 1	-	3
Intertidal Cap 2	-	3
Intertidal Cap 2 (FD)	-	3
Intertidal Cap 3	-	3
North Shoal 1	1	-
East Beach 1	3	-
East Beach 2	3	-
East Beach 3	3	-
East Beach 3 (FD)	1	1
Point No Point 1	1	-

Varnish clams were easily located throughout the West Beach and Intertidal Cap Beach areas, approximately two to four inches beneath the surface. A team searched in the Intertidal Cap area for varnish clams and easily located 60 varnish clams to be sent to the lab for tissue weight. Varnish clams were not seen on the North Shoal or East Beach and most likely will never become abundant in those beach areas. The North Shoal and East Beach are at lower elevations in the intertidal region where varnish clams usually do not inhabit.

On July 6th, at Point No Point Park on Bainbridge Island, the same sampling procedures were followed to obtain *T. capax*. However only one horse clam (*T. nuttallii*) was collected due to the difficulty of retrieving the clams because of their depth below the beach surface. Horse clams at Point No Point Park are on average deeper than at Wyckoff because of the constantly shifting sand bars along the intertidal zone at Point No Point Park. The species of the majority of horse clams on this beach is unknown due to the inability to collect clams.

5.2 Significant Observations

Significant amounts of sheen and creosote was noticeable on both sediment and shellfish on most of East Beach and North Shoal, including the clams in the area (see Appendix C). The odor was strong and sheen/creosote was observed up to two feet deep in the sediment. The shellfish collected at the site, particularly on East Beach, are still clearly in contact with creosote. In the areas of sampling on East Beach and North Shoal, more *T. nuttallii* were found, compared to the Intertidal Cap and West Beach, where primarily *T. capax* were found. A variety of marine organisms and birds were noted in the area during the low tides, including: mussels, barnacles, moon snails, herons, and gulls. Appendix C contains photos from the sampling event.

5.3 Decontamination of Equipment and Waste Disposal

Stainless steel bowls, shovels, and clam rakes were used to collect the shellfish samples. No field decontamination between sampling locations was performed. Therefore, no waste was produced in the field aside from used paper towels and nitrile gloves. These were properly disposed into a waste receptacle after being double-bagged in plastic garbage bags. The hose near the pump and treat building was used for decontamination of all PPE. The wheels of the van were also washed.

5.4 Sample Packaging and Shipping

After sample collection was completed, the labeled shellfish sample bags placed into pre-iced sample coolers. Gel ice packs were placed into several gallon size Ziploc® bags to keep the samples cool until being frozen by the laboratory. A chain of custody form was affixed to the inside lid of each cooler listing the cooler contents. Two shipping coolers were hand delivered by Jayson Osborne to MEL on 5 July 2016. Chain of custody (COC) copies can be found in Appendix B.

On 6 July 2016, one cooler was hand delivered to MEL by the USACE field team, following the procedures described above.

6.0 Deviations from the QAPP

In general, field activities were conducted in accordance with the QAPP. As noted above, not all samples proposed in the QAPP were collected. At the Wyckoff site, while clams could be collected, there were problems locating the preferred clam species (*T. capax*). At Point No Point, there was difficulty collecting horse clams, of either species, due to the substrate and depth of clams in the beach. Only one *T. nuttallii* horse clam was located (see Section 5.1

above). All chain of custody forms were completed and updated according to EPA's protocol in Scribe.

8.0 Recommendations for Future Sampling Events

The following are recommendations for implementation in future sampling events.

- Sample for horse clams at the Wyckoff site and Puget Sound beaches in May. This allows for sampling during the lowest daytime tides, and also allows for additional time throughout the summer, if sampling needs to occur again. An ideal tide level would be at least -3 ft. MLLW.
- Choose a new background sampling beach that has stable water dynamics (as compared to Point No Point Park) which may result in horse clams at shallower depths below beach surface and easier retrieval.
- Preload GPS coordinates of previous sample points on a GPS in order to locate clams as close as possible to previous sample locations.
- Recommended team size of 5 people with clearly established roles.
    - 3 clam diggers.
    - 1 data recorder/photographer.
    - 1 scout to survey beach and mark possible clam locations and run samples to sample processer.
- Ensure teams have all necessary supplies. Long "sleeve gloves" could be helpful to prevent/reduce water and NAPL getting into gloves since the digging is 1-2 feet below ground surface. Regular length nitrile gloves are too short to protect the whole arm during digging. Clam shovels with narrower heads may work better than typical garden-type shovels.
- Add additional locations for possible background sampling. Locations should be selected based on easier clam retrieval. The additional locations will provide more background clam tissue data.

Conclusion of Field Sampling Report

References

USACE (1994) U.S Army Corps of Engineers. *Record of Decision – Wyckoff Co./Eagle Harbor*. September 1994.

USACE (2016) U.S Army Corps of Engineers. *Quality Assurance Project Plan Update – Wyckoff/Eagle Harbor Superfund Site*. June 2016

APPENDIX A

Project Location and Site Maps

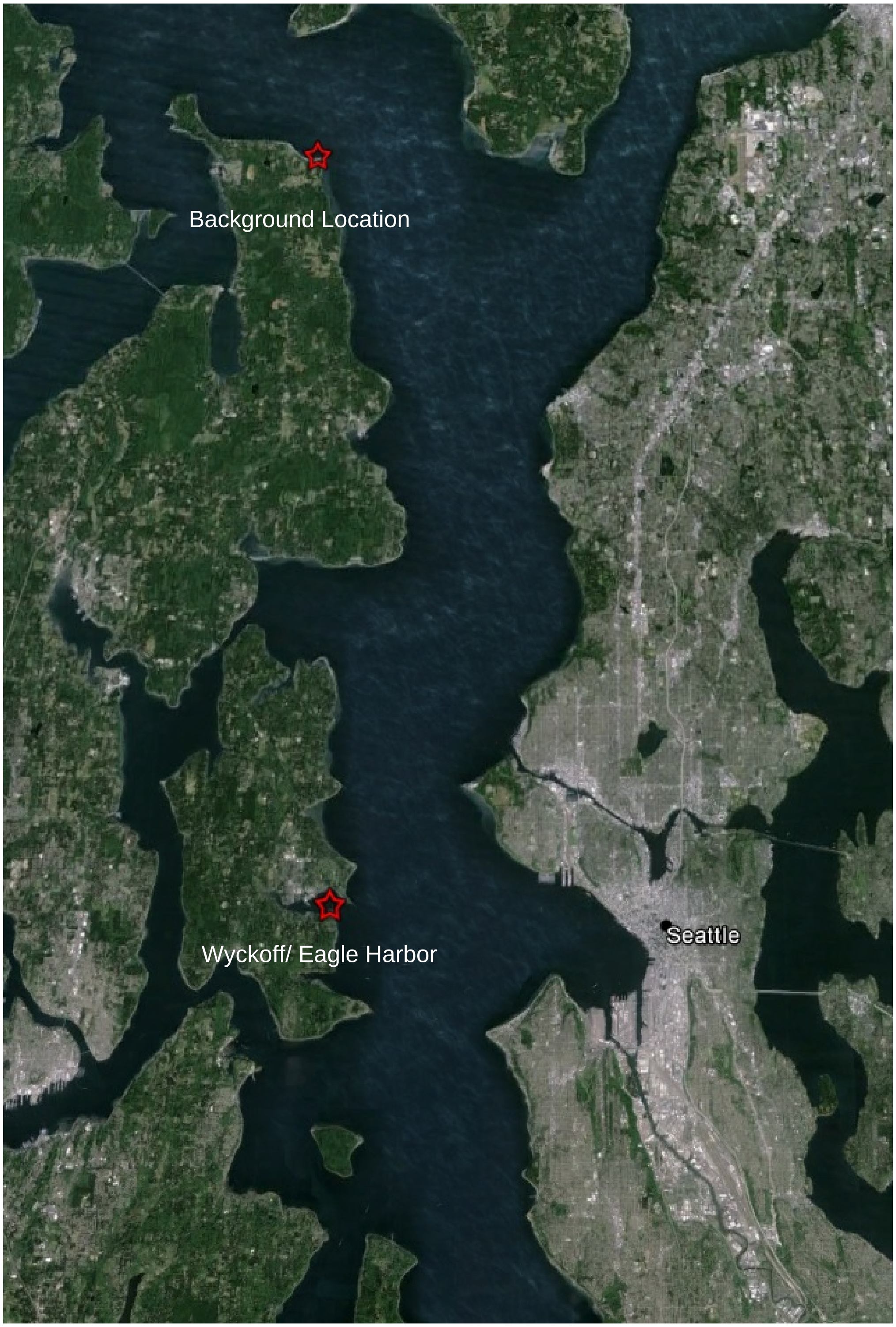


Figure 1. Sampling Locations Vicinity Map

Figure 2 Location of sampling points at the Wyckoff site

Figure 3 Map of background location sampling area

APPENDIX B

Field Notes, Acknowledgement Form, COC Forms

WYCKOFF CLAM SAMPLING
BAINBRIDGE ISLAND, WASHINGTON
DATE REVISED: 12 April 2016

SITE-SPECIFIC SAFETY AND HEALTH PLAN Review

Prepared by:

______________________ ______________________

Deborah Johnston Date

Army Corps of Engineers Review

______________________ ______________________

Signature Date

____

Name (print)

The following personnel have reviewed a copy of the SSHP. By signing below, these personnel indicate that they have read the plan, including all referenced information, and that they understand the requirements which are detailed for this project.

PRINTED NAME	SIGNATURE	PROJECT DUTIES	DATE
Jake Williams	[signature]	Sampling	7/5/16
Nancy Gleason	[signature]	sampling	7/5/16
Marlowe Laubach	[signature]	sampling	7/5/16
Kathryn Cerise	[signature]	"	7/5/16
Helen Bottcher	[signature]	"	7/5/16
Aaron King	[signature]	"	7/5/16
Zach Wilson	[signature]	"	7/5/16
KRISTEN [illegible]	[signature]	"	7/5/16
Jayson Osborne	[signature]	"	7/5/16
Alex Mehncke	[signature]	" "	7/5/16
Blair Bosch	[signature]	" "	" "

Rite in the Rain
ALL-WEATHER WRITING PAPER

Name Blair C Kinser

Address

Phone 206 764 6875

Project Wyckoff

CONTENTS

Team Members

Kristen Kerns
Aaron King
Zack Wilson

Sample: EB-3
Time:

Notes: Depth

N/A

Sample: EB-4
Time:

Notes: Field Duplicate
Depth
N/A

Sample: NS-1
Time: 1330

Notes: Depth - 15"

Nutella

Sample: NS-2
Time:

Notes: Depth -

N/A

No species of Interest Located

Sampling ID	Time	Note
EB-1	N/A	
EB-2	N/A	
EB-3	N/A	
EB-4	N/A	Duplicate
NS-1	1330	
NS-2	N/A	
NS-3	N/A	
NS-4	N/A	Duplicate
WB-3a	1046	
WB-31	1109	~~MS/MSD~~ BCH
WB-2	1300	> Same
WB-1	1245	GPS point

Sample: EB-1
Time:

Notes: Depth -

N/A

Sample: EB-2
Time:

Notes: Depth -

N/A

~~WB-1~~ WB-2
Time: 1300

Note: Depth ± 18" avg on all

Same GPS point within 15'

WB-1
Time 1245

Note: Depth ± 18" Avg

Species of Interest were clustered in WB-1 area
WB-2 also collected in area.

Sample: NS-3
Time:

Notes: Depth -

N/A No species of interest located.

Sample: NS-4
Time:

Notes: Duplicate
Depth -

N/A No species of interest located

Sample: WB-2a
Time: 1046

Notes: Depth - Clam 1 - ~~24"~~ 16"
Clam 2

Sample: WB-3b
Time: 1109

Notes: Depth - Clam 1 24"
GPS point taken within 15ft radius of samples
Clam 2 - 18"
Clam 3 - 18"

Sample: IC # 1
Time: 11:03 am

Notes: Depth: ~~1 ft~~ 12 in
10 inches
10 inches

~~Sample IC 4 (Field Duplicate)~~
~~Time: 11:07 am~~

~~Notes: Depth 17 cm~~ →

Sample: IC # 2
Time: 11:35

Notes: Depth: 9 in
12 in
8 in

Sample: IC 4 (Field Duplicate)
Time: 11:42 am

Notes: Depth: 12 in
14 in
12 in

Sample: IC 3
Time: 11:56 am

Notes: Depth 8 in
8 in
10 in

Sample: EB 1
Time: ~~12:6~~ 12:36 pm

Notes: Depth: 9 in (a)
15 in ~~(a)~~
~~8 in~~ 8 in
- Questionable Species
- ~~Lots of Sheen (oily)~~

Sample: EB 2
Time: 1:0 pm

Notes: Depth: - 8 in
- 9 in
- 8 in
- Questionable Species
- lots of oily Sheen

~~Sample: EB 3~~
~~Time~~

~~Notes: Depth: 9 in~~
~~10 in~~
~~9 in~~

~~oily Sheen, Questionable Species~~

Sample: EB 3
Time: 1:57 pm

Notes: Depth 12 in
12 in
12 in

Sample: EB 4 (Duplicate of EB 3)
Time: 2:00 pm

Notes: Depth: 12 in

- Only 2 samples
- 1 of each species

Sample:
Time:

Notes: Depth

Sample:
Time:

Notes: Depth:

Sample: Point No Point Background (B-1)
Time: 11:33 am

Notes: Depth 22 in
Overturnable Speaker

SAMPLE:
Time:

Notes: Depth:

EPA R10 Lab (MEL) COC (LAB COPY)	CHAIN OF CUSTODY RECORD	No: 10-061716-114334-0001
DateShipped: 7/5/2016		2016T10P302DD210S1LA00
CarrierName: Hand Deliver	Project Code: WEH-021C	Contact Name: Jake Williams
AirbillNo: NA	Cooler #: 1	Contact Phone: 206 316 3157

Sample Identifier	CLP Sample No.	Matrix/Sampler	Coll. Method	Analysis/Turnaround (Days)	Tag/Preservative/Bottles	Location	Collection Date/Time	For Lab Use Only
16274200		Clam Tissue/ Kerns, King, Wilson	Grab	PAH_PL(8 Weeks)	N1 (< 6 C) (1)	East Beach 1	07/05/2016 12:36	
16274201		Clam Tissue/ Kerns, King, Wilson	Grab	PAH_PL(8 Weeks)	N1 (< 6 C) (1)	East Beach 2	07/05/2016 13:01	
16274202		Clam Tissue/ Kerns, King, Wilson	Grab	PAH_PL(8 Weeks)	N1 (< 6 C) (1)	East Beach 3	07/05/2016 13:57	
16274203		Clam Tissue/ Kerns, King, Wilson	Grab	PAH_PL(8 Weeks)	N1 (< 6 C) (1)	East Beach 3	07/05/2016 14:00	
16274204		Clam Tissue/ Laubach, Osborne, Gleason	Grab	PAH_PL(8 Weeks)	N1 (< 6 C) (1)	North Shoal 1	07/05/2016 13:30	
16274220		Clam Tissue/ Kerns, King, Wilson	Grab	Shuck & Weight	A (< 6 C) (1)	Eagle Harbor	07/05/2016 10:30	

Sample(s) to be used for Lab QC: 16274201 Tag N1 - Special Instructions: Lab QC first day if possible with provided sample	**Shipment for Case Complete? N**
	Samples Transferred From Chain of Custody #
Analysis Key: PAH_PL=PAHs and Percent Lipids	

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt

EPA R10 Lab (MEL) COC (LAB COPY) **CHAIN OF CUSTODY RECORD** **No: 10-062116-105523-0002**

DateShipped: 7/6/2016
2016T10P302DD210S1LA00

CarrierName: Hand Deliver
Project Code: WEH-021C
Contact Name: Jake Williams

AirbillNo:
Cooler #: 2
Contact Phone: 206 316 3157

Sample Identifier	CLP Sample No.	Matrix/Sampler	Coll. Method	Analysis/Turnaround (Days)	Tag/Preservative/Bottles	Location	Collection Date/Time	For Lab Use Only
16274216		Clam Tissue/ Williams, Meincke, Laubach	Grab	PAH_PL(8 Weeks)	N1 (< 6 C) (1)	PNP 1	07/06/2016 12:30	

Special Instructions:	**Shipment for Case Complete? Y**
	Samples Transferred From Chain of Custody #
Analysis Key: PAH_PL=PAHs and Percent Lipids	

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt

EPA R10 Lab (MEL) COC (LAB COPY)

CHAIN OF CUSTODY RECORD

No: 10-062816-102333-0003

DateShipped: 7/5/2016

2016T10P302DD210S1LA00

CarrierName: Hand Deliver

Project Code: WEH-021C

Contact Name: Jake Williams

AirbillNo: NA

Cooler #: 3

Contact Phone: 206 316 3157

Sample Identifier	CLP Sample No.	Matrix/Sampler	Coll. Method	Analysis/Turnaround (Days)	Tag/Preservative/Bottles	Location	Collection Date/Time	For Lab Use Only
16274208		Clam Tissue/ Kerns, King, Wilson	Grab	PAH_PL(8 Weeks)	N1 (< 6 C) (1)	Intertidal Cap 1	07/05/2016 11:03	
16274209		Clam Tissue/ Kerns, King, Wilson	Grab	PAH_PL(8 Weeks)	N1 (< 6 C) (1)	Intertidal Cap 2	07/05/2016 11:35	
16274210		Clam Tissue/ Kerns, King, Wilson	Grab	PAH_PL(8 Weeks)	N1 (< 6 C) (1)	Intertidal Cap 3	07/05/2016 11:58	
16274211		Clam Tissue/ Kerns, King, Wilson	Grab	PAH_PL(8 Weeks)	N1 (< 6 C) (1)	Intertidal Cap 2	07/05/2016 11:42	
16274212		Clam Tissue/ Laubach, Osborne, Gleason	Grab	PAH_PL(8 Weeks)	N1 (< 6 C) (1)	West Beach 1	07/05/2016 13:05	
16274213		Clam Tissue/ Laubach, Osborne, Gleason	Grab	PAH_PL(8 Weeks)	N1 (< 6 C) (1)	West Beach 2	07/05/2016 13:10	

Special Instructions:	**Shipment for Case Complete? N** **Samples Transferred From Chain of Custody #**
Analysis Key: PAH_PL=PAHs and Percent Lipids	

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt

EPA R10 Lab (MEL) COC (LAB COPY)

CHAIN OF CUSTODY RECORD

No: 10-062816-102333-0003

DateShipped: 7/5/2016

2016T10P302DD210S1LA00

CarrierName: Hand Deliver

Project Code: WEH-021C

Contact Name: Jake Williams

AirbillNo: NA

Cooler #: 3

Contact Phone: 206 316 3157

Sample Identifier	CLP Sample No.	Matrix/Sampler	Coll. Method	Analysis/Turnaround (Days)	Tag/Preservative/Bottles	Location	Collection Date/Time	For Lab Use Only
16274214		Clam Tissue/ Laubach, Osborne, Gleason	Grab	PAH_PL(8 Weeks)	N1 (< 6 C) (1)	West Beach 3	07/05/2016 11:35	

Special Instructions:	**Shipment for Case Complete? N** **Samples Transferred From Chain of Custody #**
Analysis Key: PAH_PL=PAHs and Percent Lipids	

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt

APPENDIX C

Sampling Event Photos

APPENDIX C
Sampling Event Photos

View of Wyckoff/Eagle Harbor site looking east from the west beach

USACE field team digging for clams on west beach. Bainbridge Island ferry terminal seen in the background

Tresus capax horse clam found on the intertidal cap beach area

Wooden dowel used to locate clams

Sheen on clams in the east beach area

Sheen easily visible on surface of east beach area