PROPOSED ESTIMATE OF NATURAL RESOURCE DAMAGES IN PORT ANGELES HARBOR PORT ANGELES, WASHINGTON

Prepared By: The Port Angeles Harbor Natural Resource Trustee Council

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PORT ANGELES, WASHINGTON

1. Introduction

This document, produced by the Port Angeles Harbor Natural Resource Trustee Council (Trustees)[1], presents the results of a streamlined natural resource damage assessment (NRDA) for Port Angeles Harbor (Harbor) in Port Angeles, Washington. These results, presented in units of discounted service acre years (DSAYs), are intended to serve as an estimate of natural resource damages for the Harbor. The Trustees' DSAY estimate was calculated using habitat equivalency analysis (HEA) to provide a basis for a potential settlement with the parties of the Western Port Angeles Harbor Group[2] (WPAHG) for injuries to ecological resources resulting from releases of hazardous substances. The assessment area of the Harbor, for the purposes of this estimate, is depicted in **Figure 1** and hereafter referred to as the assessment area.

Settlements between Trustees and Potentially Responsible Parties/Potentially Liable Parties (PRPs/PLPs) can be based upon an agreement on suitable restoration actions that develop a number of DSAYs equivalent to those calculated for natural resource injuries. The actual cost of a DSAY can vary depending on expenses associated with conducting habitat restoration actions and the number of DSAYs provided as a result of those actions. In principle, however, it may be possible to generate DSAYs at a relatively low cost per unit where the costs are irrelevant to the resolution of the NRDA claim. A typical cooperative NRDA process affords PRPs/PLPs with the opportunity to propose restoration actions and therefore influence, substantially in many cases, the actual costs associated with restoration implementation.

2. Habitat Equivalency Analysis Inputs and Assumptions

The Trustees used HEA to calculate DSAYs in the assessment area associated with measured concentrations of hazardous substances (i.e., contaminants) in Harbor surface sediments. In its simplest form, HEA quantifies ecological components lost due to contamination (in terms of ecological services provided by an area of habitat) to estimate how much restoration will be required to generate an equivalent amount of similar services. Because environmental losses and gains are not experienced at a single point in time, the estimation procedures also take into account the number of years during which losses were experienced and the rate at which losses or gains decrease or increase over time due to active clean-up or through natural recovery. Losses and gains are expressed in an area-time currency – DSAYs – that quantifies the amount of a given service lost or gained over a specified period of time and in present value terms via discounting.

[1] Washington State Department of Ecology, Lower Elwha Klallam Tribe, Jamestown S'Klallam Tribe, Port Gamble S'Klallam Tribe, National Oceanic and Atmospheric Administration, and the U.S. Fish and Wildlife Service.
[2] City of Port Angeles, Port of Port Angeles, Nippon Paper Industries USA Co., Merrill & Ring, and Georgia-Pacific LLC.

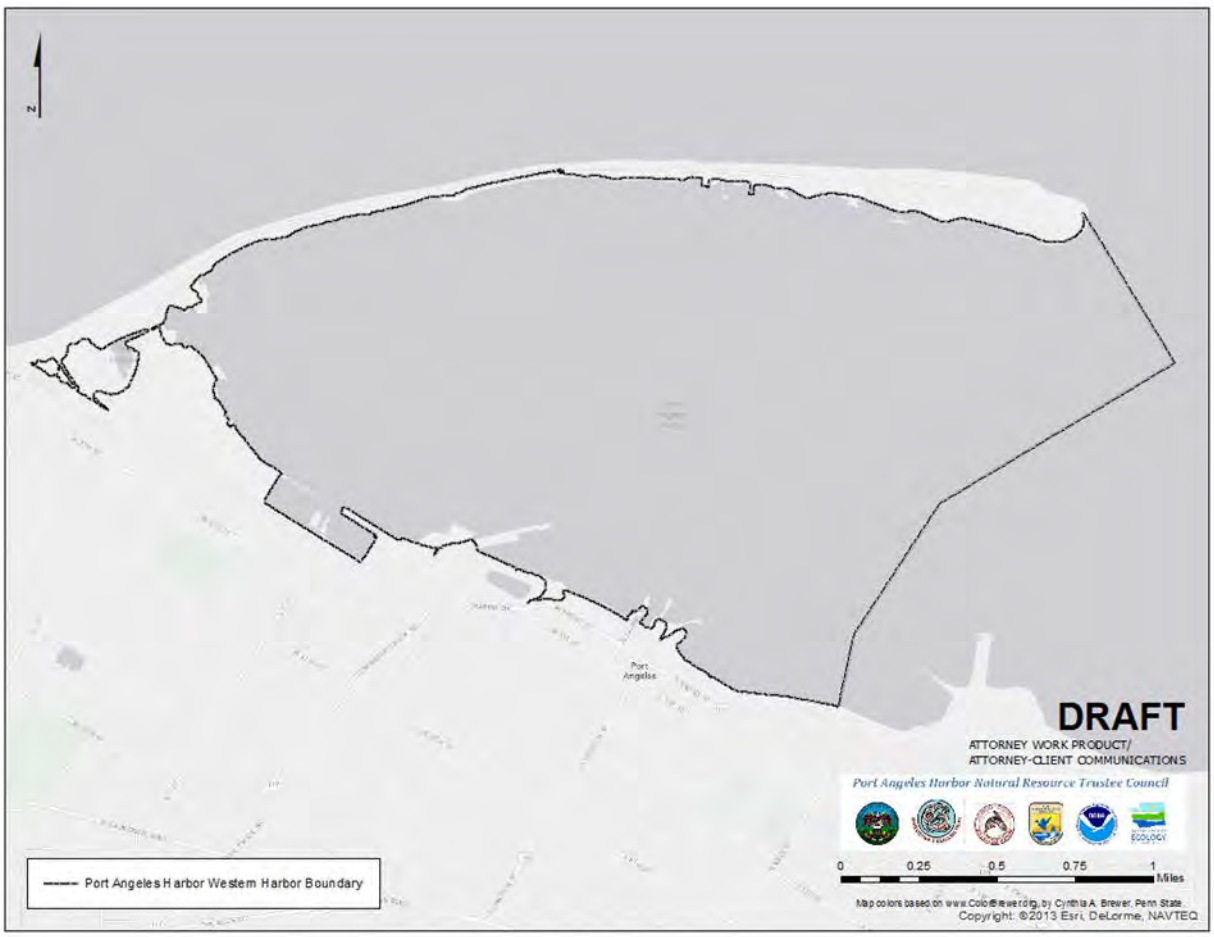


Figure 1. ***Port Angeles Harbor Assessment Area***

Outputs from HEA are determined by a number of input parameters. For a geospatial HEA such as the one described in this report, a substantial amount of geo-processing of data is necessary in order to prepare underlying inputs to the model (e.g., interpolated contaminant surfaces, habitats, etc.). The primary parameters of the HEA model are applied to these underlying inputs in order to generate ecological service losses in DSAYs. Examples of primary parameters include the year in which calculations of injuries begins (i.e., the "start" year), the years until the system recovers, the "discount rate," acres of injured area, ecological service loss thresholds, etc. This report provides a summary of the underlying inputs and HEA parameters the Trustees applied to calculate injuries in the assessment area.

2.1 Service Losses

The Trustees' analysis was limited to the following hazardous substances: mercury, zinc, cadmium, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), dioxin toxic equivalents (TEQ), 4-methylphenol, and phenol. The calculation of DSAYs for this assessment is based primarily on geospatial HEA methods. Such methods rely generally upon the use of Geographic Information System (GIS) software, specifically Environmental Systems Research Institute (ESRI) ArcGIS software suite, and

customized HEA software to calculate ecological service losses, and thus DSAYs, associated with measured surface sediment chemistry for multiple contaminants.

Ecological service losses are calculated by comparing surface sediment chemistry concentrations to losses of service associated with measured effects to natural resources resulting from exposures to contaminants. In general, the lowest sediment concentrations of contaminants result in little or no loss of ecological services, but as concentrations increase so, too, do the ecological service losses (expressed as a percentage of services lost).

For this assessment, the Trustees used service loss models developed for Commencement Bay (Wolotira 2002) and the Lower Duwamish River (NOAA 2013) Superfund sites in Puget Sound. Contaminants assessed in this manner include mercury, zinc, cadmium, PCBs, PAHs, 4-methylphenol, and phenol (**Tables 2.1a, 2.1b, 2.1c**). For purposes of this expedited assessment, additional contaminants of concern were not included. For PCBs and PAHs, the Trustees also calculated injuries with service loss models used in a recent NRDA settlement for the St. Lawrence River in Massena, New York (Natural Resource Trustees of the St. Lawrence River Environment 2013). Thus, for PCBs and PAHs a range of service losses are presented, with the lower and upper bounds provided by the application of the St. Lawrence River and Puget Sound models, respectively. Finally, the Trustees developed a service loss model for dioxins and used it to calculate injuries associated with this class of contaminant (**Table 2.1d**). The dioxin TEQ model is discussed in more detail in section 2.4.

Table 2.1a. ***Puget Sound (Hylebos Waterway, Lower Duwamish River*) Service Loss Thresholds***

CHEMNAME	Units	5%	10%	15%	20%	40%	60%	80%
Cadmium	ppm	2.7	5.1	9.6	14			
Mercury	ppm	0.41	1.3	1.4	2.3			
Zinc	ppm	410	530	1,600	3,800			
PAHs, total	ppb				1,000	8,000	17,000	70,000
PCBs, total*	ppb				128	1,100	3,100	15,200
4-Methylphenol	ppb	110	670	1,800	3,600			
Phenol	ppb	180	420		1,200			

Table 2.1b. ***St. Lawrence River Service Loss Thresholds***

CHEMNAME	Units	10%	25%	50%
PAHs, total	ppb	4,000	25,000	50,000

Table 2.1c. ***St. Lawrence River Service Loss Thresholds***

CHEMNAME	Units	1%	2.1%	4.1%	5.6%	13.2%
PCBs, total	ppb	190	410	825	1,100	2,900

Table 2.1d. ***Dioxin Service Loss Thresholds***

CHEMNAME	Units	5%	9.5%	29.5%	38.5%	55.5%
Dioxin TEQ	pptr	8	15	62	92	185

2.2 Contaminant Data

The contaminant data used for this assessment were extracted from the NOAA Query Manager database for Puget Sound. These data and the Query Manager software are available for easy download and installation from the following address:

http://response.restoration.noaa.gov/environmental-restoration/environmental-assessment-tools/query-manager-marplot-data-maps.html

Only surface sediment data (upper 10 centimeters, assumed to be the biologically active zone) from within the assessment area were extracted from the Puget Sound database. Treatment of samples below analytical method detection limits was set at the time of data extraction. For each contaminant sample, reported chemistry concentration values below the detection limit were set at 0 (zero). To reduce unreliability and uncertainty associated with older data, samples collected prior to 2000 were excluded from the Trustees' analysis. Thus, the data utilized in the Trustees' assessment are from the following studies:

1. Port Angeles 2007 American Gold Seafoods NPDES
2. Port Angeles 2003 Cypress Ediz Hook Smolt NPDES
3. Port Angeles 2005 Nippon Paper Industries Sed Inventory
4. Port Angeles 2003 City of Port Angeles NPDES
5. Port Angeles 2010 NPDES/WWTP Outfall Station 4
6. Port Angeles 2006 Rayonier Mill RI Phase 2
7. Port Angeles 2008 Ecology Harbor Study
8. Port Angeles 2008 Baseline DNR Lease 22-077766
9. Port Angeles 2002 Rayonier Mill RI Phase 1
10. West Port Angeles Harbor 2013 RI/FS Sed/Lab Bioacc
11. PSAMP Spatial Monitoring 2003

2.3 Summary of Steps for Preparing and Running HEA

Following is a general description of the steps undertaken to prepare and run the HEA.

1. The Trustees assembled contaminant chemistry point data and imported to GIS. The Trustees used NOAA's Query Manager database for Puget Sound to extract and compile available Harbor surface sediment chemistry data (as described in Section 2.2).
2. In GIS, the Trustees interpolated surface sediment chemistry point data to create a raster grid surface for each contaminant. For this assessment, the Trustees used Inverse Distance Weighting to create contaminant grids.
3. The Trustees assembled habitat data and imported to GIS. For this assessment, the Trustees used a digital elevation model based on high resolution topographic and bathymetric surveys. Habitat types (and thus relative values) were defined primarily by depth. (Habitat inputs are discussed in more detail in Section 2.5.)
4. The Trustees assembled information on habitat areas where anthropogenic activities (other than contaminant releases) have resulted in a degraded ecological baseline and imported to GIS. Note that habitat and baseline inputs were combined for efficiency. (Baseline inputs are discussed in more detail in Section 2.5.)
5. Geo-processed data inputs described in the preceding steps were "imported" into a Microsoft Access database with a customized HEA tool interface that enables the user to input (and adjust on-the-fly) primary HEA parameters. The HEA tool interface was used to run analyses based on the input parameter values described in **Table 2.3a**.

The Trustees ran three HEA scenarios to estimate the impact of various conceptual, generalized remedial alternatives on ecological function recovery rates. "HEA 1" assumes active remediation with substantial sediment removal and the application of capping and/or in situ treatment technologies. "HEA 2" assumes active remediation with an emphasis on the application of capping and/or in situ treatment technologies and little or no sediment removal. "HEA 3" assumes an emphasis on monitored natural recovery. (HEA scenario results are summarized in Section 3.)

Table 2.3a. ***HEA Input Parameters***

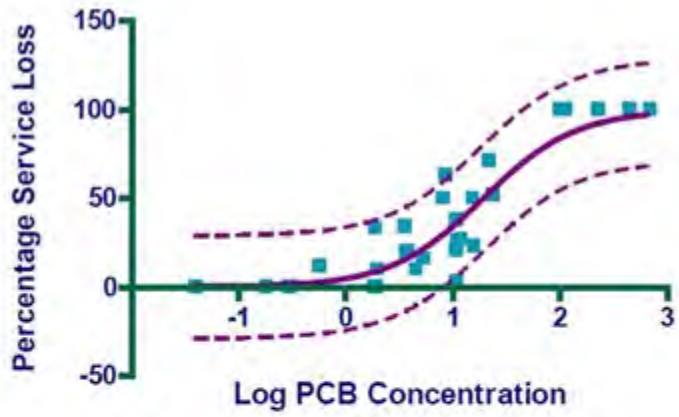
Parameter	HEA 1	HEA 2	HEA 3
HEA Start Year	1981	1981	1981
HEA Current Year	2014	2014	2014
Remediation Start Year	2015	2015	None
HEA Years of Recovery	**10**	**20**	**50**
HEA End Year	**2025**	**2035**	**2065**
Discount Factor	3%	3%	3%
Assessment Area (Acres)	2,102	2,102	2,102

2.4 Dioxins

Service losses associated with dioxins were scaled using a TEQ to TEQ-based approach that relies on the understanding that the site/mode of action is similar between dioxins, furans, and certain PCB congeners. Because dioxin-like compounds are the principal toxic component in PCBs, and since no relevant dioxin/furan NRDA models currently exist, the Trustees developed a TEQ scaling tool using the PCB injury model developed for the St. Lawrence River NRDA case in Massena, New York (Natural Resource Trustees of the St. Lawrence River Environment 2013).

In the St. Lawrence River case, site-specific toxicity tests and data from literature were used to develop a relationship between PCB concentration and ecological service loss to benthic organisms (Ingersoll et al. 2005, ACOE and EPA 2004, O'Keefe 2002, MacDonald et al. 2000, Wood et al. 1997, Metcalfe-Smith et al. 1996). Both sub-lethal and lethal effects for a given PCB concentration in sediment were included in that analysis and are expressed as a dose-response curve for log PCB concentrations in sediment (**Figure 2.4a**).

Figure 2.4a. ***PCB Concentration and Sediment Service Loss (from St. Lawrence River NRDA)***



Notes:
The dotted lines are 95% prediction limits.
Equation: Sigmoidal dose-response Y = (100)/(1+10^(1.283-X))
X is the logarithm of concentration. Y is the response (i.e., percentage service loss).
R^2 = 0.84
Constraints: Bottom Y = 0, Top Y = 100
Because the equation is not currently constrained to 0.04ppm (0% service loss) and 100 ppm PCBs (100% service loss), this analysis artificially truncates the curve at those two concentrations.

The PCB Aroclors used at the Alcoa Plant in the St. Lawrence River case were identified as a mixture of Pydrauls with Aroclors 1242, 1248, and 1260. Using literature values for Aroclor TEQs from Fluor, 2008, an intermediate TEQ value for Aroclor 1254 – 7.7 – was selected to convert from PCB concentration to an equivalent TEQ value (**Table 2.4a**). The resultant model then predicts injury from input values of sediment dioxin/furan TEQ values (**Figure 2.4b and Table 2.4b**). For the purposes of this assessment,

the World Health Organization (WHO) Toxic Equivalency Factors (TEFs) for mammals were used (Van den Berg, 2006).

Table 2.4a. ***Aroclor TEQ values from Fluor, 2008***

TEQ (1248)	TEQ (1254)	TEQ (1260)
11.7	**7.7**	1

Figure 2.4b. ***Loss of Services and Dioxin TEQ value generated from St. Lawrence PCB injury model***

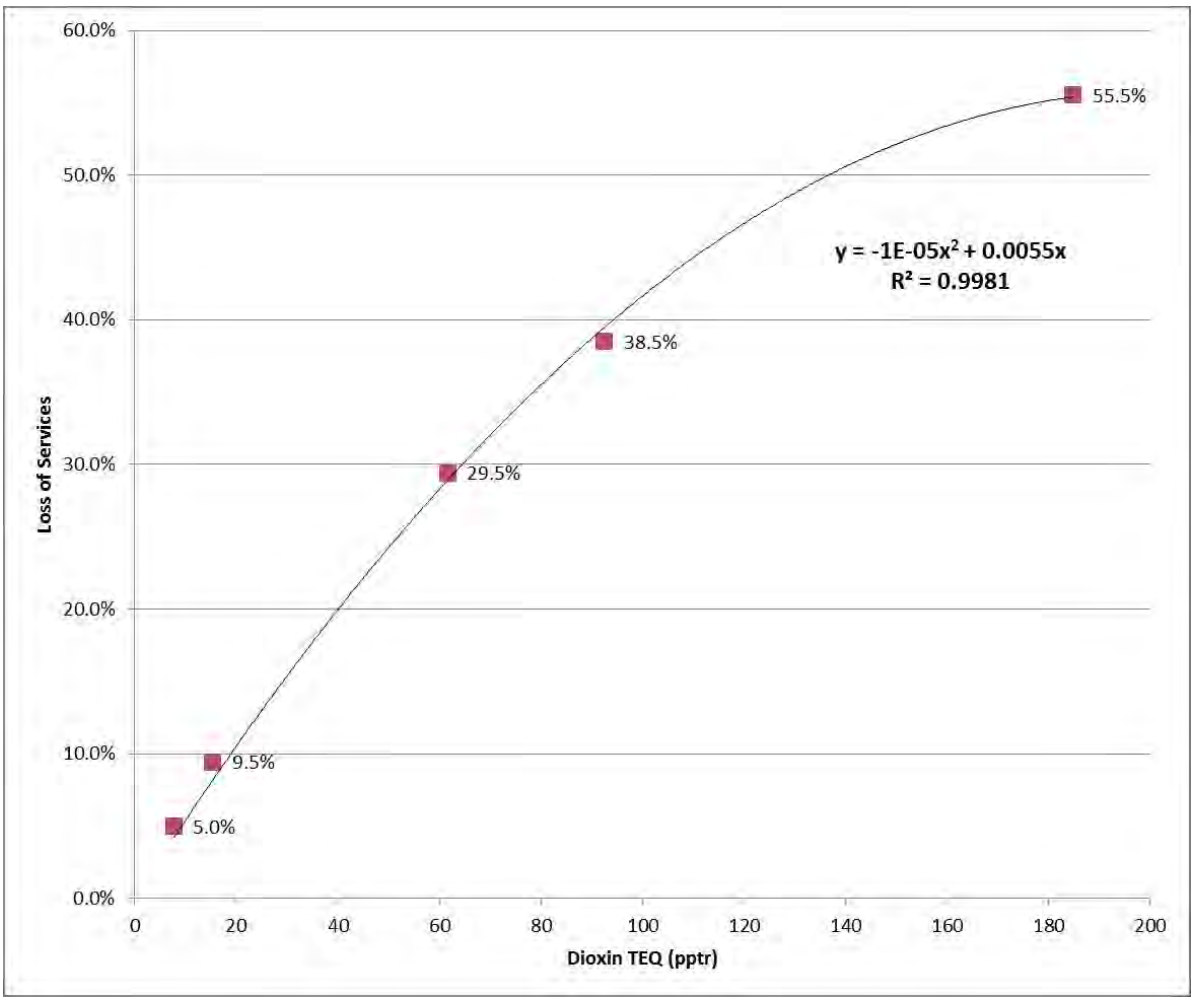


Table 2.4b. ***Loss of Services and TEQ value generated from St. Lawrence PCB injury model (*value of 7.7 selected to convert from PCB concentration to an equivalent Dioxin TEQ value)***

Conc PPM (tPCB)	Log Conc	% Service Loss	Injury Scale	TEQ (1248)	TEQ (1254)	TEQ (1260)
1	0	5%	8	11.7	**7.7 ***	1
2	0.3010	9.5%	15	23.4	15.4	2
8	0.9031	29.5%	62	93.6	61.6	8
12	1.0792	38.5%	92	140.4	92.4	12
24	1.3802	55.5%	185	280.8	184.8	24

2.5 Habitat and Degraded Baseline

To quantify service gain or loss in this HEA, a habitat value rating is used to describe the level of habitat services provided by a one-acre area. A Habitat value describes the relative services provided by a given footprint to trust resources on a scale of 0 to 1. For example, a value of 1.0 is provided by a highly productive salt marsh or high quality eelgrass bed, and value of 0.1 by a subtidal area covered in wood waste, and a value of 0 applied to areas that do not provide services to injured trust resources. Injury caused by contamination is quantified as a proportional loss of that baseline habitat service value.

Degradation caused by permitted injuries or physical modifications is not compensable under CERCLA. For the purpose of evaluating injury from contamination, habitat value is based on a "degraded baseline condition"— the condition of habitat that would exist after development impacts, but without contamination. Final habitat values used to calculate a proportional loss of service from chemical contamination are therefore lowered by anthropogenic modifications like docks or wood waste accumulation, reducing the injury caused by contamination.

2.5.1 Topobathymetry and Elevation Zones

In the Harbor, injuries were primarily sustained by marine nearshore organisms found in sediments and their food webs. Elevation strongly affects how biota access their habitats and the primary production by plants and macroalgae that provides both a structural and a bioenergetic basis for habitat services. Assessment of habitat value is strongly affected by elevation.

Clallam County developed a LiDAR-based bare-earth digital elevation model (Martinez & WSI 2012) which describes ground surface elevation for areas in Port Angeles Harbor ~1.5 feet above the North American Vertical Datum of 1988 (NAVD88). Lower elevations were likely underwater during the survey. In addition, NOAA's National Ocean Service (NOS) has published a bathymetric survey describing areas below minus 6 feet NAVD88 (NOS 2007). To create a complete topobathymetric elevation model

we identified the extent of reliable elevation data provided by these two sources, and then filled the gap between the low intertidal and the shallow subtidal by interpolating between the two surface edges.

To establish elevation zones, tidal range parameters were taken from the Port Angeles gauge 9444090 (NOS 2013), which provides a continuous water level record between 1983 and 2001. Using our topobathymetric model three elevation contours were selected to define the boundaries between four elevation zones: supratidal, intertidal, shallow subtidal and deep subtidal (**Table 2.5.1**).

The WPAHG parties have agreed with the Washington State Department of Ecology to address sediment contamination located below mean higher high water (MHHW) as part of their remedial work plan (as of May 20, 2013). MHHW was used to define the boundary between the supratidal and intertidal zones, and the landward edge of the injury assessment area. Mean lower low water (MLLW) was used to define the boundary between the intertidal and subtidal zones, consistent with a typical upper elevation for eelgrass reported by Mumford (2007) and observed in Port Angeles Harbor by Norris & Fraser (2009). A boundary at -20 feet MLLW was selected between the shallow subtidal (photic zone) and deep subtidal zones based on the Norris & Fraser (2009) which shows a final drop in eelgrass density at this depth within the harbor (**Figure 2.5.1**). Dive observations by Lower Elwha Tribal staff and other Trustee partners suggest that this may be a shallow estimate for the potential extent of submerged aquatic vegetation (SAV) such as macroalgae, the dominant subtidal vegetation, which are typically more tolerant of lower light levels than eelgrass.

Figure 2.5.1. ***Mean eelgrass shoot density at transects inside and outside Ediz Hook. A zone between 0 and -20 feet MLLW was used to describe the 'photic zone' based on the occurrence of eelgrass on inner Ediz Hook.***

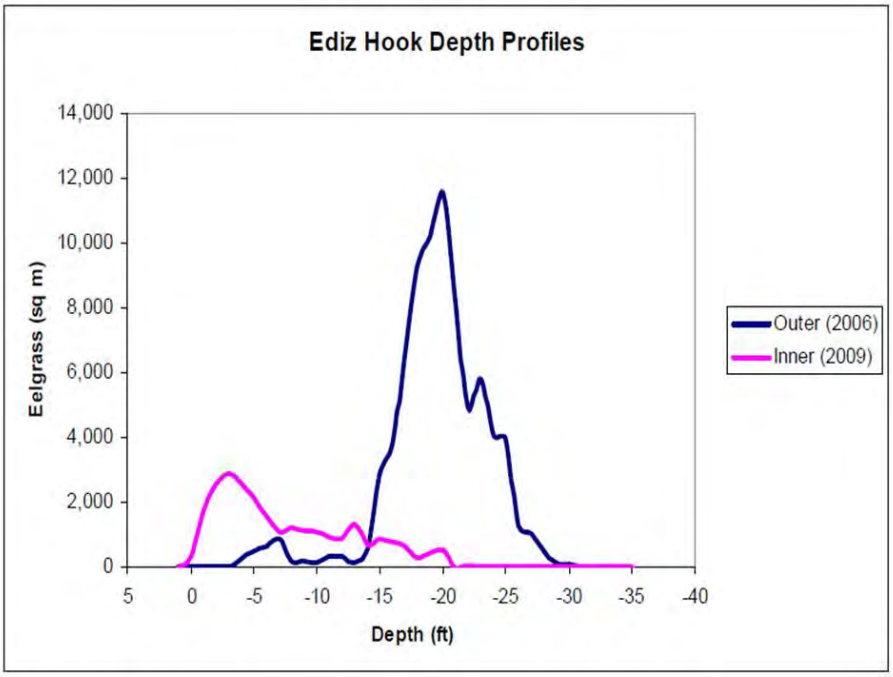


Table 2.5.1. ***Elevation Zones and Tidal Range benchmarks at Port Angeles based on 19 years of observations 1983-2001.***

Datum	meters	feet MLLW	feet NAVD88
Above MHHW	**Supratidal -** "Shoreline Buffer"	Above +7.06	Above +6.64
MHHW	2.15	+7.06	+6.64
MHHW to MLLW	**Intertidal Zone** - "Beach, Mudflat, or Marsh"	+7.06 to 0.00	+6.64 to -0.42
MLLW	0.00	0.00	-0.42
MLLW to Eelgrass Boundary	**Shallow Subtidal - "**Photic Zone"	0.00 to -20.00	-0.42 to -20.43
Eelgrass Boundary	-6.10	-20.00	-20.43
Below Eelgrass Boundary	**Deep Subtidal**	Below -20.00	Below -20.43

2.5.2 Baseline Habitat Value

NOAA recently developed the Puget Sound Nearshore Habitat Valuation (NHV) Model for the purpose of quantifying habitat services for threatened juvenile Chinook and summer-run chum salmon in the Puget Sound nearshore (Ehinger et al. 2014). This model uses a checklist scoring system to define habitat value, based primarily on elevation, vegetation, substrate conditions, anthropogenic impacts, and landscape context. The model provides a criteria-based and repeatable method for establishing habitat value – generally consistent with past NRDA analyses – and with substantial review and testing by NOAA technical staff. This model was used to establish base habitat values for the three elevation zones within the injury assessment area: intertidal, shallow subtidal, and deep subtidal.

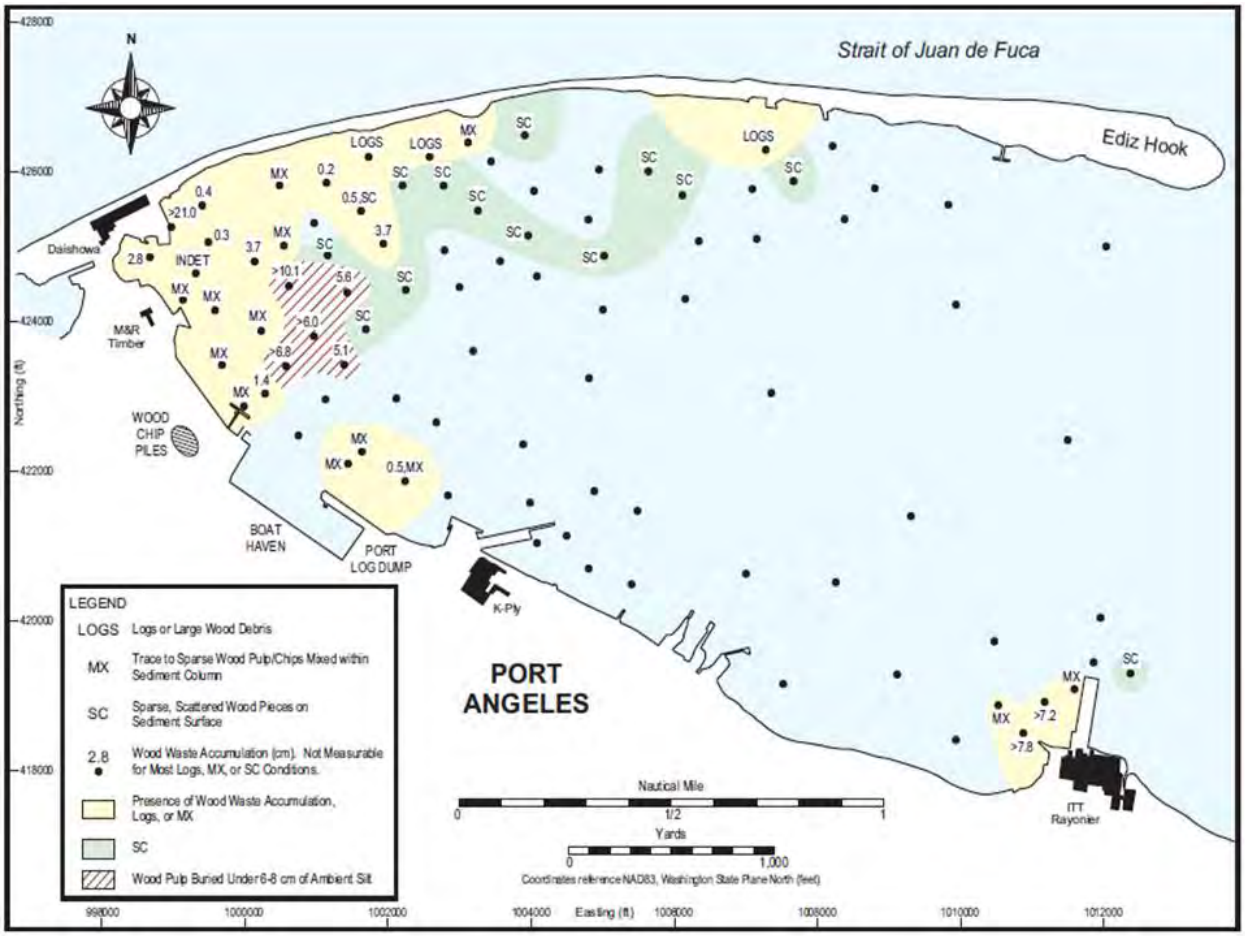
In this model, the value of shallow subtidal habitat is strongly affected by the density and height of SAV. No spatial data were discovered that systematically characterize the composition or abundance of SAV across the Harbor. Norris & Fraser (2009) indicates that eelgrass is rare in the Harbor. Underwater videography and dive work reported to the Trustees by tribal staff and other partners suggests that a low coverage of macroalgae is common in areas not affected by wood waste. Photic zone habitat value was based on an assumption of "very low" SAV value (resulting in a habitat value of 0.44). Below the photic zone, the SAIC report (1999) suggests that "areas of the harbor bottom with no apparent wood

debris have healthy sediment conditions with epibenthic organisms present on the sediment surface".

2.5.3 Degradation of Baseline

Extensive areas in the far western harbor have accumulated wood waste particularly in the deep subtidal (SAIC 1999). A 1999 sediment profile imaging survey differentiated between three general zones of wood waste accumulation (**Figure 2.5.3**). The SAIC map was imported to GIS and traced to define areas affected by wood waste. Zones with sparse, scattered wood pieces on the sediment surface, or where wood pulp is buried under silt were assumed to function at half of the baseline value. The SAIC report supports this assumption of partial function by observing that "at many locations with scattered wood debris, apparent RPD (Redox Potential Discontinuity) depths are well developed, Stage III infaunal communities are present, and epibenthic organisms are observed on the sediment surface." Areas with accumulations of logs and wood waste were considered to have a low function (a value of 0.1) consistent with both the NRDA completed in Commencement Bay (Idanza 2001) and the NOAA NHV Model.

Figure 2.5.3. ***Distribution of wood waste accumulation, from Figure 6 in SAIC 1999.***



Overwater structures were delineated as part of the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP; Simenstad et al. 2011). Because of discrepancies between PSNERP data and recent aerial photography, heads-up digitization was used to develop a reasonable estimate of 2013 overwater structure coverage. Various aerial imagery sources were used to compare the overwater structure coverage over time and determine the current extent. ESRI's ArcGIS World Imagery map service provided 0.3 meter data from 2010 (ESRI 2014). The United States Department of Agriculture Farm Service Agency National Agriculture Imagery Program (NAIP) map service provided 1 meter imagery from 2013 (USDA 2013). Google Earth Pro v. 7.1.2.2041 map service provided less than 1 meter resolution imagery from 2013 (Google 2014).

During the digitization process all three of these sources were referenced to determine the presence and spatial extent of overwater structures in 2013. While older, the ArcGIS World Imagery provided some of the higher resolution imagery. Overwater structures seen in the ArcGIS World Imagery were compared to the overwater structures seen in the lower resolution 2013 NAIP imagery and checked against the high resolution imagery in Google Earth Pro. By viewing and checking these three imagery sources, it was possible to accurately delineate overwater structures coverage. This level of overwater structures coverage was then assumed over the period of impact for the HEA. Due to the co-occurrence of docks, wood waste, and the relatively small area of overwater structures, imprecision in these estimates was not anticipated to strongly affect the HEA calculations.

The Trustees separated the western Harbor lagoon as a single unit for the purpose of habitat valuation. The absence of shallow water bathymetry makes accurate delineation of elevation zones in this area particularly difficult. The system is isolated from other nearshore habitats by distance, degradation of the connecting channel, and industrial development of the surrounding landscape. Connectivity to migration corridors has been shown to affect use of nearshore habitats by juvenile salmonids (Greene & Beamer 2011) and it is likely that habitat services are compromised due to the relatively isolated position of the lagoon. The whole site was defined as intertidal mudflat using the Puget Sound Nearshore Habitat Valuation (NHV) Model (value of 0.44). This baseline habitat value was halved because of its isolation and the high likelihood of physical degradation.

A summary of final habitat values, incorporating degradation of baseline and used for calculation of injury, is provided in **Table 2.5.3**.

Table 2.5.3. ***Final habitat values used as the degraded baseline to assess injury from contamination.***

Habitat Zone	Value	Zone Description	Basis for Value
Intertidal	0.5	Area between MHHW and MLLW.	NHV Model
Shallow Subtidal	0.44	Area between Zero and -20' MLLW	NHV Model
Deep Subtidal	0.25	Area Below -20' MLLW, no wood or overwater structures present	NHV Model
Lagoon	0.22	Area within the lagoon below MHHW.	50% of intertidal mudflat value from NHV Model
Buried Pulp or Scattered Wood	0.125	Identified by SAIC (1999)	50% of deep subtidal
Wood Waste	0.1	Identified by SAIC (1999)	Hylebos model (Idanza 2001)/NHV Model
Overwater structure	0.1	Area under docks, etc.	Hylebos model (Idanza 2001)

3. HEA Results

The Trustees ran three HEA scenarios for this assessment, the results of which are summarized in **Table 3**. These results are the product of an expedited, assumption-based approach that relies on robust site-specific data. Variability in the HEA scenario results herein presented is associated exclusively with the "Years of Recovery" input in an effort to estimate changes in DSAYs associated with a general range of remedial strategies. More refined remedial strategies such as spatially-explicit sediment removal or capping may alter the amount of DSAYS generated by our three HEA scenarios.

Table 3. ***HEA Scenario Results***

Parameter	HEA 1	HEA 2	HEA 3
HEA Start Year	1981	1981	1981
HEA Current Year	2014	2014	2014
Remediation Start Year	2015	2015	None
HEA Years of Recovery	10	20	50
HEA End Year	2025	2035	2065
Discount Factor	3%	3%	3%
Assessment Area (Acres)	2,102	2,102	2,102
DSAYs (Ranges)	508-1,133	532-1,193	589-1,323

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Appendix

Map1: Port Angeles Harbor Assessment Area

Map2: Query Manager Station List

Map3: HEA Analysis Areas

Map4: All Depth Habitats

Map5: Habitat Types

Map6: Wood Waste

Map7: Over Water Structures

Map8: Cadmium

Map9: Dioxin

Map10: 4-Methylphenol

Map11: Mercury

Map12: PAHs, total (Puget Sound Service Loss Thresholds)

Map13: PAHs, total (St. Lawrence River Service Loss Thresholds)

Map14: PCBs, total (St. Lawrence River Service Loss Thresholds)

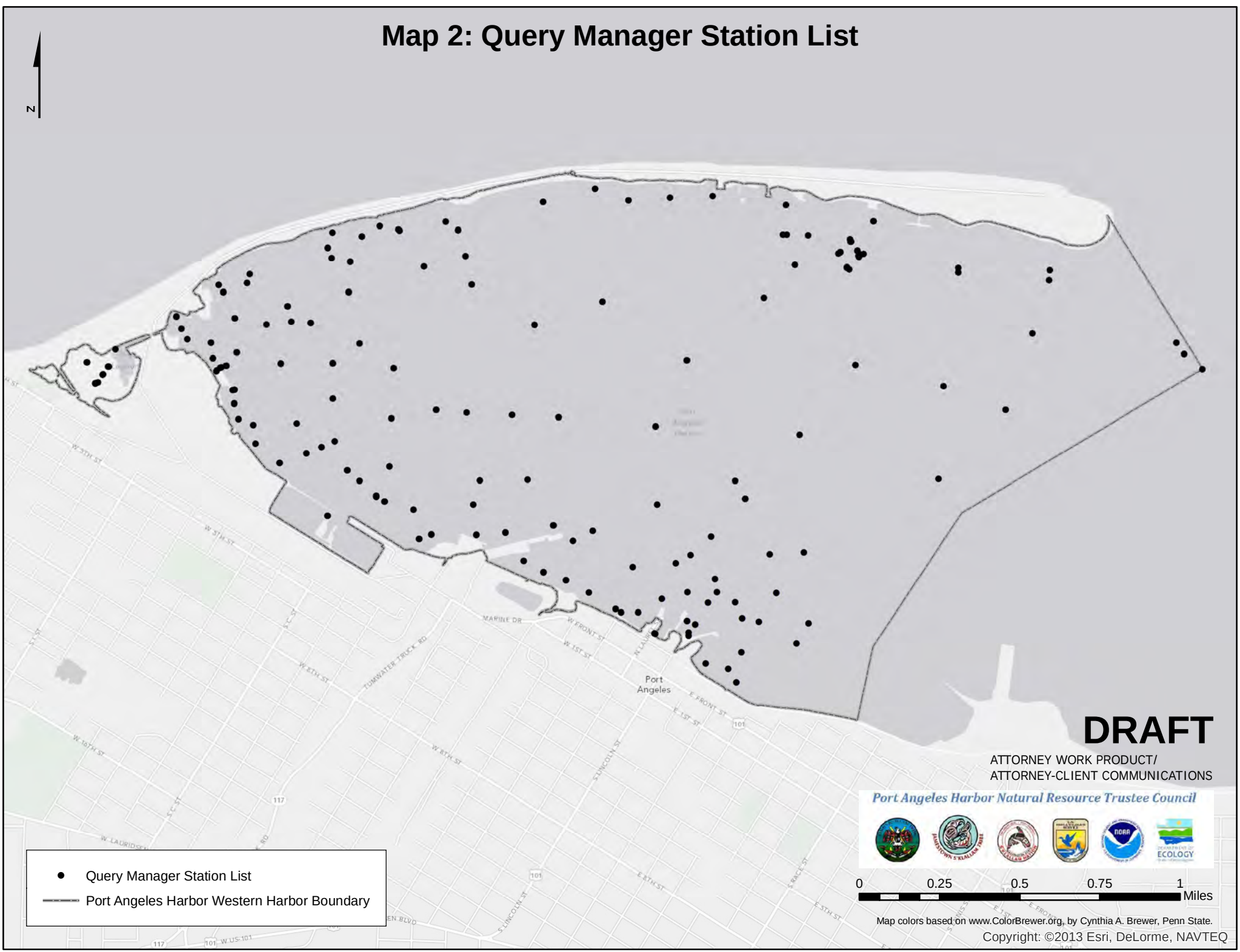
Map15: PCBs, total (Lower Duwamish River Service Loss Thresholds)

Map16: Phenol

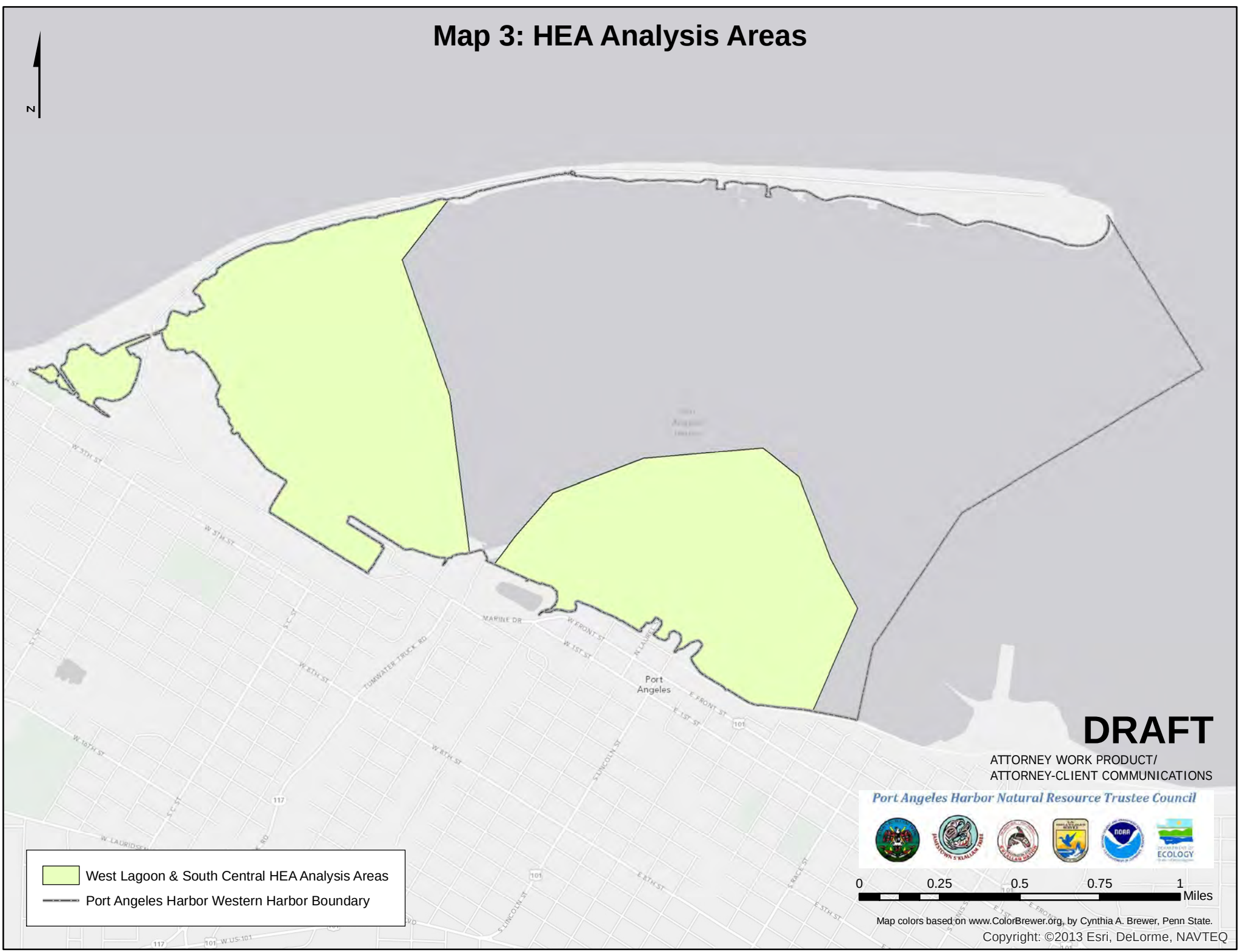
Map17: Zinc

Map 1: Port Angeles Harbor Assessment Area

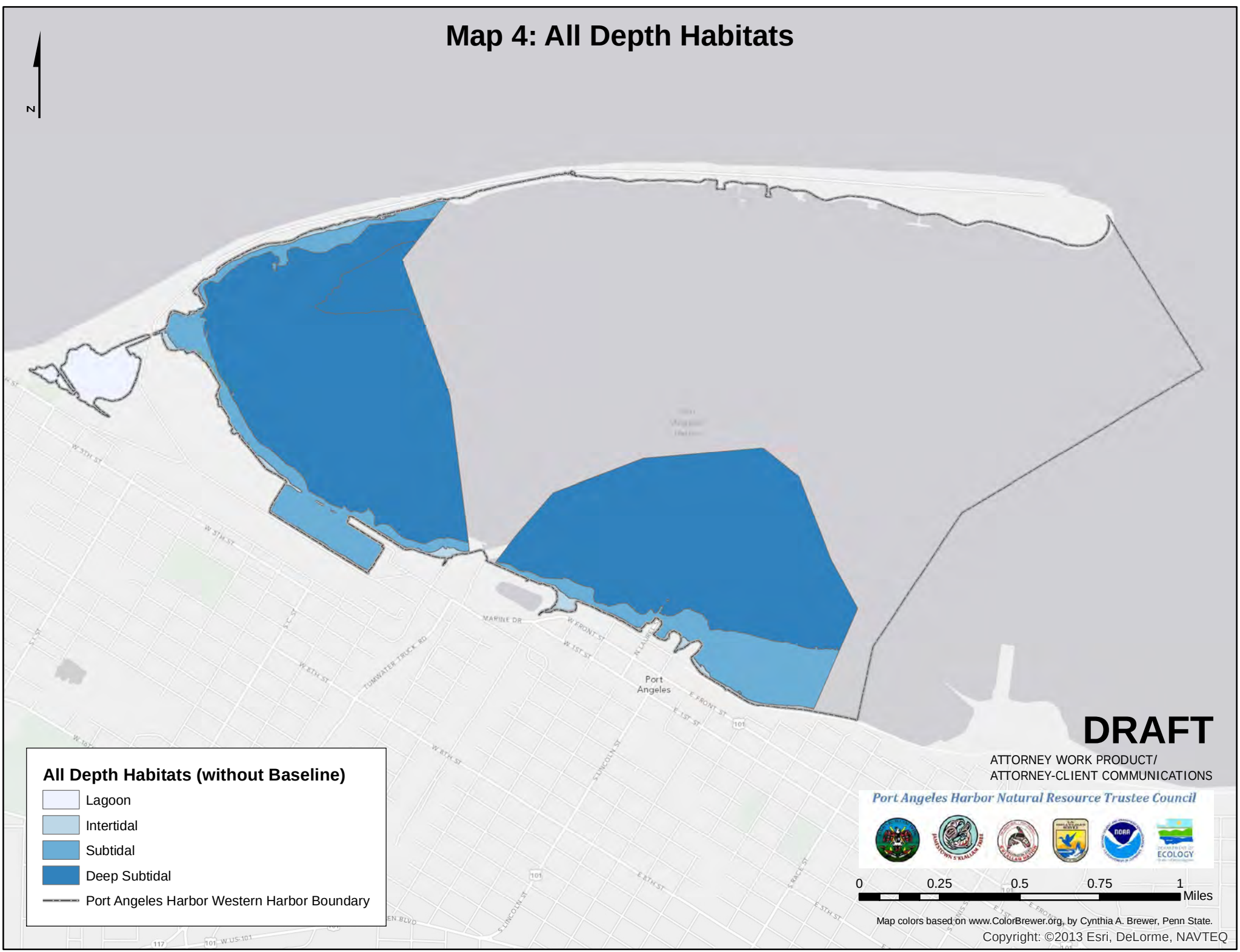
Map 2: Query Manager Station List



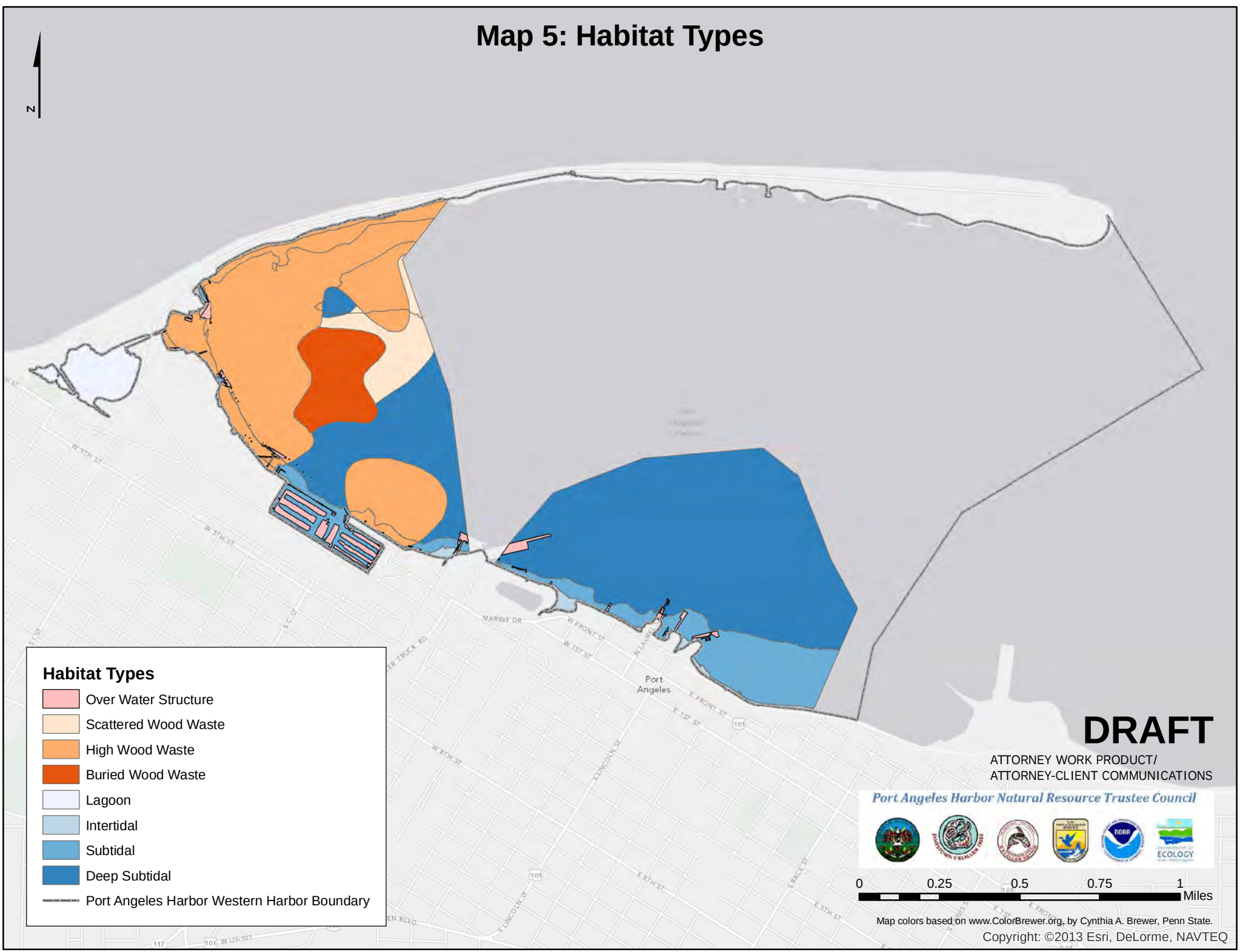
Map 3: HEA Analysis Areas



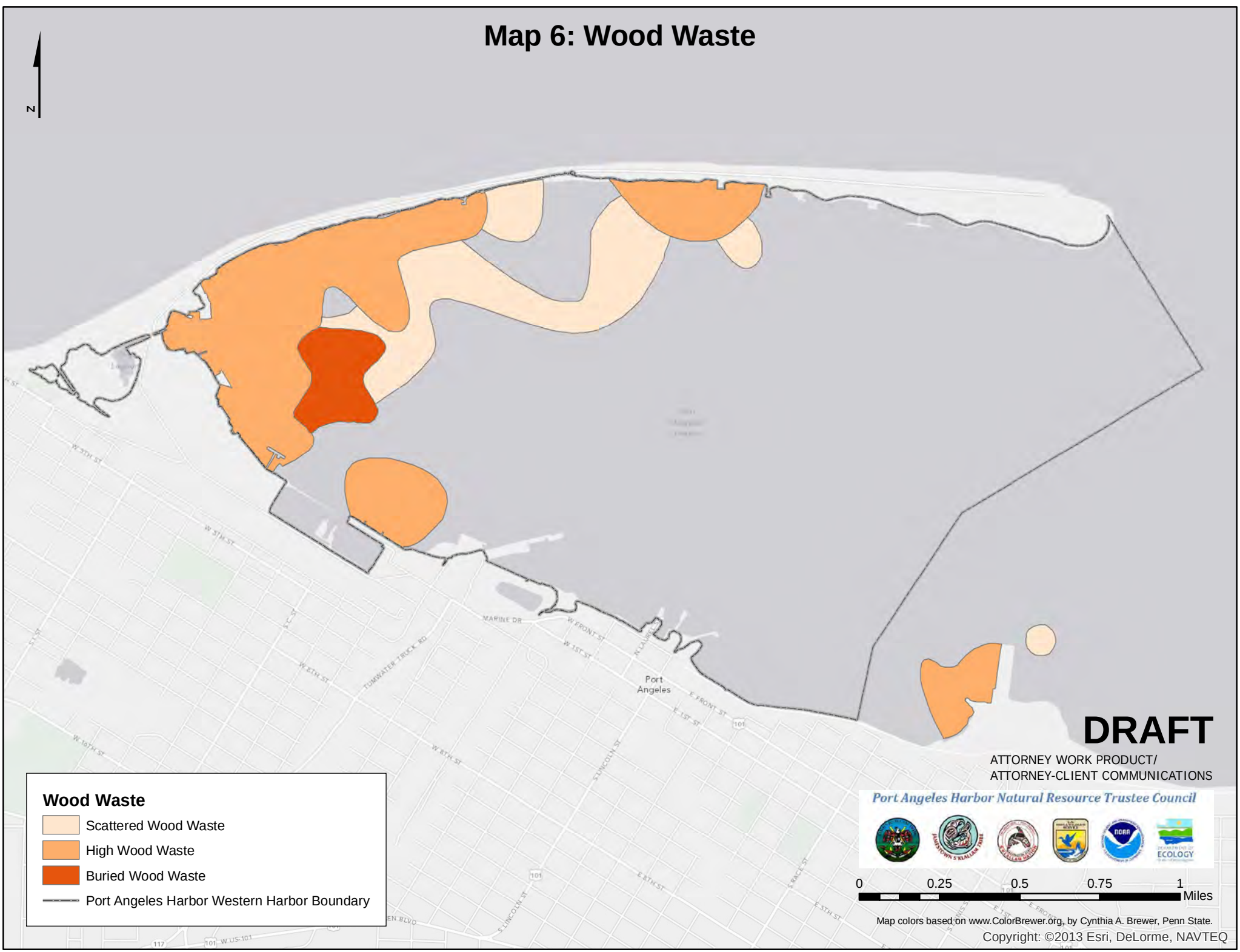
Map 4: All Depth Habitats



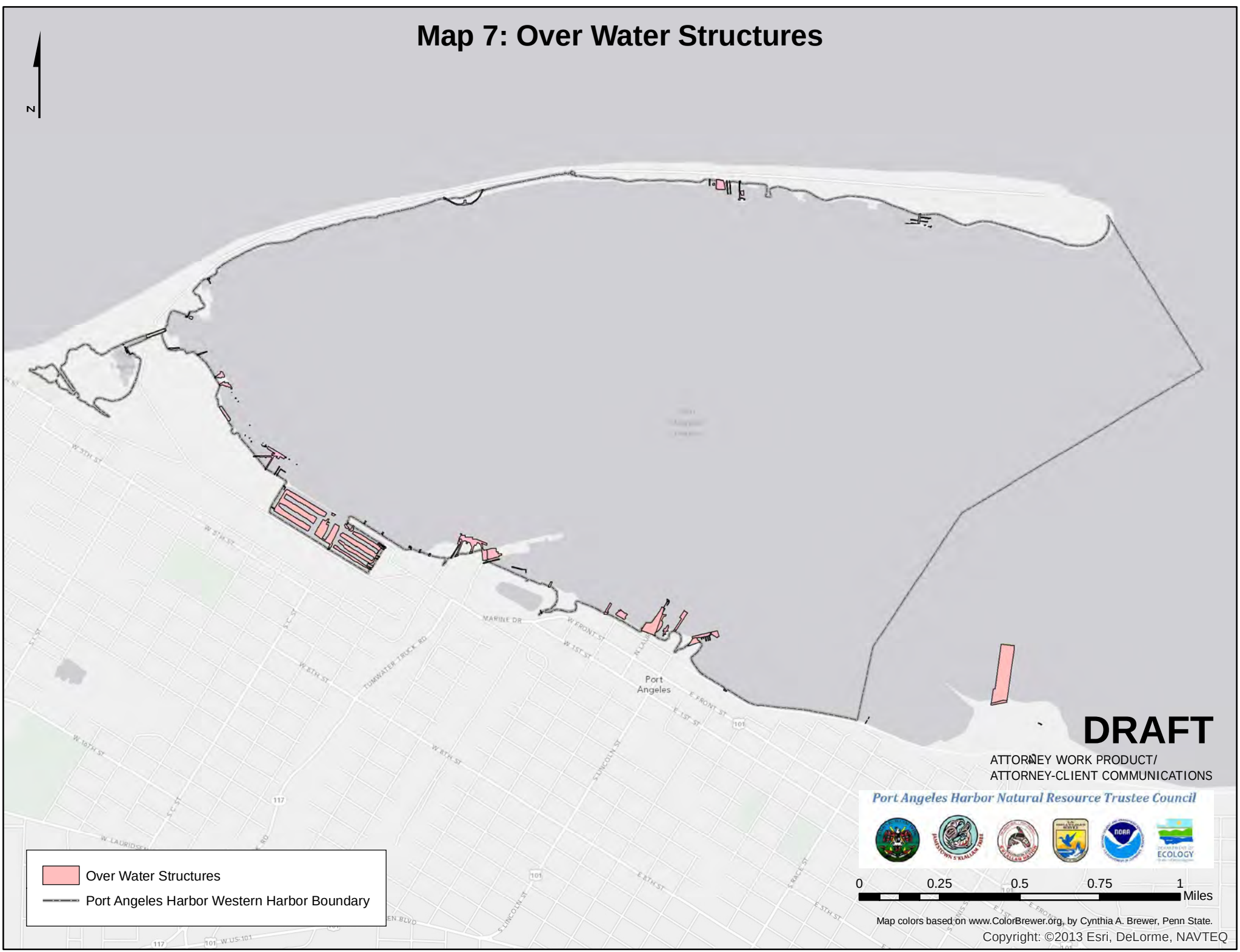
Map 5: Habitat Types



Map 6: Wood Waste



Map 7: Over Water Structures



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Port Angeles Harbor Natural Resource Trustee Council

0 0.25 0.5 0.75 1 Miles

Map colors based on www.ColorBrewer.org, by Cynthia A. Brewer, Penn State.

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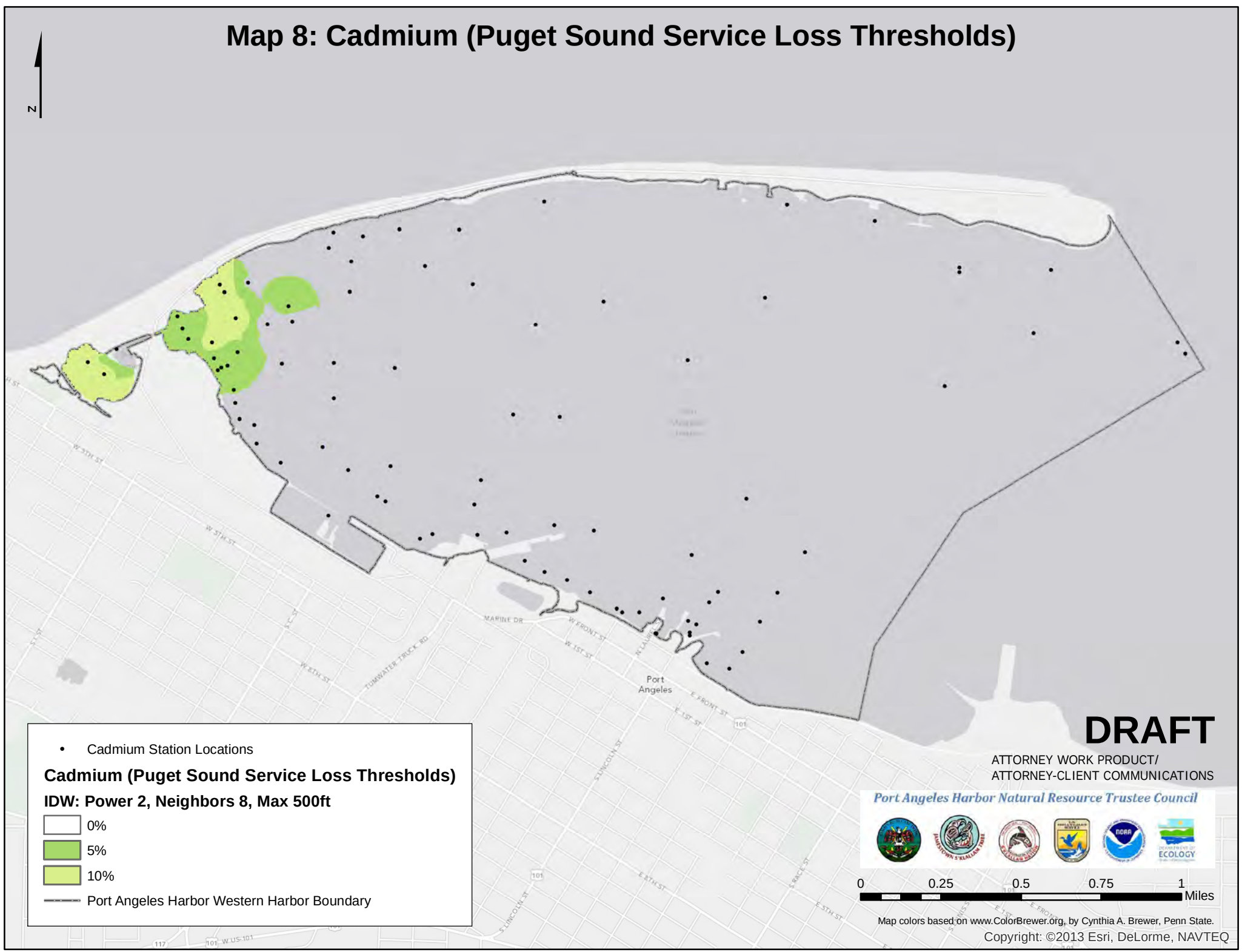
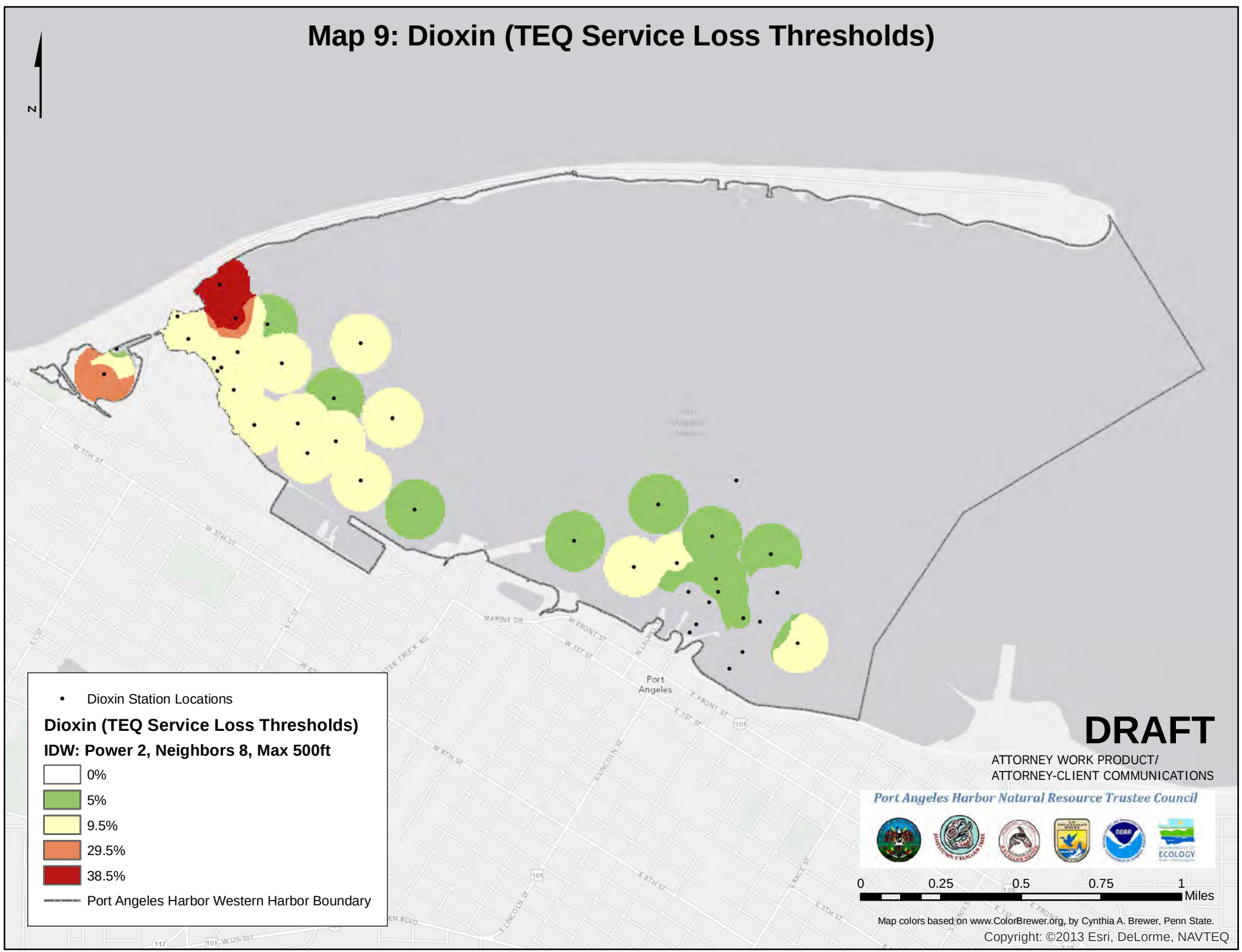
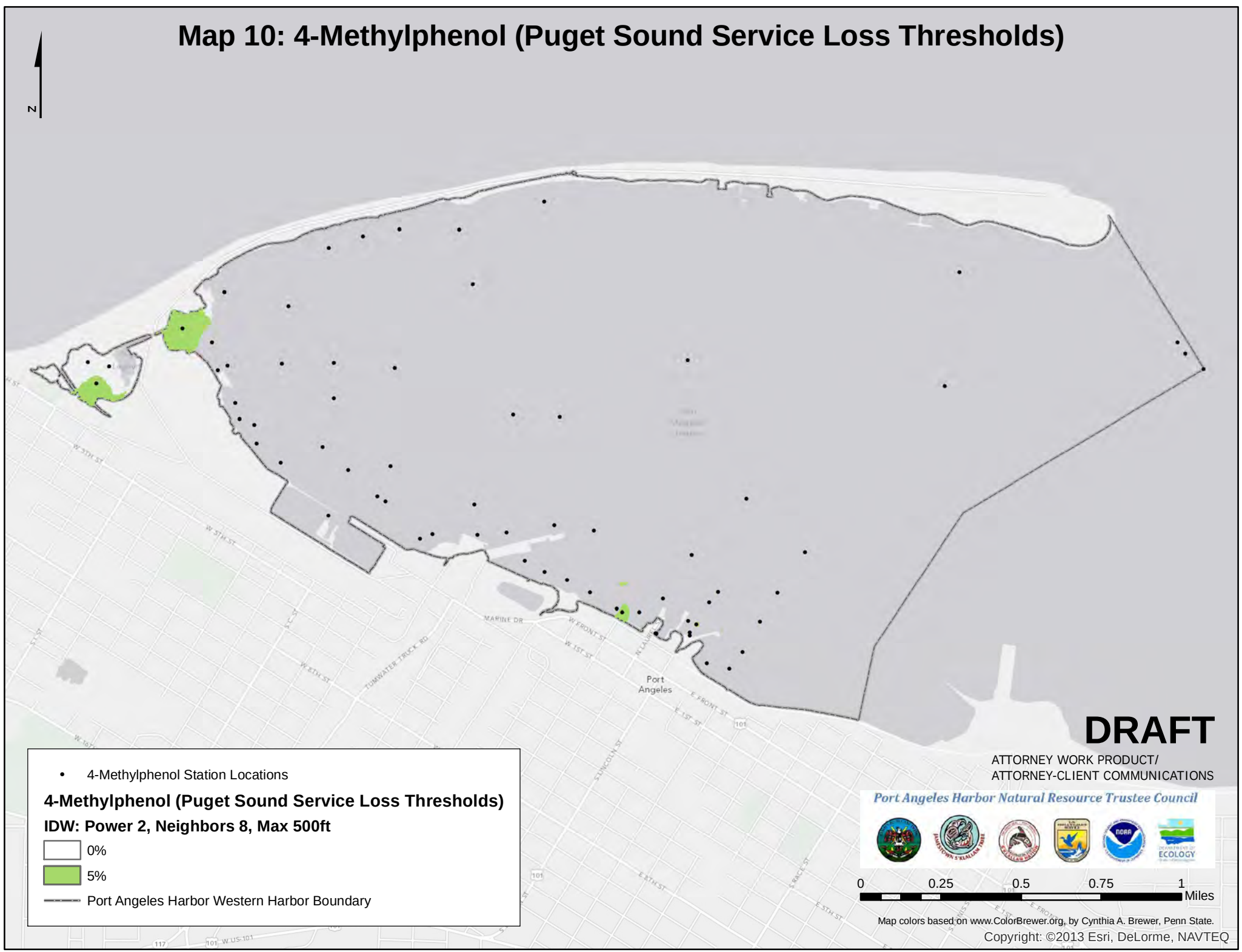
Map 8: Cadmium (Puget Sound Service Loss Thresholds)



Map 9: Dioxin (TEQ Service Loss Thresholds)



Map 10: 4-Methylphenol (Puget Sound Service Loss Thresholds)



- 4-Methylphenol Station Locations

4-Methylphenol (Puget Sound Service Loss Thresholds)

IDW: Power 2, Neighbors 8, Max 500ft

- 0%
- 5%
- Port Angeles Harbor Western Harbor Boundary

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0 0.25 0.5 0.75 1 Miles

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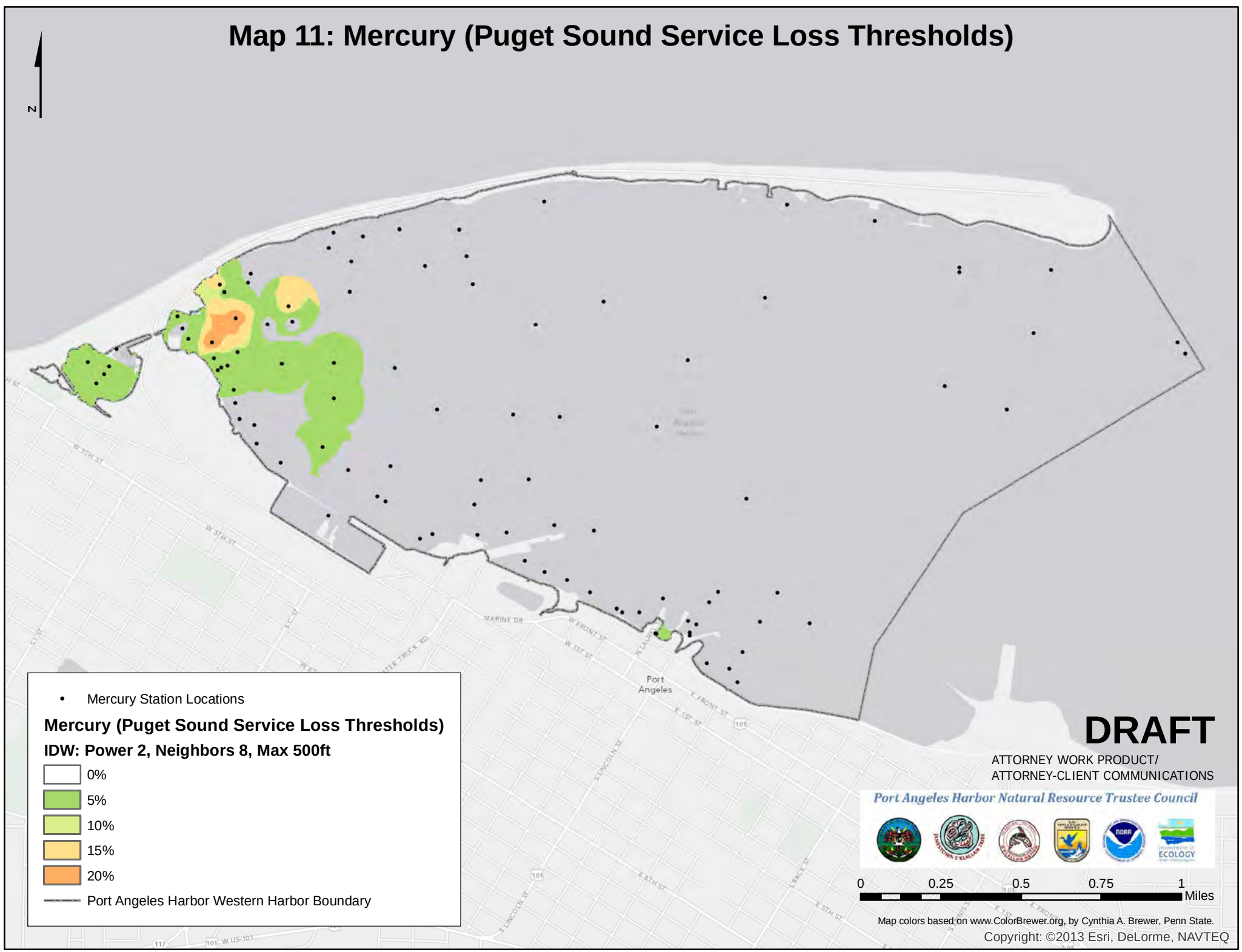
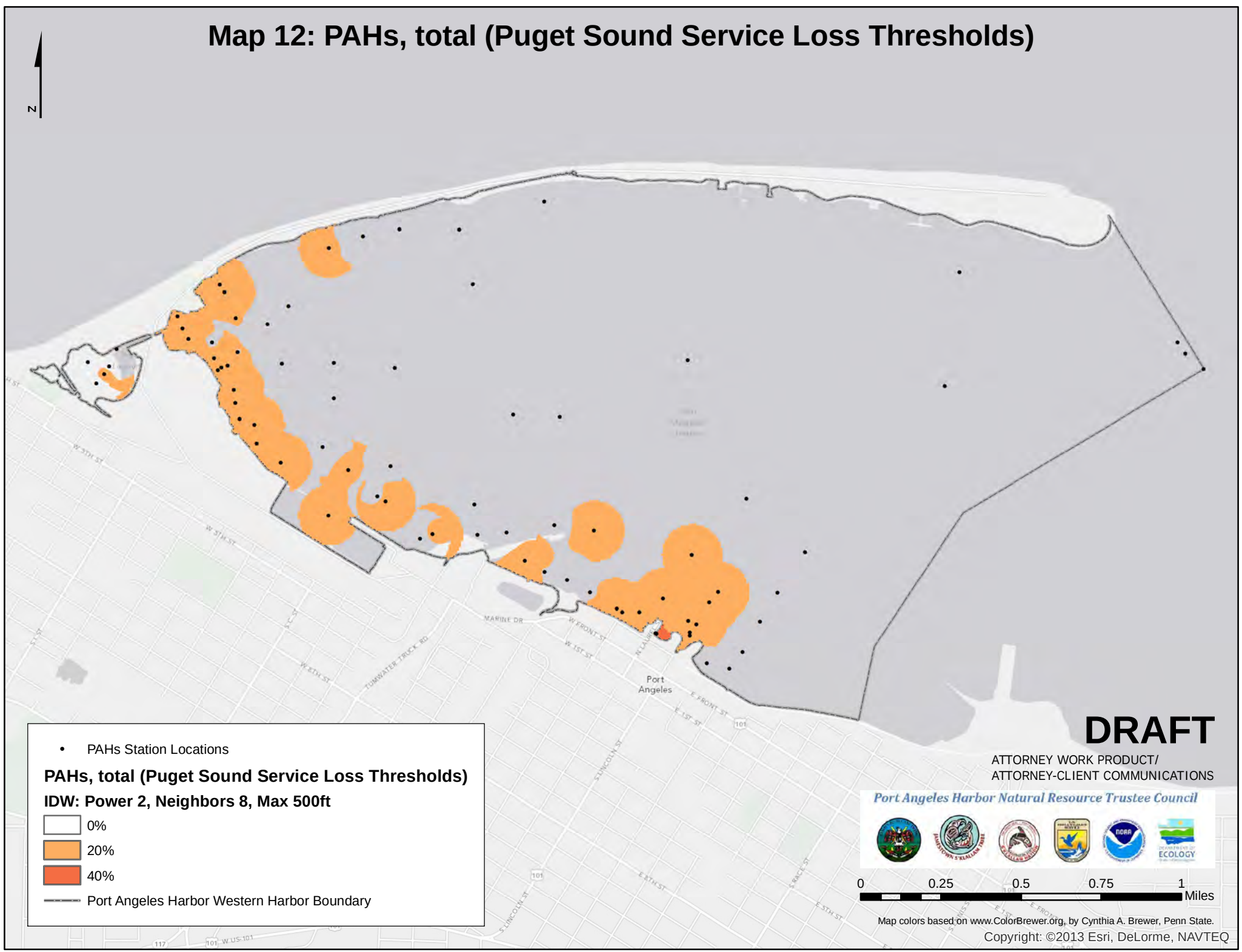
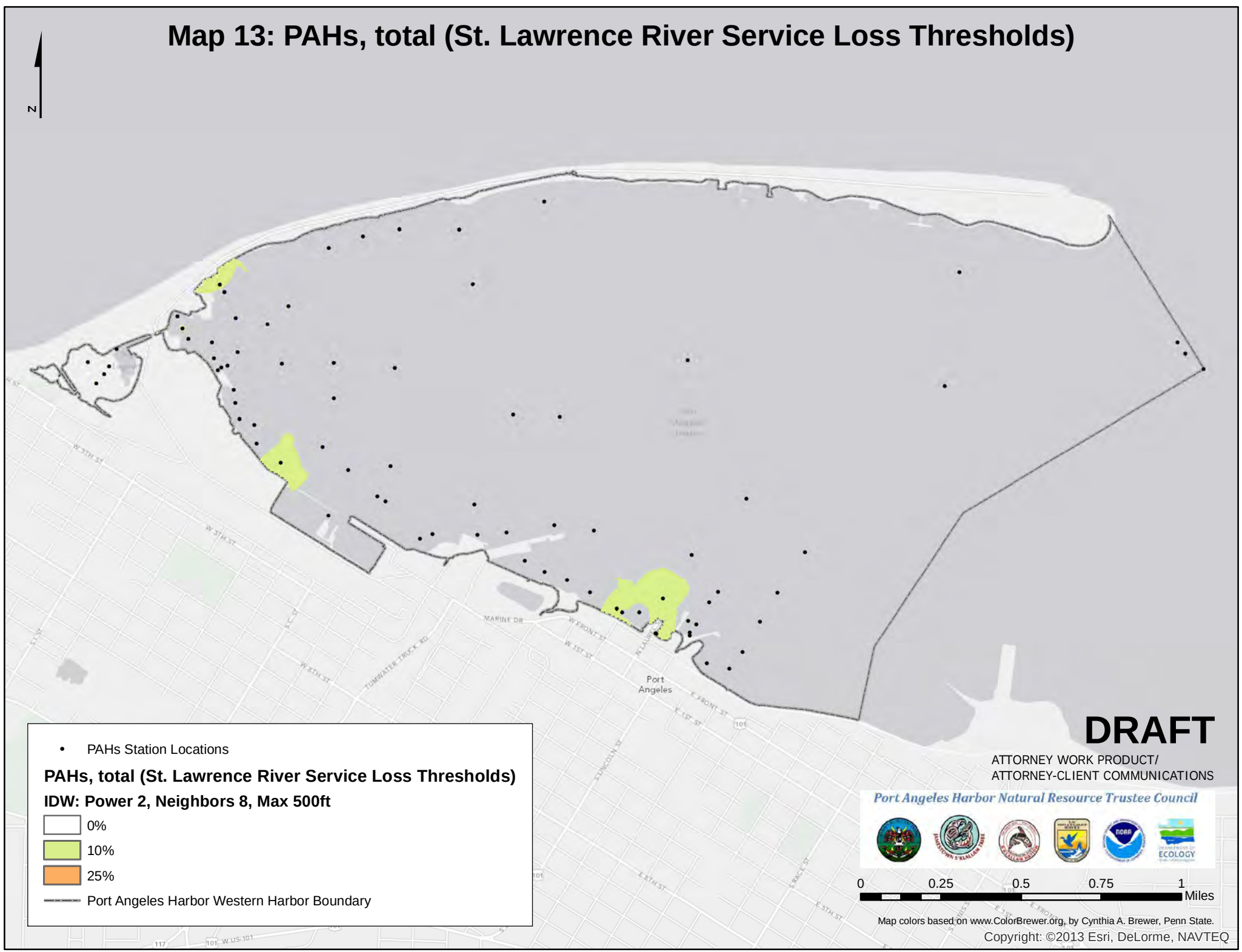
Map 11: Mercury (Puget Sound Service Loss Thresholds)



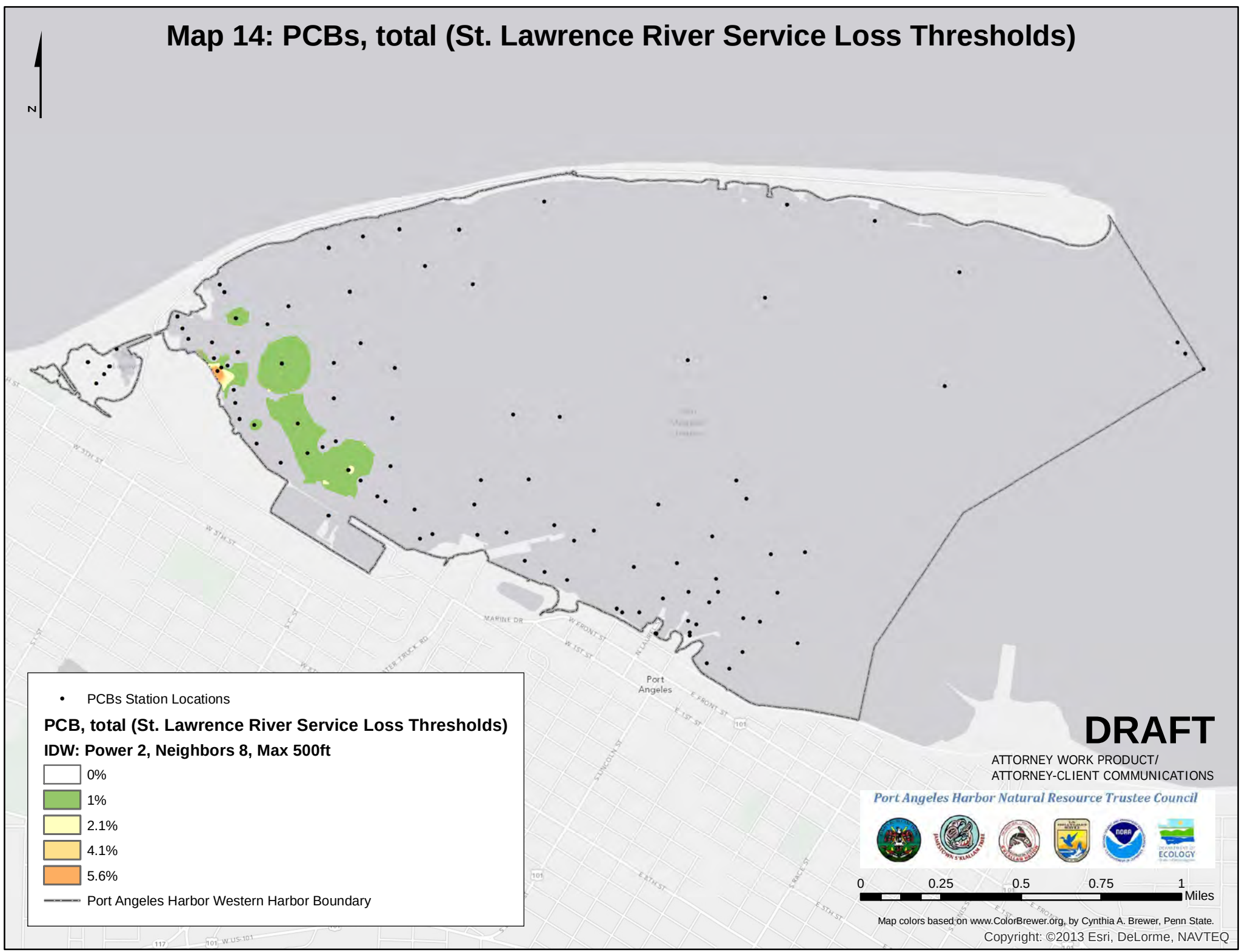
Map 12: PAHs, total (Puget Sound Service Loss Thresholds)



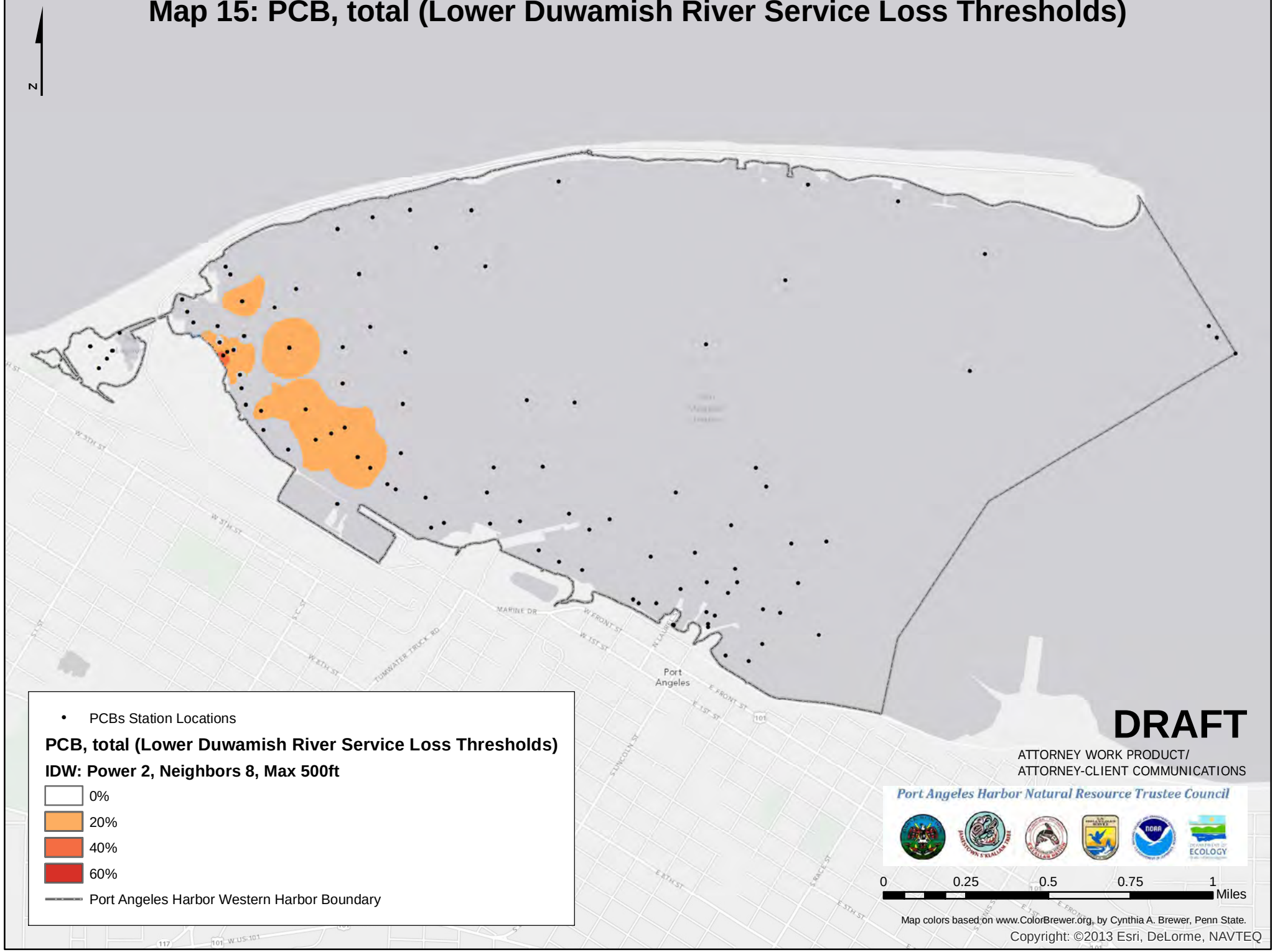
Map 13: PAHs, total (St. Lawrence River Service Loss Thresholds)



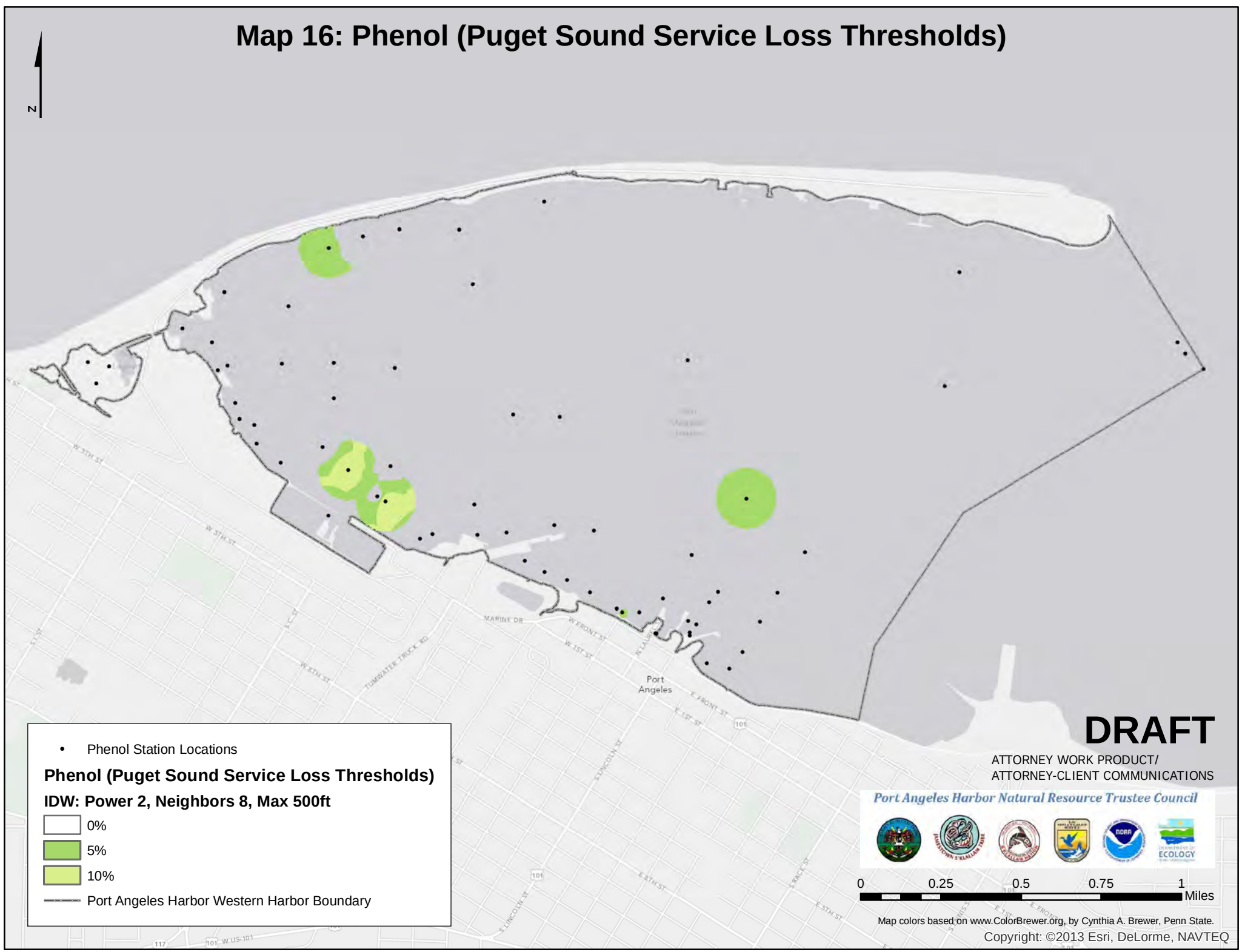
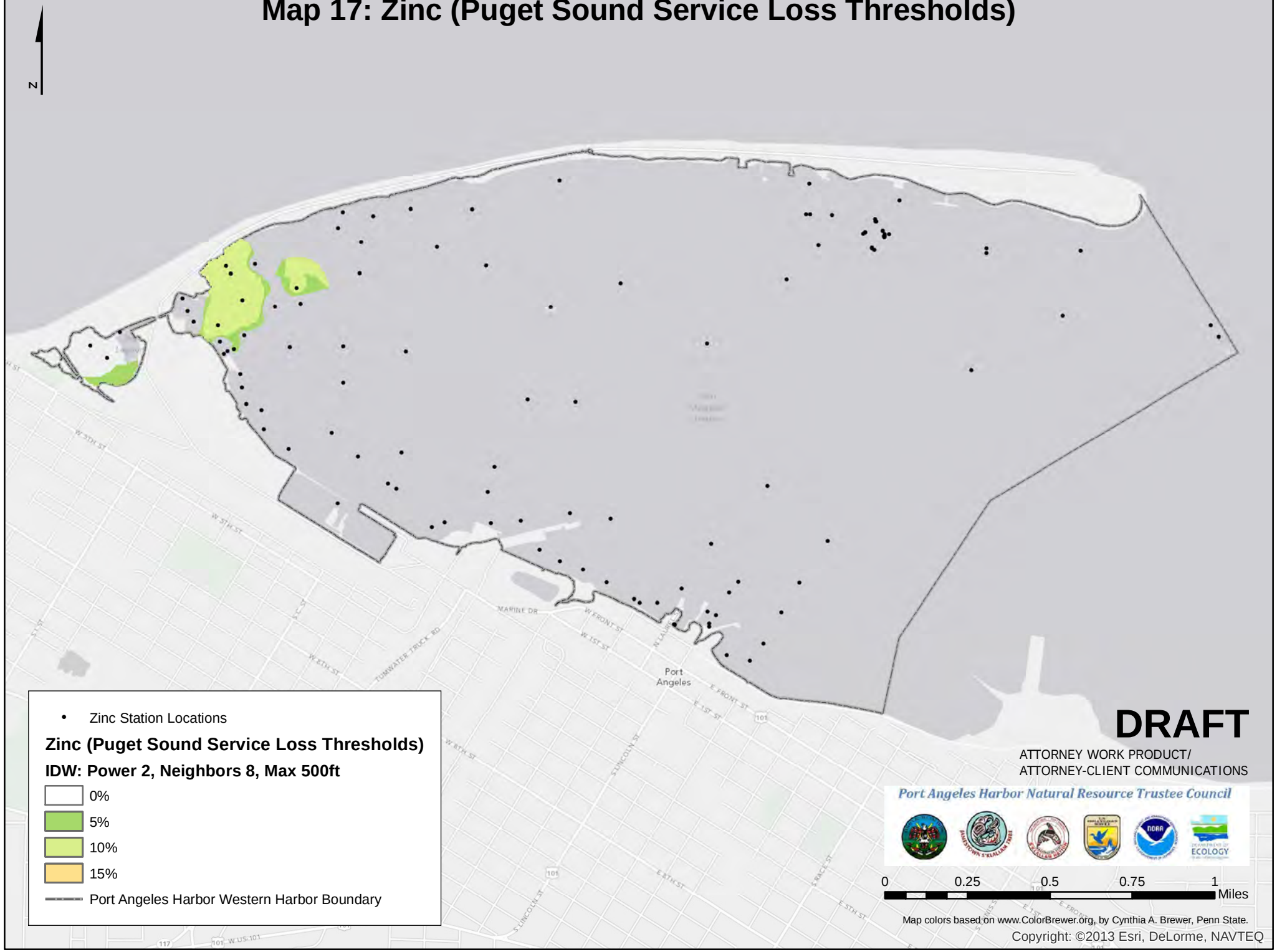
Map 14: PCBs, total (St. Lawrence River Service Loss Thresholds)



Map 15: PCB, total (Lower Duwamish River Service Loss Thresholds)



Map 16: Phenol (Puget Sound Service Loss Thresholds)



Map 17: Zinc (Puget Sound Service Loss Thresholds)