2016 Benthic Infauna Sampling of the Port Orford Dredged Material Disposal Site

Prepared for ANAMAR Environmental Consulting, Inc. December 2016

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INTRODUCTION

The United States Army Corps of Engineers (USACE) maintains a nearshore dredge material disposal site for a clean sand hereafter referred to as (Nearshore Disposal Site) near the entrance of the mouth of Port Orford Harbor in Port Orford, Oregon. The site is designated as the Port Orford Nearshore Disposal Site and is intended as a receiver site for dredged material removed from the harbor in Port Orford (Figure 1).

The purpose of this report is to present the methods and results associated with the 2016 infaunal invertebrate monitoring of the Port Orford Nearshore Disposal Site and the adjacent proposed Port Orford Nearshore Disposal Site expansion site. Benthic infaunal communities can be used as indicators of ecosystem health. Diverse infaunal communities are generally indicative of a healthy seafloor environment that provides for beneficial uses to other wildlife species at higher trophic levels. Infaunal communities dominated by few species may indicate significant disturbance due to physical, environmental, or biological stress. In the current context, analysis of the benthic community can provide insight into whether or not the Port Orford Nearshore Disposal Site is ecologically perturbed by its recent disposal history and how the proposed expansion area compares to the Nearshore Disposal Site and surrounding area.

METHODS AND MATERIALS

MTS staff Seth Jones and Dr. Robert Mooney worked with Michelle Rau of ANAMAR Environmental Consulting to perform trawls for demersal fish and epibenthic invertebrates while adhering to methods outlined by the USACE in the project's quality assurance project plan. The team worked aboard the MTS Research Vessel and was assisted by USACE representatives Wendy Briner and James McMillan. Benthic grab samples were collected at the Port Orford Nearshore Disposal Site on August 20, 2016.

The benthic infaunal study used a 0.05-square-meter (0.54 square foot) stainless steel Wildco Ponar grab sampler to collect biological grabs. The grab sampler was also used to collect separate sediment samples for physical and chemical analysis while on station. Those additional samples were processed by the USACE representatives.

Benthic infaunal cores were collected at 10 stations in accordance with the sampling plan (Figure 1). Three of the sampled stations were within the existing Nearshore Disposal Site, three were within the proposed expansion area (hereafter referred to as the Expansion Area), and four stations were sampled outside of the Nearshore Disposal Site and the Expansion Area (hereafter referred to as the Reference Area). Sample grab logs were maintained by ANAMAR staff during the sampling. The logs contain position and sediment characteristics and are included as Appendix A. The sampled depths ranged from 9.1 to 15.8-meters MLLW (-30 to -52-feet MLLW). All infaunal grab samples were collected within 9 meters (29.5 feet) of the intended sampling station. The actual sample location coordinates are provided in Table 1.





Figure 1. The above figure shows the position of the Port Orford Nearshore Disposal Site relative to Port Orford, Oregon and shows the proposed location of benthic grab samples relative to the Nearshore Disposal Site and the proposed Expansion Area.



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Table 1.	The below	table provides	s the infauna	grab sa	ample lo	cations,	distance	from i	intended	station,	and
depth at t	the Port Orf	ord Nearshore	Disposal Site	infaunal	grab san	npling st	ations. Sa	mplin	g date wa	s August	20,
2016. Coo	ordinates are	e geographic, V	/GS84, decima	al degree	es.						

Grab	Station Coordination	Distance from	Depth	
Station ID	Latitude (°N)	Longitude (°W)	Target (m)	(ft MLLW)
PO15-1	42.7362033	124.4981183	7	39
PO15-2	42.7365417	124.4937683	5	32
PO15-3	42.7336917	124.4978733	1	52
PO15-4	42.7340683	124.4933683	8	45
PO15-5	42.7369433	124.4961983	6	30
PO15-6	42.7361817	124.4960933	5	39
PO15-7	42.7354017	124.4959467	4	38
PO15-8	42.7345950	124.4957467	9	45
PO15-9	42.7338300	124.4956933	4	49
PO15-10	42.7332517	124.4956117	3	52

Benthic infauna samples were sieved through a 0.5-millimeter (0.020-inch) screen and the retained material was placed in a container and fixed with a 10% solution of buffered formalin and seawater for a minimum of 72 hours. In the MTS laboratory, the samples were then rewashed through a 0.25-millimeter (0.010-inch) screen to remove the formalin solution and transferred to appropriately sized containers. The containers were filled with a mixture of 70% isopropyl alcohol and Rose Bengal stain. Rose Bengal is a protein stain added to facilitate sorting the animals from any retained detritus.

The transferred and stained samples were sorted under a dissecting microscope. All animals were removed and placed in major phyla groups (Polychaeta, Mollusca, Crustacea, Echinodermata and miscellaneous). Twenty percent of the remaining detritus in each sample was then resorted as part of a quality control step. This quality control step follows the protocols set forth for benthic studies in EPA Region 10 (Tetra Tech 1987).

Following the sorting of animals to major phyla groups, specialist taxonomists then identified all organisms to the lowest practical taxa within each sorted group. The number of each identified taxa was recorded and entered into a Microsoft[®] Excel[®] spreadsheet.

Following identification and data entry, benthic indices and statistics were calculated for each sampled station. Where appropriate, the individual station data were retained and used to calculate means for the indices and statistics for the Nearshore Disposal Site, Expansion Area, and Reference Area.

The calculated statistics and indices included infaunal abundance, infaunal density, Shannon-Wiener species diversity index (H' [refer to Krebs 1989]), Pielou's evenness index (J' [refer to Pielou 1966]), and Bray Curtis dissimilarity (Bray and Curtis 1957).



Specifically, the provided measures were calculated as follows:

Abundance was calculated as the sum of all captured individuals across all taxonomic classifications.

Density was expressed per square meter by multiplying the number of animals captured in each 0.05-meter core by 20.

Species richness was simply the number of unique taxonomic classifications made by the taxonomists within each provided sample. The term taxon richness is more appropriate because not all identifications were made to the level of species. It is notable that the taxonomic specialists utilize standardized procedures and identifications for identifying regional species. Thus, the data are externally consistent with other regional studies.

The Shannon Function was calculated as,

$$H' = \sum (p_i)(log_2p_i)$$

where H' is the index of species diversity and p_i equals the proportion of total sample belonging to ith species.

The Pielou species evenness index was calculated as,

$$J' = \frac{H'}{\log_2 S}$$

where J' is the species evenness index based on H', H' is the Shannon diversity and S is the number of species sampled.

Bray Curtis Measure was calculated as,

$$B = \frac{\sum |X_{ij} \quad X_{jk}|}{\sum (X_{ij} + X_{jk})}$$

Where X_{ij} , X_{jk} is the number of individuals in species *i* in each sample. The measure ignores cases in which a species is absent from both samples.

The analysis of similarity (ANOSIM) was used to test for statistical significance among the sampled areas (refer to Clarke 1993). The ANOSIM requires the a priori assignment of samples to groups. For the test, the invertebrate station data were assigned to three groups based on whether the stations were within the Port Orford Nearshore Disposal Site (Nearshore Disposal Site group), within the potential Expansion Area (Expansion Area group), or within the



Reference Area (Reference Area group). The ANOSIM relies on the Bray-Curtis dissimilarity measure. The null hypothesis is that there are no differences between the groups.

The ANOSIM test statistic "R" is calculated by comparing the means of the ranked dissimilarities between groups and within groups (Henderson and Seaby 2014). R ranges from +1 to -1. A value of +1 means that all the most similar samples are within the same groups. A value of -1 means that all of the most similar samples are outside of the groups. A value of zero means that the high and low similarities are perfectly mixed with no relationship to the group assignment (null hypothesis).

The ANOSIM test for significance compares the ranked similarity within and between groups to the similarity that would happen by random chance. In the analysis, the samples are randomly assigned to groups repeatedly to calculate a value of R based on the random distribution of samples across groups. The observed value of R can then be compared to the random distribution to determine if it is significantly different from random (Henderson and Seaby 2014). A significant value means that the null hypothesis should be rejected and that samples within groups are more similar than samples between groups. An *a priori* alpha of 0.05 was chosen for all statistical tests.

A similarity percentages (SIMPER) analysis was performed. SIMPER analysis allows for observance of the contribution of each element (species) to the observed dissimilarity between samples (Henderson and Seaby 2014). The analysis relies on definition of group members similar to the ANOSIM. The group members for the SIMPER analysis were the same as those specified for the ANOSIM.

The SIMPER analysis uses the Bray-Curtis measure. It compares each sample in the first group with each sample in the second group. Since the Bray-Curtis measure can be calculated at the species level, the mean similarity between groups can be obtained for each species (Henderson and Seaby 2014). The ANOSIM and SIMPER analyses were performed using Community Analysis Package 5.0 (Henderson and Seaby 2014).

RESULTS

There were a total of 91 benthic invertebrate taxonomic identifications and 35,485 individuals captured by the August 2016 Port Orford Nearshore Disposal Site infauna sampling program. The number of unique identifications within a station ranged from a low of 17 at PO15-6 (within the Nearshore Disposal Site Area group) to a high of 47 at PO15-1 (within the Reference Area group). The abundance of individuals within samples ranged from a low of 73 animals at PO15-6 (within the Nearshore Disposal Site Area Group) to a high of 11,812 at PO15-3 (within the Reference Area group). The raw invertebrate abundance data are attached as an appendix to this report (Appendix B). A tabular summary of abundance, density, richness, diversity (H'), and evenness (J') at the stations sampled is provided as Table 2. Also included are summary statistics (means) among sample locations as well as overall calculations for the site as a whole. For some calculations, the difference



Existing Nearshore Disposal Site - Summer 2016									
Station	PO15-5	PO15-6	PO15-7	Existing Nearshore Disposal Site					
Abundance	197	73	178	448					
Mean Abundance				149					
Density (per square meter)	3940	1460	3560	2987					
Species (Taxa) Richness	24	17	23	40					
Mean Richness				21					
Diversity H'	2.67	2.87	2.62	2.91					
Mean H'				2.72					
Evenness (J')	0.58	0.70	0.58	0.55					
Mean J'				0.62					

Table 2. August 2016 statistics and indices calculated from benthic infaunal core data at the Port OrfordNearshore Disposal Site, the proposed Expansion Area, and surrounding Reference Area.

Expansion Area - Summer 2016										
Station	PO15-8	PO15-9	PO15-10	Expansion Area						
Abundance	1644	9367	3622	14633						
Mean Abundance				4878						
Density (per square meter)	32880	187340	72440	97553						
Species (Taxa) Richness	30	38	30	55						
Mean Richness				33						
Diversity H'	0.77	0.19	0.39	0.33						
Mean H'				0.45						
Evenness (J')	0.16	0.04	0.08	0.06						
Mean J'				0.09						
		-	-	-						

Reference - Summer 2016										
Station	PO15-1	PO15-2	PO15-3	PO15-4	Reference					
Abundance	5899	207	11812	2486	20404					
Mean Abundance					5101					
Density (per square meter)	117980	4140	236240	49720	102020					
Species (Taxa) Richness	47	24	38	36	76					
Mean Richness					36					
Diversity H'	0.70	2.96	0.24	0.53	0.51					
Mean H'					1.11					
Evenness (J')	0.13	0.65	0.05	0.10	0.08					
Mean J'					0.23					



between the mean and the calculation of an index for the entirety of the site is meaningful. For instance, species diversity (H') is provided as a mean of the sampled stations within the Port Orford Nearshore Disposal Site to understand the average diversity among stations. However, the calculation of H' for the Port Orford Nearshore Disposal Site as a whole uses the total richness and evenness of organisms for pooled station data across the entire site.

Figures are provided for each of the calculated parameters except density; density is not provided graphically since it is merely scaled abundance and the scale is the same across all stations. Each of the figures compare the parameters across stations and include a mean for the presented index or statistic for the stations within each of the three studied areas. Within the figures, means are presented with their associated standard error as error bars in the figures. Figure 1 shows the total abundance of animals in each sample. Figure 2 shows the total species (taxa) richness for each of the stations. The species diversity (H') and evenness (J') for each station is provided graphically as Figure 4 and Figure 5, respectively.





Figure 2. The above figure illustrates the total benthic invertebrate abundance for each sampling station during the August 2016 Port Orford Nearshore Disposal Site infaunal sampling. The bars labeled "group means" represent the mean abundance for all sampling stations within the Port Orford Nearshore Disposal Site, the Expansion Area, and the Reference Area; the associated error bars are the standard errors of the means.



Figure 3. The above figure illustrates the benthic invertebrate taxa richness for each sampling station during the August 2016 Port Orford Nearshore Disposal Site infaunal sampling. The bars labeled "group means" represent the mean richness for all sampling stations within the Port Orford Nearshore Disposal Site, the Expansion Area, and the Reference Area; the associated error bars are the standard errors of the means.





Figure 4. The above figure illustrates the benthic invertebrate Shannon diversity (*H*') index for each sampling station during the August 2016 Port Orford Nearshore Disposal Site infaunal sampling. The bars labeled "group means" represent the mean diversity for all sampling stations within the Port Orford Nearshore Disposal Site, the Expansion Area, and the Reference Area; the associated error bars are the standard errors of the means.



Figure 5. The above figure illustrates the benthic invertebrate Pielou's evenness (J') index for each sampling station during the August 2016 Port Orford Nearshore Disposal Site infaunal sampling. The bars labeled "group means" represent the mean evenness for all sampling stations within the Port Orford Nearshore Disposal Site, the Expansion Area, and the Reference Area; the associated error bars are the standard errors of the means.



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Results from the calculation of the Bray-Curtis Measure are shown in Table 3. This analysis was used to quantify the compositional dissimilarity between stations/samples based on taxa counts. Each value in the Bray-Curtis ordination matrix represents a dissimilarity of a pairwise comparison of two stations. Samples with values close to 1.0 indicate a greater difference with regards to community composition.

The one notable trend with regards to the dissimilarity values is that station comparisons between the Nearshore Disposal Site Area stations relative to the Reference Area stations and Expansion Area stations show high dissimilarity. The one notable exception to this trend was with the Reference Area station PO15-02. Station PO15-02 was generally more similar to the Nearshore Disposal Site Area stations; station PO15-02 was dissimilar to other Reference Area stations as well as the Expansion Area stations.

The results of the ANOSIM show that there is a significant statistical difference between the three groups (Nearshore Disposal Site Area group, Expansion Area group, Reference Area group) when analyzed as a whole (r=0.348, p=0.001; Table 4). However, pairwise comparisons of groups did not find differences between all group comparisons. The Nearshore Disposal Site Area group was not found to differ statistically from the Reference Area group although the probability of the two groups being similar was low (r=0.481, p=0.057; Table 4). The Nearshore Disposal Site Area group was statistically distinct from the Expansion Area group (r=1.000, p=0.050; Table 4). There were no significant differences detected between the Reference Area and the Expansion Area groups (r=-0.259, p=0.943; Table 4).

The SIMPER analysis within groups showed that within group similarity was the lowest for the Reference Area group. Within group similarity was 27.8%. Group percent similarity within the Expansion Area and Nearshore Disposal Site Area groups was 47.1% and 54.1%, respectively (Table 5). The lower percent similarity among samples within the Reference Area group was driven by the dissimilarity between PO15-2 and the other stations within the Reference Area group.

Within group similarity for the Reference Area group and the Expansion Area group was dominated by *Owenia fusiformis* (Table 5). *O. fusiformis* is a wide-ranging, tube-dwelling Polychaete worm. *O. fusiformis* explained 91.6% and 97.0% of the within group similarity for the Reference Area and Expansion Area groups, respectively. More species were required to explain 90% of the within group similarity within the Nearshore Disposal Site Area group. Six species contributed to 91.6% of the within group similarity for the Nearshore Disposal Site Area. This observation combined with the greater overall similarity among stations within the Nearshore Disposal Site illustrates that the Nearshore Disposal Site is diverse and relatively consistent in community composition among its sampling stations compared to the Reference Area and Expansion Area groups.



		Station										
			Refe	rence		Nearsh	ore Dispo	osal Site		Expansion		
		PO15-1	PO15-2	PO15-3	PO15-4	PO15-5	PO15-6	PO15-7	PO15-8	PO15-9	PO15-10	
	PO15-1											
	PO15-2	0.947										
	PO15-3	0.367	0.985									
_	PO15-4	0.416	0.958	0.659								
Ę	PO15-5	0.953	0.302	0.986	0.963							
Sta	PO15-6	0.981	0.557	0.992	0.975	0.585						
	PO15-7	0.958	0.257	0.987	0.959	0.237	0.554					
	PO15-8	0.569	0.882	0.767	0.247	0.914	0.950	0.900				
	PO15-9	0.270	0.988	0.123	0.592	0.989	0.994	0.989	0.720			
	PO15-10	0.249	0.957	0.536	0.209	0.964	0.974	0.963	0.415	0.453		
	NDS - Reference				Reference	ce - Expa	nsion		NDS - Ex	pansion		

Table 3. The below table provides the Bray-Curtis ordination matrix of all pairwise comparisons betweensampled stations. Colored cells represent pairwise comparisons between stations that occur across regions.

Table 4. The below table summarizes the results of the ANOSIM among all groups "whole model" and for each pairwise comparison between groups "pairwise tests". The stations within each group are provided at the bottom "group names".

	Analysis of Similarity - Port Orford Nearshore Disposal Site							
Whole Model (all data)								
Sample Statistic (r)	0.348							
P Value	0.001							
No. Randomizations	1000							
Observations W>=B	1							
Pairwise Tests								
1st Group	2nd Group	Permutations	Permutations	Observation	P Value	Sample Stat. (r)		
			Done	W>=B				
Reference Area (4)	NDS Area (3)	35	35	2	0.057	0.481482		
Reference Area (4)	Expansion Area (3)	35	35	33	0.943	-0.259259		
NDS Area (3)	Expansion Area (3)	10	10	1	0.050	1		
Group Names	Stations							
Reference Area	PO15-1	PO15-2	PO15-3	PO15-4				
NDS Area	PO15-5	PO15-6	PO15-7					
Expansion Area	PO15-8	PO15-9	PO15-10					
				4				



Table 5. The below table provides the results of the similarity percentage (SIMPER) analysis. Average similarity within groups refers to the average similarity between members (stations) of a group based on Bray-Curtis dissimilarity. Within groups the contribution of the most relevant taxa are shown that are required to describe at least 90% of the within group similarity.

SIMPER Analysis - Taxa Percent Similarities Within Groups								
Reference Area	Average Sim	27.8						
Species	Ave. Abund	Ave. Simil	% Contribution	Cumulative %				
Owenia fusiformis	4845.0	25.5	91.6	91.6				
NDS Area	Average Sim	54.1						
Species	Ave. Abund	Ave. Simil	% Contribution	Cumulative %				
Spiophanes bombyx	75.7	32.3	59.7	59.7				
Magelona sacculata	25.0	11.1	20.5	80.1				
Scoloplos armiger	6.7	2.9	5.3	85.4				
Chaetozone setosa	3.7	1.2	2.3	87.7				
Tellina modesta	2.3	1.0	1.9	89.6				
Carinoma mutabilis	3.3	1.0	1.9	91.6				
Expansion Area	Average Sim	47.1						
Species	Ave. Abund	Ave. Simil	% Contribution	Cumulative %				
Owenia fusiformis	4728.0	45.7	97.0	97.0				

The between group SIMPER analysis looks at the dissimilarity contributions of taxa between groups. Overall, the analysis showed the Nearshore Disposal Site Area group was most dissimilar to the Expansion Area group with an average dissimilarity 96.0% (Table 6). The Nearshore Disposal Site Area group was 82.3% dissimilar to the Reference Area group. The Reference Area and Expansion Area groups has the lowest average dissimilarity of 53.3%. These results are consistent with the ANOSIM results. The SIMPER analysis found that *O. fusiformis* contributed the most to dissimilarity between groups. *O. fusiformis* explained more than 90% of the dissimilarity between the Reference Area and Expansion Area groups. Three taxa were required to explain more than 90% of the dissimilarity between the Nearshore Disposal Site Area and Expansion Area groups. Three taxa were required to explain more than 90% of the dissimilarity between the Nearshore Disposal Site Area and Reference Area groups; however, *O. fusiformis* still accounted for 85.3% of the dissimilarity between these groups.



Table 6. The below table provides the results of the similarity percentage (SIMPER) analysis. Average dissimilarity between groups refers to the average dissimilarity between group members (stations) based on the Bray-Curtis dissimilarity. The between group contribution of the taxa that provide at least 90% to the total dissimilarity is provided for each pairwise group comparison.

SIMPER Analysis - Taxa Percent Dissimilarities Between Groups									
Reference Area With NDS Area	a Average Dissim 82.3								
	Reference Area	NDS Area							
Species	Ave Abund	Ave Abund	Ave Dissim	% Contribution	Cumulative %				
Owenia fusiformis	4845.0	2.0	70.2	85.3	85.3				
Spiophanes bombyx	51.0	75.7	2.9	3.6	88.8				
Nemertinea	7.8	0.0	1.1	1.4	90.2				

Reference Area With Expansion Area Average Dissim 53.3

Reference Area Expansion Area										
Species	Ave Abund	Ave Abund	Ave Dissim	% Contribution	Cumulative %					
Owenia fusiformis	4845.0	4728.0	50.0	93.8	93.8					
NDS Area With Expansion Area	Average Dissin	n 96.0								
Species	NDS Area Ave Abund	Expansion Area Ave Abund	Ave Dissim	% Contribution	Cumulative %					
Owenia fusiformis	2.0	4728.0	90.6	94.5	94.5					

DISCUSSION

The results of the infaunal sampling generally show that the area outside the Port Orford Nearshore Disposal Site is different to that inside the Nearshore Disposal Site with regards to the invertebrate communities present. The abundance of captured animals were higher at the Reference Area and the Expansion Area relative to the Nearshore Disposal Site. The difference in abundance was largely attributed to a single organism. At the Reference Area *O. fusiformis* ranged from 18 to 11,550 animals per sample (refer to Appendix B). At the Expansion Area *O. fusiformis* ranged from 1,484 to 9,215 animals per sample. In contrast, the most *O. fusiformis* captured in an Nearshore Disposal Site sample was 5. Thus, this single species is responsible for the much higher abundance observed outside the Nearshore Disposal Site and was the primary species responsible for the significant results observed for the ANOSIM and SIMPER analyses.

The dominance of *O. fusiformis* in stations sampled outside of the Nearshore Disposal Site Area was also responsible for the relatively low diversity calculated outside of the Nearshore Disposal Site. The calculation of diversity (H') is dependent upon the number of species encountered and the evenness (J') with which those species are found within the community. The high abundance of *O. fusiformis* within most of the stations outside the Nearshore Disposal Site meant evenness was low and therefore so too was diversity.



O. fusiformis has been reported and studied at multiple locations around the globe (Dauvin et al. 2003, Trott 2004, Fauchald 2007). However, recent taxonomic study has erected multiple species within this genus where previously *O. fusiformis* was the only known species (Koh et al. 2003). Thus, it is possible that the *O. fusiformis* identified within this study could be separated into additional taxa if the eastern Pacific population were subject to further study. While such distinction could change the calculation of metrics, it would not change the ecological implications. Moreover, taxonomic differentiation would not necessarily mean that there was more than one species of *Owenia* within the studied samples.

Ultimately, determination of the extent to which a portion of seafloor is affected by dredge material disposal is dependent upon interpretation of the extent to which potential changes "matter". In other words, to what extent are changes in the local ecology and various processes noticed? This is a difficult question to answer, but there are some general points that can help guide resource managers. First, does the activity cause a reduction of ecosystem processes such as nutrient cycling and trophic interactions? Second, does the activity impact sensitive or endangered species? Finally, does the activity result in localized loss of unique or diverse ecological features that in turn alter beneficial uses of the resource by wildlife or humans? Arguably, impacts that affect the first question relative to ecosystem processes can automatically have implications for the second and third questions. However, small-scale impacts don't necessarily have large-scale implications and in some cases may increase ecosystem functions (*sensu* Connell 1978).

Within the Port Orford Nearshore Disposal Site it is likely that the disposal of dredge material made measureable changes to the infaunal community but at a scale too small (and likely to be too short) to have meaningful implications for ecosystem processes. The Nearshore Disposal Site received 24,567 cubic meters (32,132 cubic yards) of Port Orford dredge material in July 2016; this was one month prior to the benthic sampling. Although benthic communities can recover quickly following disturbance (Mooney 2010), the speed at which they recover and the successional stages they go through is dependent upon disturbance timing. The number and diversity of organisms found within the Nearshore Disposal Site samples illustrates how quickly benthic infauna colonize open space when it is made available. The absence of some species, and most notably the absence of the otherwise abundant O. fusiformis, is likely due to disturbance timing and the elapsed time since disturbance. The abundance of O. fusiformis outside the Nearshore Disposal Site indicates that recruitment was significant in 2016. Samples processed by Marine Taxonomic Services along the Pacific Coast for other investigations in 2016 have also had large numbers of O. fusiformis (S. Jones personal communication). However, for O. fusiformis and other species to colonize the open space within the Nearshore Disposal Site there would have to be planktonic stages available to colonize the Nearshore Disposal Site. This is regulated by spawning such that for some species significant colonization may not be possible until the next spawning season.

Ultimately, the expansion of the Nearshore Disposal Site may alleviate significant but localized impacts of dredge material disposal. The Port Orford Nearshore Disposal Site is a relatively small Nearshore Disposal Site. This means that disposal activities will have localized impacts



that can be readily measured. Expanding the site will spread the impacts out somewhat. This may create a mosaic of habitat types that vary in terms of grain size and organic content. The periodic disturbance of different portions of the Nearshore Disposal Site may also lead to greater diversity due to greater heterogeneity of successional stages within the Nearshore Disposal Site (Connell 1978).

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APPENDIX A

Infaunal Grab Sampling Logs



APPENDIX B Infaunal Data



Port Orford Nearshore Expansion

Port Orford Nearshore Disposal Site SPECIES DATA For ANAMAR By Marine Taxonomic Services August 20, 2016

		Station										
		Reference				hore Dispos	al Site	Expansion				
	PO-01	PO-02	PO-03	PO-04	PO-05	PO-06	PO-07	PO-08	PO-09	PO-10		
ANNELIDA COUNTS	5657	167	11749	2415	156	51	152	1602	9260	3562		
Aricidea sp	1											
Ampharete sp	4		1	2								
Autolytus sp			1									
Chaetozone setosa	1	4	3	1	6	1	4	3	4	8		
Eteone sp	1	3										
Glycera macrobranchia			1		1							
Glycera nana		1						1				
Glycinde armigera	2		1					1	1			
Hypereteone fauchaldi	1				1							
Levinsenia gracilis		1										
Lumbrineridae			3									
Magelona longicornis								1				
Magelona sacculata	32	29	40	3	39	14	22	5	4	21		
Mediomastus sp	6		67		1					9		
Nephtys caecoides		1	1					1	1	2		
Nephtys longosetosa					1		1		1	1		
Nereis sp	5			2								
Onuphis sp			2		1				1	2		
Ophelia limicina	1	1		2								
Owenia fusiformis	5460	18	11550	2352	1		5	1484	9215	3485		
Paraprionospio pinnata	2		1						1			
Phyllodoce hartmanae	54	5	46	29	2	1	9	41	16	15		
Phylo felix			1									
Priopospio lighti	4						1			1		



Scoloplos armiger	4	9	9	1	3	6	11	3	2	
Sigalion sp	2	1	1	2						
Spiochaetopterus pottsi	1									
Spiophanes berkeleyorum			5				1			
Spiophanes bombyx	74	93	16	21	100	29	98	61	13	18
Syllidae	2									
Terebellidae									1	
Typosyllis sp		1						1		
MOLLUSCA COUNTS	133	11	32	25	16	12	7	7	65	31
Astyris gausapata	4							2		
Axinopsida serricata			1							
Bivalvia sp juv	10		10	3						3
Caesia fossata			1				1		2	
Callianax biplicata						1				
Callianax pycna		7	3	1	4	9			1	17
Clinocardium sp juv									3	
Cylichna alba		1								
Gastropoda spp									1	
Lacuna sp juv	1			2						
Macoma sp juv	2							1	1	1
Mactridae sp juv	6		3	4				2	21	
Mytilidae sp juv	23		2	5			1			
Rochefortia tumida	1									
Siliqua alta	60		3	4	9	1	2		30	3
Tellina modesta	26	3	9	6	3	1	3	2	6	7
ARTHROPODA COUNTS	84	13	17	40	17	8	11	25	36	22
Americhelidium shoemakeri						2		1	1	1
Ampelisca sp			1							
Anchicolurus occidentalis				2					1	
Aoroides sp	22			1	1				1	
Atylus tridens				1				3	1	
Cancer magister juv				8				1	1	



cf Foxinhalus obtusidens	4	3				1	2	3		
Cumella vulgaris	1					_	_			
Cylindroleberidinae sp							1			1
Decapoda sp juv	1	1			1					1
Diastylopsis dawson	14	1	3	1	5				11	1
Hausteriidae sp										1
Hyperia medusarum	1			2						
Ischyrocerus sp				3					1	
Isopoda sp juv	1									
Lissocrangon stylirostris	1	1				2		1	1	
Mandibulophoxus gilesi	1					1				
Neomysis sp juv				2	6		1			
Ostracoda								1		
Pacifoculodes spinipes	2		1	2	2	1	4		1	
Pagurus sp				2				2	1	3
Photis macinerneyi	4	1	1	1				3	2	1
Photis sp	13		5	5	1		1	5	8	5
Phoxocepahlidae sp juv	14		1	1				2		
Pinnixa faba			5	1	1					
Protohyale frequens				6						
Psammonyx longimerus							1			
Rhepoxynius abronius							1		3	3
Rhepoxynius vigitegus	2	6				1			2	3
Synidotea sp				2						
Upogebia sp juv	3							3	1	2
MISCELLANEOUS	25	16	14	6	8	2	8	10	6	7
Amphiuridae juv	1		1	1	1				1	1
Carinoma mutabilis			2	4	3	1	6		4	3
Clypeasteroida								3		
Echinoidea				1						
Lineidae						1				
Micrura sp			1							
Nematoda	4				4			1		1



Nemertinea	16	15				3		
Phoronida	4	1				3		
Phoronis sp			9		1		1	2
Tetrastemma sp					1			
Tubulanus sp			1					

