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Port Angeles Harbor Final Summary of Existing Information and Identification of Data Gaps Report

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List of Abbreviations and Acronyms

ac	acre
AST	Aboveground Storage Tank
ATSDR	Agency for Toxic Substances and Disease Registry
BMP	Best Management Practices
CCHD	Clallam County Health Department
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
COPC	Constituents of Potential Concern
CSO	Combined Sewer Outfalls
CWA	Clean Water Act
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
E & E	Ecology and Environment, Inc.
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERL	NOAA Effects Range Low
ERM	NOAA Effects Range Median
ESI	Expanded Site Investigation
ft	feet
gal	gallon
ha	hectare
Harbor	Port Angeles Harbor
HPAH	high molecular weight polynuclear aromatic hydrocarbon
in	inch
kg	kilogram

List of Abbreviations and Acronyms (cont.)

km	kilometer
L	liter
LAET	lowest apparent effects threshold
lbs	pounds
LEKT	Lower Elwha Klallam Tribe
LNAPL	light non-aqueous phase liquid
LPAH	low molecular weight polynuclear aromatic hydrocarbon
LUST	Leaking underground storage tank
m	meter
m^3	cubic meter
mi	mile
mi^2	square mile
MSMP	Marine Sediment Monitoring Program
MTA	Marine Trades Area Group
MTCA	Model Toxics Control Act
NFA	No Further Action
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
ORC	oxygen release compound
PAH	polycyclic aromatic hydrocarbon
PBT	Persistent, Bioaccumulative, and Toxic Chemical
PCB	polychlorinated biphenyl
RBC	Risk-Based Concentration
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SMS	Sediment Management Standards
SQS	Sediment Quality Standard
STP	sewage treatment plant
SVOC	semi-volatile organic compound

List of Abbreviations and Acronyms (cont.)

SWRO	Southwest Regional Office
TBT	tributyltin
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TEQ	Toxicity Equivalent
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRI	EPA Toxics Release Inventory Program
TSS	total suspended solids
TVS	total volatile solids
UST	Underground Storage Tank
VOC	volatile organic compound
WAC	Washington Administrative Code
WDNR	Washington Department of Natural Resources
WDFW	Washington Department of Fish and Wildlife
WDOH	Washington Department of Health
WSDOT	Washington State Department of Transportation
yd^3	cubic yard

1 Introduction

1.1 Background and Purpose

Port Angeles Harbor (Harbor), Washington has been identified as a priority environmental cleanup and restoration project by the Washington State Department of Ecology (Ecology) as part of the Puget Sound Initiative. Ecology's Toxics Cleanup Program has identified the Harbor for focused source control actions, sediment cleanup, and restoration efforts. Environmental investigations throughout the Harbor have indicated that chemicals of concern generated by intensive industrialization and urbanization activities exist within the Harbor. These previous investigations have indicated that chemicals in marine sediments and biota may pose a risk to the environment, with data that exceed the Washington State Sediment Management Standards (SMS) Chapter 173-204 Washington Administrative Code (WAC) (Ecology 1995), and other established thresholds of environmental concern (EPA 1998, Long & Morgan 1991, Long et al. 1995).

As part of the effort to cleanup and restore the Harbor, there is a need to adequately characterize marine sediment issues throughout the Harbor as related to current and historic potential contaminant sources. Ecology has tasked Ecology and Environment, Inc. (E & E) to conduct sediment investigations, a risk assessment, and a current study of the Harbor, which will focus on the marine environment and associated terrestrial and aquatic source areas. This Summary of Existing Information and Identification of Data Gaps Report has been prepared to help guide the development of a Sampling and Analysis Plan (SAP) for field investigations of the Harbor. The purpose of this report is to compile readily available information concerning sediment characterization within the Harbor (i.e. data from potential sources and activities relating to chemicals in sediments, results from prior marine environmental investigations, etc.) and to identify data gaps that will be addressed by the SAP.

Information for the report has been gathered from the following sources:

- Reference literature on prior investigations conducted in the Harbor
- Ecology Southwest Regional Office (SWRO) Central Records
- Ecology Facility/Site Identification System: http://apps.ecy.wa.gov/website/facsite/viewer.htm

- Ecology Online Publication Archives: http://www.ecy.wa.gov/pubs.shtm

- Ecology Underground Storage Tank and Leaking Underground Storage Tank (UST/LUST) lists

- Ecology Online Shoreline Aerial Photos: http://apps.ecy.wa.gov/shorephotos/index.html

- EPA Envirofacts Warehouse: http://www.epa.gov/enviro/index.html

- EPA Toxics Release Inventory (TRI) Program

- Washington State Department of Health (WDOH)
  - Shellfish Safety Information: http://ww4.doh.wa.gov/scripts/esrimap.dll?name=bioview&Cmd=Map&Step=1

- Washington Department of Natural Resources (WDNR)
  - Online maps of leased aquatic lands: http://www.dnr.wa.gov/Pages/default.aspx

- Washington Department of Fish and Wildlife (WDFW)
  - Online publications: http://www.wdfw.wa.gov/search/
  - Communications with Dave Molenaar, former Wildlife Marine Habitat Manager for Clallam County

- The City of Port Angeles Public Works Department
  - Communications with Jeff Young, Wastewater Utility Department
  - Storm Water System Map: http://www.ci.port-angeles.wa.us/PDFs/Stormwater/System%20Map1.pdf
  - Port Angeles CSO Map: http://www.ci.port-angeles.wa.us/PDFs/PWorks/CSOMap.pdf
  - Port Angeles Watershed Map: http://www.ci.port-angeles.wa.us/PDFs/Stormwater/FiguresMaps.pdf

- Clallam County
  - Communications with Dr. Tom Locke, Clallam County Health Department
  - Clallam County Marine Resources Committee: http://www.clallammrc.org/CCMRC/allframes.html
  - Clallam County Department of Community Development: http://www.clallam.net/streamkeepers/

- Communications with the Lower Elwha Klallam Tribe (LEKT)
  - Larry Dunn, Tribal Lead on Rayonier Cleanup Project
  - Doug Morrill, Fisheries Manager

- Communications with National Oceanic and Atmospheric Administration (NOAA)
  - Kurt Fresh, Biologist

- Communications with Olympic Environmental Council Coalition
  - Darlene Schanfald, Project Coordinator for Rayonier Cleanup Project

1.2 Report Organization

Section 2 of this report describes the overall site attributes of the Harbor, including general physical characteristics and historic land-uses. This section also provides a list of anthropogenic chemicals of concern for Harbor marine sediments and the potential pathways of those chemicals into the system. Section 3 discusses specific commercial, industrial, and municipal facilities and other current land-uses that represent potential point and non-point sources of pollutants into the Harbor. For each facility, the following are outlined:

1. Historic and current operations including known discharges to the Harbor,
2. Prior marine sediment investigations, if any,
3. Potential contaminants of concern associated with facility activities, and
4. Data gaps.

Section 4 outlines the general state of biological resources within the Harbor, and discusses the potential relationship of biological communities to sediment contamination. Section 5 of the report summarizes the data gaps identified for the Harbor, and Section 6 provides a list of documents cited in this report.

2 Port Angeles Harbor

2.1 Site Description and Historical Background

The city of Port Angeles is located on the northern coast of the Olympic Peninsula in Clallam County. The city of Port Angeles contains 26 miles (42 km) of marine shoreline, including Ediz Hook, a 2.5 mile-long sand spit (Figure 1). The Harbor is bounded to the west and south by the city of Port Angeles and to the north by Ediz Hook. The Harbor is considered a deep-water harbor, with depths greater than 90 feet near the eastern end of Ediz Hook. Intertidal shorelines exist in the southeastern portion of the Harbor, as well as along the eastern shoreline of Ediz Hook. The marine waters of Port Angeles Harbor are currently listed as impaired by the State of Washington under Section 303(d) of the Clean Water Act (CWA) due to low dissolved oxygen levels (EPA 2004).

Over the past century, Port Angeles Harbor has been utilized by a number of industries including saw mills and plywood manufacturing, pulp and paper production, marine shipping/transport, boat building and refurbishing, marinas, and commercial fishing (Table 1). Since the early 1900s, pulp and paper mills have comprised a dominant portion of Port Angeles' industrial sector (Oldham 2007). Four major mills and one plywood manufacturing company began operations in the period 1914-1941 along the Port Angeles waterfront. Only one of those mills, Nippon, is still in operation. K-Ply, a plywood manufacturing facility, recently closed in March 2008 (Dickerson 2008). Sizable over-water log booming areas along the nearshore of the Harbor were, and in some cases, still are associated with these businesses (Figure 2). Prior to the advent of the CWA, untreated process effluent from the mill facilities was discharged to the Harbor through the early 1970s (Table 2) (Shea et al. 1981). After passage of the CWA, industrial wastewater discharges to the Harbor from the mills required treatment. Pulp and paper mill treated effluents continued to be discharged into the Harbor until 2008, and wood product sources throughout the Harbor have been identified as significant sources of COPCs in marine sediments from various chemicals derived from the paper and pulp mill process. In addition, the remediation/redevelopment of the Rayonier Mill property has been specifically designated an important component of the Port Angeles Harbor investigation.

Port Angeles Harbor has supported many industries associated with commercial and recreational shipping, including goods transport, ferry services, and other marine logistical operations. Petroleum-based facilities have been a significant part of the Harbor's industrial community as part of those shipping services. A number of petroleum bulk stations and terminals have been located near the Harbor waterfront since the 1920s in conjunction with the shipping and lumber industries (Table 1). Many of these facilities have experienced episodes with leaking above and underground storage tanks. There have also been incidents of crude oil and fuel spills since the 1980s from tankers refueling or accidentally running aground (Table 1). Other general businesses along the Port Angeles waterfront include: automotive services, telecommunications, a newspaper, and other urban businesses.

The city of Port Angeles has an estimated population of 18,640 people (Oldham 2007), with associated municipal wastewater and stormwater infrastructure to support the local community. Historically and currently, the Harbor has received discharges from Combined Sewer Outfalls (CSO), the city of Port Angeles wastewater outfall on the side of the Harbor, septic systems in various stages of maintenance outside the city limits, and non-point source runoff from stormwater (CPAPWD 2006, CCMRC 2001) (Table 2). The Harbor also receives direct surface water discharge from six freshwater creeks in the area (Figure 1), all of which have varying degrees of residential and commercial land-use influences. Five of the creeks are listed as impaired in terms of water quality and biological quality by the Clallam County Streamkeepers (CCDCD 2004).

Shellfish harvesting and fishing in the Harbor have historically been important commercial and subsistence activities in the Harbor, particularly for the LEKT who are subsistence-level consumers of fish and shellfish throughout the Harbor (ATSDR 2000a, Ecology 2008a). Harbor fisheries have been impacted due to environmental quality issues (Beaverson 1998, Clallam County Marine Resources Interactive Workshop 2001). Anthropogenic impacts from various sources, including wastewater pollution, industrial-based contaminants, and stormwater runoff, may have contributed to apparent declines in shellfish and fish populations, as well as the closure of historic shellfish tracts for commercial harvesting (Beaverson 1998, Clallam County Marine Resources Interactive Workshop 2001, WA DOH 2008a).

2.2 Constituents of Potential Concern (COPCs) in Marine Sediments

Constituents of potential concern to Harbor sediments and biota were identified based on known chemical associations with historic and current land-uses, as well as a significant amount of data from prior sediment investigations within the Harbor (E & E 1998 and 1999, Malcolm Pirnie 2005 and 2007). Data from prior investigations forms a list of COPCs based on chemical concentrations in Harbor sediments exceeding Washington State SMS. These investigations also identified chemicals commonly associated with wood debris degradation, which likely contribute to exceedances of SMS biological criteria, and chemicals of concern from a bioaccumulation standpoint. The following chemicals are identified as COPCs, some of which have Washington State SMS chemical criteria (Table 3):

- Polychlorinated dibenzo-p-dioxins (dioxins) and polychlorinated dibenzofurans (furans)
- Polychlorinated biphenyls (PCBs)
- Chlorinated pesticides
- Semi-volatile organic compounds (SVOCs), including polycyclic aromatic hydrocarbons (PAHs), phenols, and phthalates
- Resin acids/guaiacols
- Tributylin (TBT)
- Heavy metals, including inorganic and organic forms

Many of these chemicals are known to be persistent in the environment, potentially bioaccumulative, and toxic (PBTs). Of particular concern are dioxins/furans, PCBs, and PAHs. Dioxins/furans are byproducts produced from the combustion of organic compounds with chloride present and pulp bleaching practices. Processes include the incineration of municipal and medical wastes, boilers/industrial furnaces, diesel heavy-duty trucks, sintering plants, automobiles using leaded gasoline, oil-fired utilities, lightweight aggregate kilns that combust hazardous waste, petroleum refining, crematoria, and drum reclamation (EPA 2006). Penta (pentacholorophenol) is sometimes used as a wood preservative in lumber and plywood mills, and the production of penta produces dioxins and furans. Dioxins/furans tend to be carried out to sediments in an oil/penta phase, and once the oil and penta degrade, dioxins/furans are left behind. This dioxin/furan contamination of technical-grade penta has an identifiable chemical signature that is different from either stack emissions or combustion byproducts (Pers. Comm. Dr. Teresa Michelsen, 2008). Dioxins and furans can also be produced as by-products from the production of PCB mixtures. Dioxin source assessments conducted in Washington show incinerators, hog fuel (wood waste) boilers, bleached pulp and paper mills, cement kilns, and municipal wastewater treatment as medium to high priority for source reduction/control (Ecology 1998a).

PCBs are synthetic mixtures of chlorinated compounds that are no longer manufactured in the U.S. but are still found in many products. PCBs have been used as coolants and lubricants in electrical equipment (transformers, capacitors), and are found in older fluorescent lighting fixtures and electrical appliances, in paints, pesticide additives, sealants and hydraulic oils (ATSDR 2000b). PCBs were extensively used in ship manufacturing as a fire retardant, and may be introduced into waters through ship-building and decommissioning activities, as well as during ship maintenance and the release of oily bilgewater.

DDT is a chlorinated pesticide once widely used in the U.S. before being banned in 1972. Dichlorodiphenyldichloroethylene (DDE) and dichlorodiphenyldichloroethane (DDD) are derivatives of DDT that contaminate commercial DDT preparations, and their use has also been banned. These fairly insoluble chemicals are highly persistent in the environment, particularly in sediment and biota (ATSDR 2002).

SVOCs are a class of compounds that include PAHs, phenols, methylphenols, and phthalates. Pyrogenic PAHs are a group of over 100 chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances. PAHs are usually found as a mixture made up of two or more chemicals. PAHs are found in coal tar, crude oil, creosote, marine diesel fuel and exhaust, automobile exhaust and street runoff through CSOs and storm drains, roofing tar, and products used to make dyes, plastics, and pesticides (ATSDR 1996). Phenols are a class of widely distributed chemicals that are both manufactured and occur naturally. Phenols are used primarily in the production of phenolic resins, the manufacture of synthetic fibers, slimicides, disinfectants, and in various consumer products (ATSDR 2006). Cresols are methylphenols and are one of the chemicals that along with PAHs make up creosote, which is created from the high temperature treatment of wood, coal, or from the resin of the creosote bush. Creosote is used as preservative in marine lumber applications (e.g. dolphins, pilings). Creosoted pilings and remnants have been identified as a continuous source of marine pollution, as they leach methylphenols and PAHs to marine waters and sediments. Abandoned pilings usually wash up on beaches and leach PAHs into the coastal habitat for years (MRC 2008). Phthalates are widely distributed synthetic compounds, used primarily in vinyl products, plastics, and in personal care products such as fragrances and nail polish. Phthalates are widely present in CSO and stormwater discharges.

Resin acids and guaiacols are plant derived chemicals found in association with wood debris, hardwood tar, and pulp and paper mill processes (Malcolm Pirnie 2005). Resin acids are a component of most softwoods and are usually released from wood chips during the pulping process. Their acute toxicity towards fish and other aquatic life has been shown in previous studies. Resin acids may account for as much as 70% of the toxicity of effluents (Li et. al. 1996). Guaiacols have been identified as being toxic to humans as well as aquatic organisms (PAN 2008).

TBT is a highly toxic compound that is used as an anti-fouling agent in marine paints applied to the bottom of boats. It is ubiquitous in use, and can be released to marine sediments through leaching from paint into the water and during the practice of scraping vessel hulls. Any harbor or bay with large international vessel traffic will have ongoing TBT sources. NOAA's Mussel Watch Program, a long-term status and trends program that monitors contaminants in sediments and mussels, includes TBT as an important monitored analyte (NOAA 2007).

Metals such as inorganic arsenic, lead, zinc, copper, mercury, and cadmium occur naturally from geologic processes, and are also used extensively in manmade products (e.g. paints, cigarettes, fertilizers, industrial solvents, batteries, thermometers, dental fillings, light bulbs, etc.) (ATSDR 2008). Common sources of metals from anthropogenic sources include car brake dust, incineration, medical and municipal waste, boat paints, other vessel-related sources (e.g., anodes, mercury-containing instruments), and the automotive industry (i.e. manufacturing and wrecking disposal) (ATSDR 2008).

3 Potential Sources of Aquatic Sediment Contamination and Data Gaps

3.1 Rayonier Mill Site

The Rayonier Mill property is located at 700 North Ennis Street on the southeastern shore of Port Angeles Harbor. The site covers approximately 80 acres of land, is zoned Industrial Heavy, and is bordered to the east by Ennis Creek. The terrestrial and marine structures formally associated with the mill can be seen on Figure 3. The only remaining mill features are the embayment area on the west side where logs were stored for later wood chipping (Log Pond) and the mill dock that extends into the Harbor. The Mill produced pulp and paper from 1930 until 1997, when production ceased and the company began deconstructing the site. Site dismantling was completed in 1999, although a few structures still remain on the property.

3.1.1 Historic Operations

Detailed information on the pulp production process can be found in the Rayonier Marine Remedial Investigation (RI) (Malcolm Pirnie 2005). The process of producing pulp and paper required a large store of wood chips, acid digestion facilities, blow pits, bleaching plants, hog fuel boilers, a limerock scrubbing tower, landfill disposal staging areas, and a digestion chemical storage lagoon. Air emissions were regularly discharged from the mill's boilers and limerock towers as part of normal operations, and were regulated by Ecology. From 1930-1972, site stormwater and non-treated process wastewater was discharged directly into the Harbor at five nearshore outfalls (Figure 3). In 1972, a primary wastewater treatment plant and sewer system was built that re-routed all Harbor discharge to one deepwater outfall equipped with an end diffuser (Figure 2). This outfall extends 7,900 feet toward the Strait of Juan de Fuca (Malcolm Pirnie 2005). An average of 39 million gals/day of effluent was discharged from the deepwater outfall during mill operations. In 1979, Rayonier constructed a secondary treatment system to further segregate and treat process wastewater and stormwater. At present, stormwater is dispersed from the property via percolation through the soil (for most of the industrial areas), as well as by four outfalls that discharge into Ennis Creek (Malcolm Pirnie 2005).

3.1.2 Cleanup and Remedial Investigations

For the past thirty years and prior to final closure, the mill property has been the focus of numerous internal and external environmental investigations, in relation to both routine regulatory compliance and documented spill/leak response and site remediation (E & E 1998 and 1999, Malcolm Pirnie 2005 and 2007). These investigations are summarized, and further in-depth information can be found in referenced documents (E & E 1998 and 1999, Integral 2006, and Malcolm Pirnie 2005 and 2007).

Numerous NPDES discharge violations were noted in the period 1975-1980 prior to and immediately after installation of the secondary effluent treatment facility (Shea et al. 1981). Violations were mostly for pH exceedances or failure of effluent bioassay tests (E & E 1998). Rayonier's operations were also monitored for particulates by local air authorities starting in 1974 (Foster Wheeler 1997), and beginning in 1990, were additionally regulated under Ecology's Air Pollution Control Regulations (Ecology Regulatory Order DE80-196) (EPA 1993) until mill closure. Due to noted air quality violations, the Ecology order required monitoring of sulfur dioxide, particulates, and opacity on boiler stacks and the two rock towers. Air emission violations involving chlorine, ammonia, and sulfur dioxide occurred in excess of a dozen times during 1990-1997 (E & E 1998). Air violations prior to that period were not determined.

From 1988 to 2002, several interim cleanup actions were conducted on the site after routine investigations found evidence of contaminant releases. In 1989, hydraulic fluid was observed seeping through the riprap on the west bank of Ennis Creek. Remedial actions for this incident included the removal of soil and riprap adjacent to the creek, ground/surface water quality testing, and habitat restoration (Integral 2006). Confirmatory sampling occurred after soil excavation, and several samples had detections of TPH. In 1990 and 1993, localized hydrocarbons were remediated from soil and groundwater at Fuel Oil Tank #2 and the hog boiler fuel pile area (Integral 2006). In 1995, as part of the National Pollutant Discharge Elimination System (NPDES) permit compliance, Rayonier conducted Dungeness crab (*Cancer magister*) tissue analyses for dioxins near the deepwater outfall (Malcolm Pirnie 2005). Elevated dioxin concentrations were detected in all tissue samples.

Sediment and monitoring actions occurred in conjunction with the removal of over 2,500 sunken logs, 200 creosoted dolphin pilings, and 100 cubic yards of sunken jetty rock in 2000. Monitoring results established compliance with established water and numeric sediment quality criteria (Foster Wheeler 2001) with one sample exceeding SMS criteria for methylphenol. Data was collected on chemicals without SMS criteria (i.e. resins, guaiacols, dioxins), and although there was no evaluation of that data, results prompted the inclusion of these constituents as COPCs in Rayonier's later marine sediment investigations.

After mill closure in 1997, the EPA initiated an Expanded Site Investigation (ESI) to determine if the site should be recommended for the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (E & E 1998 and 1999). The ESI involved the collection of surface and subsurface soil, freshwater and marine sediments, groundwater, and marine shellfish tissue samples from onsite and marine areas. Figure 4 shows sediment sample locations. The ESI found chemical levels of concern in on-site soil, surface water (i.e. Ennis Creek), groundwater, and Port Angeles Harbor marine sediments from Rayonier operations (E & E 1998 and 1999). On-site locations found elevated concentrations of metals, SVOCs, dioxin/furans, phthalates, and PCBs. Marine sediments showed gradients of dioxin/furan congener concentrations in relation to industrial/urban areas, with the highest levels around the mill site and in the west end of the Harbor, and lower levels in the deeper waters toward Ediz Hook. Nearly all samples had elevated SVOCs; metals, PCBs, pesticides, and volatile organic compounds (VOCs) concentrations in samples showed no distinct pattern. Samples from Ennis Creek had exceedance of dioxin toxicity equivalent (TEQ) and detections of elevated phthalates, chromium, and carbon disulfide. For marine biota tissue, metals and dioxins/furans were detected at elevated concentrations in all Harbor stations. Crab samples had elevated PCBs and dioxin/furan congeners, while geoduck (*Panopea spp.*) showed elevated dioxin/furan and mercury levels. Neither SVOCs nor pesticides were found in tissues at any Harbor stations.

The EPA deferred the CERCLA listing and has allowed Washington State to take over the cleanup process under the Model Toxics Control Act (MTCA) (Ecology 1990). Per MCTA requirements, Rayonier conducted a Remedial Investigation and Feasibility Study (RI/FS) at the site in accordance with provisions of an Agreed Order between Ecology and Rayonier (Malcolm Pirnie 2005). The RI was undertaken in two parts – the Uplands Environment (Integral 2006) and the Marine Environment (Malcom Pirnie 2005 and 2007). This report summarizes the marine portion only.

Rayonier RI

Three areas were targeted for sampling in the vicinity of the mill site: 1) Mill Dock, 2) Log Pond, and 3) Deepwater Outfall. Surface and core sediment samples were collected, with most near the mill and outfall areas and a few in nearshore areas of the city of Port Angeles to the west of the site (Figure 4), as well as in the two reference bays Dungeness and Freshwater. Cores (average depths of 2.1-3.2 ft) were located where ESI sampling found SMS exceedances in sediments. Sediment was analyzed for heavy metals, SVOCs, resin acids, guaiacols, dioxins/furans, PCBs, pesticides, ammonia, sulfides, grain size, and total organic carbon (TOC). Bioassays were conducted at select stations based on SMS criteria exceedances from both the ESI and RI sediment results. Benthic fish and invertebrate tissue were collected from site and regional background locations, and analyzed for the above analytes.

Deepwater outfall sediment locations had no exceedances of SMS chemical criteria, although two samples had dioxin/furan concentrations above background levels. No wood debris was found at deepwater outfall stations. Stations within the Mill Dock area had elevated pesticides (DDT or derivatives) and dioxin/furan concentrations above background. Two out of eighteen samples had elevated phenols that exceeded SMS criteria. Fifteen samples detected resin and fatty acid concentrations. One station near Ennis Creek exceeded SMS criteria for PCB concentrations. The mill dock had varying levels of TOC and wood debris: the west side of the dock had TOC greater than 10 percent, while the rest were lower (i.e. averaging 2.8 percent). Cores indicated that some wood debris was present in the top layers. In the log pond area, elevated levels of resin acids and guaiacols, pesticides, PCBs, phthalates, phenols, selenium, and mercury were found at stations. Specifically, dioxins/furans were detected at all 20 sampling stations, most above ERLs and ERMs. The east side of the log pond had the heaviest accumulations of wood debris in the top layers of cores. Resin acids and guaiacols above background concentrations and the highest concentrations of SVOC, mercury, and selenium were also observed in the eastern half of the pond. One station exceeded the SQS for phthalates, methylphenols, and mercury.

Confirmatory bioassay testing at three stations near the mill dock did not reveal acute or chronic toxicity, despite exceedances of SQS criteria for PCBs and phenols at all three stations. All twelve stations in the log pond area did not pass bioassay testing per SMS biological criteria. Marine biota tissue analysis near the mill site and outfall area found widespread elevated tissue concentrations of PCBs and dioxins/furans in horse clam (*Tresus spp.*), coon-stripe shrimp (*Pandalus danae*), and Dungeness crab. Other chemicals found in tissue to varying degrees above background or EPA RBCs included DDT and PAHs in horse clam, geoduck, shrimp, Dungeness crab, and rock sole (*Lepidopsetta polyxystra*). Inorganic arsenic, lead, mercury and other heavy metals were found in varying concentrations in sampled biota. Based on bioassay results and chemistry exceedances, the log pond area was identified as an area of concern along with the Port Angeles Harbor stations (Figure 4). Phenols were not detected in any tissue at the mill site or in Port Angles Harbor.

RI Phase II Addendum

A second, addendum sampling was conducted for the RI to further characterize PCB and dioxin/furan sources at the Rayonier site and harbor-wide. Surface and core sediment samples were collected from the mill dock area, the log pond, and within nearshore and inner Harbor areas. Biota tissue was collected from the southwest corner of the mill dock, at the eastern edge of the log pond area near the breakwater, and within two reference bays. Tissue collected included horse clam, Dungeness crab, and geoduck, although geoducks were only collected from Freshwater Bay.

The highest levels of dioxins/furans and PCBs in sediments were found near the mill dock, in the log pond near the breakwater, and in the west and east end of the Harbor. There were a few high concentrations of PCBs in the west end of the Harbor as compared to the east Harbor. Dioxin and PCB congener patterns were comparable among the mill site and throughout Harbor areas, with a 99 percent correlation between the log pond and west end of Harbor, suggesting a relationship of common pulp/papermill/wood waste sources. Cores confirmed woody debris accumulations in subsurface layers.

Concentrations for PCBs and dioxins/furans in tissue at the site increased from initial sample collections of the RI. This was most likely due to changes in tissue separation methodology and labs reporting lower detection limits for sediment. Dioxins in crab and horse clam were above both RBCs and background. PCBs in horse clam were above background and many exceeded RBCs. Horse clam ages near Rayonier ranged from 1-11 years (average 6), while geoduck in the reference bay ranged 25-78 years.

3.1.3 Other Related Investigations

The Ecology Marine Sediment Monitoring Program (MSMP) was implemented in 1989 to characterize baseline sediment quality conditions and trends throughout Puget Sound (Ecology 1998b and c). Eighty-six stations were established throughout Puget Sound, one of which is located in Port Angeles Harbor with reference in Dungeness Bay. From 1989-1995 co-located sediment, bioassays, and benthic infaunal studies were conducted annually in the southeastern portion of the Harbor. The sediment was analyzed for metals, SVOCs, pesticides, PCBs, resin acids/guaiacols, TOC, total sulfide, and grain size. The Harbor had high TOC (generally greater than 3% for all years), a low detection of PCBs, the highest concentration of resin acids/guaiacols of any bay sampled, and was above thresholds of expected biological effect (ERLs and ERMs) for metals, resins, and hydrocarbons. There were no correlations found between bioassays and chemical concentrations. Benthic diversity, and species richness and abundance were not significantly different than other areas in Puget Sound.

In 1991, the EPA conducted a study on dioxin/furan concentrations in Puget Sound. The Port Angeles Harbor sample station was located near the former mill site and three red rock crabs were collected. The composite had higher than background concentrations of dioxins/furans compared to the reference sample in Dungeness Bay. Dungeness Bay is considered an appropriate reference area for dioxins in Port Angeles Harbor, as it has some of the lowest dioxin/furan concentrations sampled to date in the Strait of Juan de Fuca or Puget Sound (Pers. Comm. Dr. Teresa Michelsen, 2008).

Ecology conducted a Washington State Dioxin Source Assessment in 1998, to further characterize the potential sources of dioxin to the environment and to provide recommendations for source reduction (Ecology 1998a). For wastewater discharges, Ecology identified eight mills (one of which was Rayonier) that operate bleach plants and thus, could contribute substantially to dioxin loads. Rayonier's dioxin load was estimated to be 45% of the total load for pulp and paper mill effluent statewide. The study also determined that hog fuel/wood waste boilers and incinerators rate the highest in importance for further source reduction, and found Rayonier to be one of the highest air emitters of dioxin. However, care should be taken with these interpretations since the study data set was limited by a lack of data from other facilities in Washington.

In 2005, at the request of the LEKT, the WDOH conducted a health exposure investigation of shellfish east of the Rayonier site near the Tribe's usual and accustomed fishing area. Levels of dioxin TEQ in shellfish were found to be within the range of reference samples, and lower than levels typically found by WSDOH in other typical food sources. No advisories were issued for shellfish consumption in the Tribe's fishing area.

3.1.4 Chemicals of Concern

Based on the results of the above investigations, the following contaminants of concern have been identified for the marine and freshwater environments at and near the former Rayonier site:

- Heavy metals from mill processes such as boiler ash production
- SVOCs (PAHs, phenols, phthalates) produced from processes such as lumber storage and also released during documented spills/leaks of petroleum-based substances such as hydraulic fluid and fuel
- PCBs contained in process wastewater effluent and from incidents of leaking transformers
- Dioxins/furans contained in process wastewater effluent and air emissions from hog fuel boilers and the main stack
- Resin acids, guaiacols, ammonia, and sulfides produced from pulping processes and wood waste degradation

3.1.5 Potential Contaminant Pathways to the Aquatic Environment

There are several routes of potential historic migration of site contaminants entering the aquatic environment. The nearshore outfalls were a direct source of untreated process wastewater to the Harbor for 42 years. The deepwater outfall also released treated process effluent for 25 years. There were several documented cases of leaking substances entering groundwater and seeping into surface waters, particularly Ennis Creek. Those sources have been remediated, although the last documented well monitoring associated with the Fuel Tank #2 leak was in 2002 and showed an exceedance of state and federal ambient water quality criteria for pentachlorophenol (Integral 2006). No other COPCs were found above those criteria. The ESI also found contaminants in groundwater samples around the site (E & E 1998). RI upland sampling found detected levels of metals, SVOCs, and pesticides/PCBs in Ennis Creek samples, although these levels were generally below sediment quality benchmarks (Integral 2006). Residual COPCs from spills/leaks cannot be ruled out at this time. Stormwater runoff from unpaved areas on the site may have contributed to the dispersion of hog fuel ash into the log pond area, as discussed previously. Currently, stormwater percolates into the soil and/or flows from portions of the property into four outfalls located on Ennis Creek, and may be a potential pathway. Air is potentially a major source of chemical loading to the Harbor. There are recorded past air emissions from the site that could have been contaminant pathways.

3.1.6 Data Gaps

Despite intensive sampling efforts around the mill for the ESI and RI, the spatial and vertical extent of COPCs in sediment needs further characterization for the following:

- Total 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) TEQ at all areas around the mill site. ESI and RI samples of the deep outfall exceed background levels. Areas around the mill dock, particularly at the upper west end of the dock and extending outwards, and along the direct east side were likewise above reference levels. The log pond has high levels of TOC present in conjunction with some of the highest levels of TCDD at the site along the eastern side of the pond.

- PCBs near and underneath the mill dock structure on the east and west sides and towards the mouth of Ennis Creek. Further spatial coverage of these areas is needed, and nearby samples beneath the dock and near Ennis Creek show levels that exceed SMS criteria.

- Pesticides (DDT and its derivatives) around the mill dock's outer extent as there were numerous samples in the ESI and RI investigations that exceeded ERLs and ERMs; at the mouth of Ennis Creek; and at the outermost edges of the log pond to delineate the spatial extent in sediments.

- Resins, guaiacols, ammonia and sulfides associated with wood waste areas at the dock and log pond. The east side of the dock had wood debris present and had levels of resins/guaiacols above background. The spatial extent from the dock and the northern edge of the log pond out into Harbor waters needs to be delineated.

- PAHs need to be characterized at the mouth of Ennis Creek due to potential hydrocarbon releases from prior fuel spill incidents.

- Phenols at the deepwater outfall were elevated and the sampling spatial coverage was minimal.

- Heavy metals and phthalates within the log pond should be further delineated.

- PCBs, TCDD TEQ, resins/guaiacols, and TOC for urban areas around the Harbor, particularly for areas where wood byproducts and debris is located

The depth of wood debris around the mill dock and in the log pond area needs further delineation. Penetration of cores was limited in the log pond and no cores were taken in the intertidal areas. Cores should also be collected throughout the site and not only in areas that have surface exceedances of SMS criteria. COPC depth in the sediment may vary with depositional rates, as reflected in Rayonier's results for certain chemicals (e.g. PCBs and resin acids concentrations were sometimes higher in deeper sediment layers). Depositional rates are currently undetermined in the mill area, and surface sediment may not be indicative of subsurface layers. Cores with depths up to a minimum of 4 feet are needed to determine potential COPCs levels from historic periods of Rayonier's operations (Malcolm Pirnie 2005). Additional coring is necessary to accurately characterize the extent of vertical concentrations and wood debris in the subsurface sediments.

The extent of potential biological impacts needs further characterization since chemical concentrations in marine biota above levels of concern are widespread for most chemicals. There was limited bioassay sampling in the mill dock area by the RI and none was conducted for the ESI. RI bioassay testing was only conducted at three stations in the mill dock area. Bioassays were only conducted where SMS criteria were exceeded in surface sediments. This limits the full characterization of the site and leaves out COPCs that have no SMS criteria. Further bioassays should be conducted in areas of the site where wood debris is present, where COPCs are found above background levels, and in areas with SMS exceedances that were not fully characterized. These areas include the mill dock (including east of the dock), the outfall, the mouth of Ennis Creek, and the Sequim Bay reference. Guaiacols, found in elevated concentrations throughout the site, were not analyzed in tissues and should be included as a biological tissue analyte. Longer lived species (e.g. geoduck, higher fish predators) were sampled only in reference bays and not at the mill site. Geoduck can live up to 150 years, a life span that would cover the period of Rayonier operations.

3.2 Other Major Facilities by Business Type

3.2.1 Wood Product Facilities

3.2.1.1 Historic and Current operations

As described in the introduction, four major mills and one plywood manufacturing company operated and discharged process effluent into Port Angeles Harbor from 1914 to present (Figure 2). Nippon, formerly Diashowa and Georgia Pacific, still operates a large mill on the western end of the Harbor at the base of Ediz Hook. Process wastewater was discharged into the Harbor until the 1960s, at which point a new discharge pipe was built that redirected effluent to the Strait of Juan de Fuca. Current operations include large log-booming areas along the nearshore areas of the west end of the Harbor (Figure 2). There is also a shallow natural lagoon located near Nippon where logs were stored. Merrill and Ring (M&R) Timber is another wood product facility just south of Nippon that once was a lumber and plywood mill with log booming areas in the Harbor, and currently produces wood chips only. Directly adjacent to M&R, Fibreboard Paper Products operated in the western end of the Harbor from 1918 into the 1970s. The Port of Port Angeles also operates and/or leases land for log storage areas in the west end of the Harbor (aka Port Log Dump Yard) (Figure 2).

The numerous over water historic and current log booming areas around the Harbor are leased aquatic lands from WDNR. WDNR currently manages 25 leases within the Harbor, twelve of which are leased by companies expressly for log booming operations. Nippon leases four aquatic areas in the western end of the Harbor along Ediz Hook. In 2001, Nippon conducted sediment sampling in one of these areas (approximately 85.7 acres) per WDNR lease requirements to characterize sunken log/woody debris distribution and augment data on surface sediment quality (Figure 4) (Anchor 2005). The study found a high density of submerged logs in the east central and southwestern portions of the lease parcel, and TOC was highest in the western portion of the parcel. Sediment chemistry indicated no exceedances of SMS criteria for metals, although mercury in the southwestern sample was only slightly below SMS levels.

The K-Ply plywood mill is located along the center shoreline of the Harbor near the Port of Port Angeles, and operated from 1941 to recently (Figure 2). The facility had historical and current log-booming areas in the Harbor (SAIC 1999), and regularly discharged wastewaters such as boiler water treatment, boiler blowdown, and non-contact cooling water into the Harbor. As noted by Ecology's NPDES permit fact sheet, these waste streams may have contained pollutants since the active control measures applied to the wastewater streams were found to have been unreliable and not of sufficient capacity to remove pollutants prior to discharge into the Harbor (Ecology 2002). In 2004, K-Ply was cited for noncompliance for the discharge of boiler ash and ash-contaminated water to the storm system, and was required to implement Best Management Practices (BMPs) to prevent the exposure of ash, fiber, and petroleum products to stormwater (Ecology 2004). In 1990, the facility had a hydraulic oil leak from press machinery into soil and groundwater under the mill structure. Penta-contaminated soils were found beneath the building, but were not excavated due to risks to the structural integrity of the building. As part of the cleanup, groundwater monitoring occurred from 1998 to 2002 and indicated increasing concentrations of benzene and gasoline (not associated with the hydraulic leak) in certain monitoring wells (Ecology 2005). Recent groundwater monitoring has detected light non-aqueous phase liquid (LNAPL), up to 0.43 ft (.13 m) thick, in one well during January 2007 (Ecology 2007a).

The facility is identified as part of the Marine Trades Area Group (MTA), an area of multiple parcels of waterfront land owned by the Port of Port Angeles and Chevron/Texaco. The MTA includes marine terminals 1 and 3 (a.k.a the Standard Oil Pier), the log sort yard, the K-Ply plant, and four former bulk fuel facilities (Chevron, Standard Oil, Arco, and D&D Distributors/Phillips 66) (Figure 4). The MTA is currently undergoing remediation due to the presence of gasoline, diesel, and benzene in soil and groundwater.

In 1999, a survey was conducted to map the extent of wood waste on the Port Angeles Harbor bottom and to assess the sediment quality (i.e. dissolved oxygen content) and biological impact from this accumulation (SAIC 1999). The log pond area of Rayonier was included in the study area. The survey found significant layers of wood pulp and debris, including logs and large wood chips in historic and active log booming areas (Figure 2). Sediments in nearshore areas by the Nippon facility, the public log dump grounds, the booming grounds near K-Ply, and the Rayonier grounds bordered on anoxia, and stressed benthic communities were generally observed in these areas. The north and west portions of the

Harbor had the greatest accumulation of wood waste, and degraded benthic habitat was observed in nearshore areas of the western Harbor.

A data review of all available sediment chemistry data (Figure 4) from the western Harbor area indicates a few potential trends in sediment contaminants. TOC levels are very high near dense log booming areas, specifically near the Nippon plant, the Port Angeles Log Dump Yard, and K-Ply's log booming areas. Metals, including mercury, have a high concentration signature in the Inner Harbor Area, from south of the Nippon mill down to the edge of the old Fibreboard property. A strong PCB signature exists in front of the M&R Timber dock, along the Fibreboard site, and in deeper waters in front of the Boathaven Marina. Portions of the M&R property were once a former shipyard (Pers. Comm. Clay Patmont, Anchor 2008). Dioxin/furan hotspots are present throughout the Inner Harbor and Marina areas.

3.2.1.2 Chemicals of Concern

Based on historical and present-day activities, areas near the above referenced properties may have been potential sources of the following:

- Resin and fatty acids, guaiacols, ammonia, and sulfides from wood waste byproducts and log booming areas
- High TOC and lower dissolved oxygen conditions associated with wood waste byproducts and log booming areas
- PAHs associated with fuel leaks/spills and heavy machinery use
- PCBs and dioxins/furans from hydraulic fluid spills/leaks, and common processes from pulp and paper mill wastewater streams, including wood bleaching, hog fuel burning and wood waste. Penta-produced dioxins/furans may be an important source from the K-Ply and Fibreboard facilities, as well as from other lumber mills if penta was used as a wood preservative.
- Metals and PCBs associated with former shipyard and marina activities
- Volatile solids associated with sludge beds

3.2.1.3 Potential Contaminant Pathways to the Aquatic Environment

Contaminant pathways to the Harbor include log rafting, groundwater routes via accidental spills/leaks, air emission violations, dredging activities, stormwater runoff from properties, and wastewater discharges from pulp and lumber mill facilities.

3.2.1.4 Data gaps

The 1999 wood waste study highlighted the fact that significant amounts of wood debris associated with historic and current pulp and lumber mill operations contribute to lower dissolved oxygen in sediments and may be impacting benthic communities. TOC, dioxins/furans, ammonia, sulfides, and resin acids/guaiacols potentially associated with wood waste need further characterization in the historic and current nearshore and deep water areas of the Harbor (Figure 2). Bioassays and tissue analysis for bioaccumulative compounds should also be conducted.

3.2.2 Marine/Shipping Services

3.2.2.1 Historic and Current operations

There are numerous marine facilities along the southern central waterfront of Port Angeles Harbor (Figure 5). The Port of Port Angeles operates a full service port with four deep-water marine terminals (T-1, T-3, T-4 and T-7), as well as terminals for ferry service and other industrial activities. The Port has been operating in various capacities for 80 years. Terminal 1 (aka Standard Oil Pier and part of the MTA) was where a WWII aircraft carrier was decommissioned over water in 1990, and dismantling activities may have dropped oil, equipment, and/or parts containing significant amounts of PCBs and metals into the sediment (Pers. Comm. with Larry Dunn 2008). Divers recovered a propeller dropped from the carrier into the sediment. As noted in the previous section, a former shipyard and manufacturing plant was once located in the vicinity of the Inner Harbor area, near M&R Timber. The Port of Port Angeles is an industrial stormwater permittee, and has had incidents when zinc, and/or lead, and/or copper levels exceeded benchmarks of the industrial stormwater permit (Port of Port Angeles 2006). Another important source of metals at shipyards and some other manufacturing types is sandblast grit. Ship-building and repair produce piles of spent sandblast grit mixed with paints potentially containing copper, lead, antimony, and zinc, all of which may migrate into sediments over time. Marine traffic areas also tend to be unusually high in zinc from anodes and in mercury from vessel instruments and anti-fouling paint.

Petroleum releases were anecdotally noted in the 1960s at the MTA, and diesel and gas contamination confirmed through investigations beginning in the late 1980s at various facilities (Floyd Snider 2007). Soil and groundwater contamination was found at the K-Ply facility, as reported in the previous section. Samples from the Port's marine terminal log yard found elevated levels of gasoline and diesel-range petroleum hydrocarbons detected across the western portion of the yard, and soil contaminant concentrations were generally higher in deeper subsurface layers (7-12 ft below ground surface) (Shannon & Wilson 1996). Diesel contamination was found at other bulk plant facilities as well, where benzene, total petroleum hydrocarbons gasoline (TPH-G), and total petroleum hydrocarbons diesel (TPH-D) were found in soil and groundwater exceeding MTCA Method A cleanup levels. In 2005, an Agreed Order was signed between the MTA (Port of Port Angeles and Chevron/Texaco) and Ecology, and an RI initiated (Ecology 2005a). The RI found that neither free product nor TPH-D in groundwater extended across Marine Drive into the Harbor, despite a zone of freshwater/marine mixing in subsurface waters adjacent to the bulkhead. The RI concluded that contamination is apparently limited to shallow groundwater and does not appear to be transported into deeper groundwater by vertical gradients. The MTA is in the process of developing a Feasibility Study to identify cleanup levels and remediation actions (Floyd Snider 2007). The MTA group is considering developing site-specific soil cleanup and remediation levels for TPH (Ecology 2008b). The MTA is currently undergoing soil and groundwater remediation and monitoring under the Agreed Order.

There are several boat moorage areas and one marina in Port Angeles. The Boathaven is a large marina facility owned by the Port of Port Angeles located north of Terminal 1 and the Standard Oil Pier (Figures 4 & 5). The marina encompasses 16.1 acres and provides permanent and temporary moorage space for over 500 boats (http://www.portofpa.com/marinas/port-angeles-boat-haven.html). The adjacent Boat Yard and commercial businesses provide repair services, retrofit services, haul out services, charter services, bait shops, and restaurants for the marina. General boat launch areas are also located south of the marina along the harbor waterfront, just north of Terminal 1 and the Standard Oil Pier. The Ferry Terminal, located in the Landings Pier Area north of downtown (Figure 5), provides space for Washington State and BC Columbia ferries, as well as other smaller commercial and recreational vessels. Densely populated marinas and boat launch areas have been associated with high accumulations of PAHs in sediments (Edirveerasingam et al. 2006). Marinas receive PAH loading from the direct release from marine engine exhaust, accidental fuel spills, and occasional oil-burdened bilge-water discharge. As most marinas are sheltered and less subject to currents and wind turbulence, sediment particles, and associated COPCs tend to settle into the sediment. TBT and heavy metals from boat scraping and hull painting activities are also a concern at historic and current boat yards/marinas. TBT tends to be used mostly on larger vessels, while smaller ones may still use copper or other types of anti-fouling paint.

The Port Angeles Graving Dock is located in the western Harbor waterfront area near M&R Timber and the former Fibreboard property. The dock was built and dredged in order to be a staging area for the construction of pontoons used in the Hood Canal Bridge replacement project. In 2003, dredging material characterization was conducted for the Washington State Department of Transportation (WSDOT) (GeoEngineers 2003). They dredged approximately 20,300 yd^3 (15,520 m^3) of material and collected one successful core (depth of 7.5ft) for TVS, TOC, and dioxins/furans. They analyzed the surface sediment portion of the core only, and found TVS and TOC concentrations at 3.5 percent and 2.0 percent, respectively. 2,3,7,8-TCDD was not detected, and other dioxin/furan congeners detected were below MCTA cleanup levels. GeoEngineers recommended further delineation of the wood waste debris.

Many of the marine facilities/businesses and large cargo vessels around the Port discharge stormwater and wastewater into the Harbor (Table 2), and have been and/or are currently regulated by EPA/Ecology for various reasons (e.g. hazardous waste generation, water discharges, air emissions, presence of USTs (Table 4)) (EPA Envirofacts 2008). A brief review of Ecology's records found instances of several facilities with LUSTs and other unspecified enforcement and cleanup actions (Ecology Facility/Site Identification System). These facilities may be potential non-point sources of COPCs to the Harbor.

3.2.2.2 Chemicals of Concern
Based on the above activities near the waterfront, the following are potential chemicals of concern to the Harbor:

- PCBs, SVOCs, TBT, and heavy metals associated with industrial stormwater and ship building/repair/decommissioning activities. TBT and metals specifically found in boat hull paint.

- TPH/PAHs associated with gas and diesel spills, marine facilities' LUSTs, creosote pilings, and boat exhaust.

3.2.2.3 Potential Contaminant Pathways to the Aquatic Environment
Ship building and repair activities conducted at terminals, including the application and scraping of paint from boat hulls, can occur directly over water or on land. If over water, anything scraped or dropped into the water becomes a potential sediment contaminant source. Antifouling paints also leach certain metals. On land, activities can generate potential industrial stormwater runoff impacts. Improperly cleaned up areas or improperly stored hazardous materials can increase the chance of spills/leaks and loading of surface chemicals into stormwater. Saturation of groundwater by contaminants is another potential pathway. Boat exhaust fumes and accidental fuel leaks are potential pathways.

3.2.2.4 Data gaps
The extent of soil and groundwater contamination at areas associated with significant hydrocarbon spills and leaks is not fully delineated, and some sites are currently in a process of active remediation (e.g. MTA). Potential constituents of concern are generated by a multitude of marine-oriented businesses and boat launch areas along the waterfront. The degree of sediment impact from numerous non-point and point source groundwater and industrial discharges to the Harbor is undetermined. Areas of particular concern along the waterfront, due to dense vessel use, are marine terminal areas, marina and boat launch areas, and the Landing pier/Ferry terminal area. The inner Harbor area should be sampled for COPCs as well to determine the potential dispersion from heavily industrialized areas. Investigations at the Graving Dock facility sampled surface sediments and collected one core. Further core sampling and analysis should occur near these areas, along with wood waste delineation.

3.2.3 Creosote-treated Marine Lumber
3.2.3.1 Historic and Current Operations
Wood pilings and other wooden marine structures have been used in waters of the U.S. for over a hundred years. These structures are usually employed as bridge or dock supports and as vessel mooring stations (i.e. dolphins). Marine-use wood has always been preserved with chemicals to prevent deterioration and ruin from wood-degrading marine organisms (e.g. boring clams and crustaceans). World-

wide, creosote is the most commonly used chemical wood preservative (Stratus 2006). Other wood preservatives include pentachlorophenol and arsenicals containing chromium, copper, and arsenic.

Port Angeles Harbor has many commercial facilities located along its shoreline. In January 2008, Ecology took a tour of the entire Harbor waterfront and provided observations and photographs of wooden marine-use structures. Numerous instances of creosote-treated timber used for support pilings and mooring dolphins were noted at the Landings Pier, the boat launch area, at deteriorating boat ramps near K-Ply, and areas along the inner side of Ediz Hook (Figure 4). The condition of these structures varied, with a number of pilings in states of significant decay. Beached creosote timber was documented on the shore of Ediz Hook, west of the Boathaven Marina (Ecology 2008d). Two docks and associated creosote pilings were recently removed by the Washington Department of Natural Resources in the western /central area of Ediz Hook (Ecology 2008d). A NOAA coastal survey map (2006) of Port Angeles Harbor denotes areas where erect or submerged pilings and dolphins are located. Approximately 39 areas harbor-wide are shown to have pier structures, pilings, or dolphins.

3.2.3.2 Chemicals of Concern

Creosote is a distillate of coal tar and its compounds are derived from several chemical classes, including PAHs, alkyl-PAHs, tar acids/phenolics, O-heterocyclics/furans (dibenzofurans), and aromatic amines (e.g. aniline). The class of PAH compounds found in creosote include the following: phenanthrene, naphthalene, acenaphthene, fluorine, 2-methylnapthalene, pyrene, anthracene, and chrysene. A majority of these aromatic hydrocarbons are found on the EPA's List of Priority Pollutants, pursuant to the CWA (Stratus 2006).

3.2.3.3 Potential Contaminant Pathways to the Aquatic Environment

PAHs can leach out into the environment. The rate at which PAHs leach from treated wood is a complex function of many factors, including water chemistry, temperature, and salinity, as well as wood type and age. In general, past practices in the wood treating industry resulted in over-saturation of the wood, increasing leaching on the surface of pilings, and pooling in soils or sediments at the base of the piling. More recent industry practices have resulted in a lower tendency to leach PAHs. PAHs in the aquatic environment are present in both dissolved form and adsorbed to particulate materials in the water column. Low molecular weight compounds dissolve more readily in the water column than the heavier PAHs. The higher molecular weight PAH compounds in creosote tend to accumulate in sediment and could be introduced to filter feeding benthic organisms (Stratus 2006). Specific identification of hydrocarbon patterns has found that PAHs in sediments were related to creosote-treated structures (Kinney 2005).

3.2.3.4 Data Gaps

A review of available data shows that there is a general lack of information on the extent of creosote timber present in the Harbor and its possible influence on sediment and water contamination.

3.2.4 Petroleum Storage Facilities

3.2.4.1 Historic and Current operations

Petroleum storage and transport businesses have historically operated and currently conduct business along the Port Angeles waterfront. Up to eight petroleum bulk plant and terminal facilities have been operating at any one time, with five major facilities closed in the early 1980s (Table 1). A bulk plant is an intermediate fuel distribution facility where delivery to and from storage tanks is by cargo tank, and may have either USTs or aboveground storage tanks (ASTs) (CA EPA 2007). Chevron operated two bulk plants near the central industrial waterfront, the first of which opened in 1922 and later became Unocal. The second plant (currently Pettit Oil) is a part of the MTA, along with former bulk plants owned by Arco, Standard Oil, and Phillips 66. BP America Inc. currently operates a bulk fuel facility located on the western edge of Ediz Hook, directly neighboring Nippon. Various other types of petroleum-based facilities with above and below ground storage tanks along the waterfront include a propane supplier (Ferrellgas), the U.S. Coast Guard station on Ediz Hook, and gas stations.

Many of these facilities have had enforcement and/or cleanup actions associated with spills and leaks from LUSTs, ASTs, or damaged infrastructure (Table 4). As discussed in previous sections, the Port's MTA is currently conducting monitoring and remediation actions as a result of petroleum contaminated soils and groundwater. The Unocal plant is also undergoing interim remediation actions and will conduct an RI/FS for soil and groundwater petroleum contamination (Ecology 2007b). In 1984, Ecology found leaks in diesel and gasoline lines during an inspection at the Unocal plant, whereby installed monitoring wells contained free product in the groundwater. Ten years ago, Unocal stopped removing free product from the groundwater when the recovery well collapsed, but continued to monitor groundwater. In 2007, Ecology and Chevron signed an Agreed Order under MTCA for cleanup. Several of the regulated facilities in Table 4 have noted discharge and/or air emissions for benzene, methanol, PAHs, dioxin, and lead.

The U.S. Coast Guard Station decommissioned 14 USTs on Ediz Hook in 1996 and found TPH contamination in groundwater during closure actions (U.S. Coast Guard 2002). A RI was completed at four areas on the property and analytical results indicated that no TPH or BTEX compounds were detected at concentrations above the MTCA Method A cleanup levels in samples collected from monitoring wells. However, reports from 2003 and 2007 indicated that TPH contaminated soils extend into the Harbor in one area and benzene was detected above cleanup levels in groundwater wells of another area (Ecology 2008e). Since 2002, oxygen release compound (ORC) has been injected into the monitoring wells to enhance the natural degradation process of hydrocarbon contamination in groundwater (U.S. Coast Guard 2005 and 2006). Based on the data, further monitoring and remedial actions are being required by Ecology (Ecology 2008e).

The Harbor has also been the site of several tanker oil spills, one of which was the largest spill in Washington State history. The Arco Anchorage oil tanker ran aground in 1985 on the innerside of Ediz Hook, spilled 239,000 gal (904,713 L) of crude oil into the Port Angeles Harbor, and resulted in 4,000 dead seabirds (Nalder and Cat Le 2004). The Gaz Diamond tanker spilled fuel twice in the Harbor while refueling (Rossiter 2003). In 2002, 1,200 gal (4,542 L) of fuel oil flowed over the side of the tanker and fouled areas of the Harbor and beaches near the innerside of Ediz Hook. The most heavily affected natural resources were in the intertidal zone along the beaches, including eelgrass beds. In 2003, the Gaz tanker again spilled 1,188 gal (4,497 L) of fuel oil when its tanks overfilled during refueling. The oil washed up on beaches and docks along the southern shore of Ediz Hook, where oil was found in nearby commercial fish pens, on docks and boats, at the public boat launch, and in eelgrass beds.

3.2.4.2 Chemicals of Concern

Petroleum-based SVOCs (including TPH, LPAH, and HPAH) and heavy metals from crude and refined petroleum products are the primary chemicals of concern associated with petroleum based facilities and major fuel spills.

3.2.4.3 Potential Contaminant Pathways to Aquatic Environment

As indicated above, petroleum products have entered soil and groundwater at many locations along the Harbor waterfront and groundwater may have been a route for entry into Harbor sediments. Refueling facilities located on docks can result in occasional spills to the water. Air emissions of heavy metals, benzene, and PAHs from some facilities may release those contaminants into sediments. Stormwater runoff from these areas may also be a source of petroleum contaminants. Acute point-source spills, particularly of heavier oil materials, are potential pathways for COPCs into marine sediments and biota.

3.2.4.4 Data Gaps

Investigations around the MTA, Unocal Bulk Plant, and other facilities indicate the need for further delineation of COPCs in soil and groundwater, specifically to determine if contamination from COPCs extends into Harbor sediments. Results from Harbor samples collected in the Rayonier ESI and RI showed no SMS criteria exceedances for PAHs; however, sample coverage around marine terminal areas and on inner shores of Ediz Hook was variable. Further sampling of surface and core sediments from the nearshore marine terminal/boat launch areas, the inner Harbor, and inner Ediz Hook areas are needed.

3.2.5 Municipal Works

3.2.5.1 Historic and Current operations

The city of Port Angeles operates several facilities along the Harbor. The wastewater treatment plant (WWTP) is located near the Rayonier site and has one deepwater outfall discharge point that began discharging in 1969 (Table 2) (Figure 2). Since that time, the WWTP has had occasional untreated effluent discharges to the Harbor (Ecology 1976). In 2006, the WWTP inadvertently released 6 to 8 million gal (23 to 30 million L) of sewage into the Harbor, prompting the Clallam County Health Department (CCHD) to close all beaches Harbor-wide (CCHD 2006). There is anecdotal information from the WWTP that sediment testing was conducted in the last NPDES permit cycle; mercury was found but no PCBs or dioxins (Pers. Comm. with Jeff Young 2008). The city also has an extensive stormwater system operating under an NPDES permit that drains approximately 10,000 ac (4,047 ha) of the Port Angeles watershed. Major stormwater outfalls are dispersed along the waterfront in the following areas: Boathaven Marina, Boat Launch and Standard Oil Pier/Port of Port Angeles Terminals 1 and 3, K-Ply area, Landings Pier, and the area in front of the Red Lion Inn. Historically, there were eleven CSOs that discharged untreated sewer and stormwater discharge into the Harbor (Figure 2). Currently, four CSOs remain, discharging into the Harbor during heavy storms. CSO discharge has occurred an average of 64 times during the period 2003 and 2006 (CPAPWD 2006). The City received several NPDES permit violations for total suspended solids (TSS) in Oct 2007 for 6,652 pounds (lbs) (3.017 kilograms [kg]) per day (with criteria being 5,880 lbs (2,667 kg) per day, and in July 2007 for 5,471 lbs (2,482 kg) per day with criteria being 4,998 lbs (2,267 kg) per day (City of Port Angeles 1998).

Recently, there was a report of vandalism to transformers resulting in an oil spill at the Port Angeles Light Operations Transformer Yard (Ecology 2008c). Approximately 300 gal (1,136 L) of transformer oil leaked. Some of this oil may have reached nearby Tumwater Creek, which flows approximately 0.75 mi (1.2 km) to the Harbor. Soil was removed for testing, and a construction oil/water separator was installed onsite for surface water runoff. Test results are still pending. There were also recent petroleum leaks into Tumwater Creek from a Pacific Pride commercial refueling station, located off Tumwater Road, approximately ½ mile from the Harbor (Pers. Comm. Doug Stolz, Ecology 2008). Ecology investigations found signatures of lube oil constituents and diesel fuel originating from a stormwater pond that discharged to the Creek. The facility has conducted several remediation actions, and source control/cleanup activities are on-going.

3.2.5.2 Chemicals of Concern

The WWTP receives leachates from the Mt. Pleasant Landfill, which holds solid waste from the decommissioned Rayonier Pulp Mill. Metals and organic chemicals in biosolids or final effluent may be a concern. Untreated sewage spills, stormwater discharge, and CSO discharges to the Harbor are of concern in marine sediments for the following: TOC/TSS, heavy metals, and various synthetically generated chemicals (phenols, phthalates, dioxins, PCBs/pesticides). The potential release of PCBs and SVOCs (TPH/PAHs) associated with the City Light transformer vandalism, and the SVOCs from the Pacific Pride leaks are both direct sources of those contaminants into the Harbor via Tumwater Creek.

3.2.5.3 Potential Contaminant Pathways to Aquatic Environment

Stormwater, CSO, and sewage from the deepwater WWTP all discharge directly into the Harbor, and serve as both direct and indirect potential sources of COPCs to Harbor sediments.

3.2.5.4 Data gaps
Stormwater and wastewater are regulated so that effluent discharge limits are protective of surface waters. However, the effects of municipal discharge on the Harbor during incidents when untreated effluent is released are not well documented in the Harbor. In 2000, an independent assessment of the WWTP's contaminant monitoring processes was conducted (Strand 2000). Influent liquids, biosolids, and final effluent liquids were collected at the City of Port Angeles WWTP in 1999 and 2000. The results indicated: 1) biosolids from the WWTP contain mercury and cadmium at concentrations that routinely exceed MCTA levels, and 2) the frequency and the number of biosolids and final effluent samples collected for chemical analyses of all analytes (conventionals, metals, pesticides, PCBs, volatile and SVOCs) are insufficient and should be conducted quarterly.

More sediment characterization near outfalls, particularly CSOs and the City's WWTP outfall is needed with respect to heavy metals, PCBs, TOC, and dioxins/furans. Also, sediment at the mouth of Tumwater Creek should be monitored for PCBs.

3.2.6 Commercial Fish and Shellfish Harvesting
3.2.6.1 Historic and Current operations
Several seafood-oriented businesses are located on Ediz Hook. The Ediz Hook Salmon Club is an EPA/Ecology regulated facility for the presence of USTs. In 1996, the Salmon Club had USTs removed and received a NFA for cleanup efforts (Tank Services Northwest 1996). There are large salmon fish pens owned by Sea Farms located off the central inner side of the Hook (Figure 4). Benthic community health near the Sea Farm pens has been studied in the past in relation to potential impacts from salmon wastes on the seafloor. Streamkeepers gave the area around the pens a healthy listing (CCDCD 2004). In 1991, the EPA conducted dive surveys at various fish pen operations around Puget Sound, including Port Angeles Harbor (PTI Environmental Services 1991). The EPA collected sediment and infauna from transects near the pens. Sediment was analyzed for TVS, nutrients, total sulfides, BOD, COD, TOC, TSS, and ammonia, and benthic indices of diversity and abundance calculated. The study found that benthic impacts, when present, were most intense under and immediately adjacent to the pens. The distance of the impact zone varied from zero to more than 200 feet.

3.2.6.2 Chemicals of Concern
Chemicals that may be associated with fish pens are PCBs, pesticides, and dioxins/furans, all of which are PBTs. Farmed salmon are fed a concentrated feed high in fish oils and fish meal derived from smaller fish that may contain pollutants. Salmon, a relatively oily, fatty fish, can bioaccumulate the PCBs, dioxins and pesticides from the feed. A recent study found PCBs in farmed salmon were at levels two to 10 times higher than in other meat sources in the food supply (Kay 2004). Excess feed and feces from the pens is released to the ocean floor, and may introduce COPCs into the sediment and biota, as well as cause habitat damage by smothering the benthic community beneath and around the net cages.

3.2.6.3 Potential Contaminant Pathways to Aquatic Environment

PBTs in sediment and water can be taken in by marine biota through various feeding and filtering uptake mechanisms, particularly for benthic organisms whose life stages are closely associated with the sediment layers. COPCs present in lower-level benthic organisms (clams, shrimp, mussels, worms, etc) may bioaccumulate up the food web to higher level predators (such as rockfish, salmonids, lingcod) for certain compounds such as PCBs, PAHs, heavy metals, and dioxins/furans (Gunther et al. 1999, O'Connor 1991). In-situ bioturbation by burrowing organisms (e.g. geoducks, clams, and worms) can also re-suspend/re-release contaminants back into the upper surface sediment layers and water column. Releases of pesticides, PCBs, and dioxins/furans from the feces of pen-reared salmon into sediment may be occurring based on current literature studies (PTI Environmental Services 1991, Kay 2004).

3.2.6.4 Data gaps

Sediment and bioassays beneath salmon fish pen areas should be characterized for PCBs, dioxin/furans, SVOCs, and pesticides. Testing of the feed associated with those pens would also be advised for evaluating chemical sources.

3.2.7 Residential

3.2.7.1 Historic and Current operations

The Port Angeles community supports a regionally significant urban and rural population. Residents outside the city limits are on septic systems that are in various stages of maintenance. All residential areas are drained by stormwater runoff. Paved and unpaved surfaces may contain applications of terrestrial pesticides, fertilizers, and other common home and automotive products. Residential areas are also served by numerous types of commercial businesses and busy highways.

3.2.7.2 Chemicals of Concern

SVOCs (especially PAHs), PCBs (still found in some consumer products), phthalates, and heavy metals are found in common commercial and residential products, as well as on road surfaces. These chemicals become associated with stormwater runoff from yards, roads, and other paved surfaces, and may also be flushed to septic systems. Conventional contaminants, fecal coliforms, personal care products, and pharmaceuticals may be contaminants of concern in septic or sewage discharges.

3.2.7.3 Potential Contaminant Pathways to Aquatic Environment

Communities reside all along the upper and lower watersheds of the creeks that flow into the Harbor. Stormwater runoff from these areas may be a non-point source of Harbor contaminants. Leaking septic systems may also be contributing chemicals of concern into surface and groundwaters.

3.2.7.4 Data gaps

Poor septic system maintenance has been listed as one important non-point source to the creeks and the Harbor (CCMRC 2001). The Clallam County Marine Resource Committee (2001) also noted that water quality declines from point and non-point pollution have resulted in ulvoid blooms on Clallam County beaches and a decline in nearshore habitat quality. Clallam County Streamkeepers conduct frequent water quality sampling, stream invertebrate collections, and physical habitat assessment on creeks around the Harbor. Tumwater Creek and Ennis Creek water quality were noted as impaired and compromised due to various types of pollution, both bacteriological and chemical. Sampling for the above chemicals of concern should occur near the mouth of all creeks entering the Harbor to discern possible contamination from non-point sources throughout the watershed.

4 Biological Resources within the Harbor and Relationship to Sediment Contamination

There are historic and recent data on the health and characterization of biological communities in the Harbor (Table 5). Studies on Harbor clam populations in the 1970's found viable populations of commercially important and non-commercial clams and concluded that the Harbor had all the requirements necessary for sustainable clam populations (Bishop & Devitt 1970 and Goodwin & Westley 1969). Those clam surveys found that beach areas near Rayonier had only pollutant-tolerant species and very low diversity, while the Ediz Hook area had higher species diversity and included the presence of other macroorganisms (annelids, crustaceans). Black sludge was noted near Rayonier and Red Lion beaches, although no chemical analyses were conducted. A geoduck tract was also identified in the vicinity of the Red Lion area in the central nearshore Harbor (Goodwin 1973). This tract is currently listed as a non-commercial bed (WDFW 2008). Recreational and commercial shellfish harvesting for geoduck and other clam species is closed in Port Angeles Harbor due to pollution by various sources (biotoxins and/or contaminants) (WA DOH 2008a). Shrimp and Dungeness crab are important commercial and fishery resources of the Harbor, although there have been recent advisories against the consumption of crabs, and recommendations limiting the consumption of rockfish (*Sebastes spp.*), due to high levels of PCBs and dioxins found by the Rayonier RI study (CCHD 2007, Shaffer 2001, and WA DOH 2008b).

Common fish present in the Harbor include salmonids (pink (*Oncorhynchus gorbuscha*) and chum (*Oncorhynchus keta)*), forage fish (herring (*Clupea pallassii*), sand lance (*Ammodytes hexapterus*), smelt (*Hypomesus pretiosus*)), flatfish (sole and flounder species (*Family Pleuronectidae*)), perch (*Family Embiotocidae*), sculpin (*Family Cottidae*), gunnels (*Family Pholididae*), rockfish (*Sebastes sp*.) and lingcod (*Ophiodon verrucosa*) (CCMC 2001, Pers. Comm. with Kurt Fresh 2008, Shea et al. 1981). Recent preliminary data on fish characterization in the Harbor has found healthy numbers of juvenile salmonids, forage fish, flatfish, and pelagic fish (Pers. Comm. with Kurt Fresh 2008). Most of the nearshore areas in industrial sections of the Harbor provide poor salmonid habitat, while eastern Ediz Hook and the beaches near the Red Lion area and east of Rayonier provide better potential habitat (Pentec Environmental 2001). Sport fishing for salmon, lingcod, Pacific halibut (*Hippoglossus stenolepis*), rockfish, and greenling (*Hexagrammos sp*.) is a viable and productive component of the Port Angeles economy (City of Port Angeles 1989). Port Angeles has identified the following areas for biological habitat improvement: the Nippon lagoon, restoration efforts at the mouths of Ennis, Peabody and Tumwater creeks, and eelgrass establishment along Ediz spit (Pentec Environmental 2001).

There are indications that sediment contamination within the Harbor may be impacting biological communities. Benthic communities were found to be impacted in areas of significant wood waste debris (SAIC 1999). Healthy benthic fish and invertebrate communities were found where there was a minimal amount of wood waste debris on the sediment; although some animals were observed associated with wood piles (crustaceans, rockfish, urchins (*Strongylocentrotus sp.*), and sea cucumbers (*Parastichopus californicus*)). In 1968, a study was conducted on juvenile salmonid toxicity and distribution as related to pulp and paper mill discharge in Port Angeles Harbor (Ziebel et al. 1968). Juvenile salmon were found throughout the Harbor, including in the Boat Haven marina. Defined zones of acute toxicity to salmon were found at nearshore areas at Crown Zellerbach, Rayonier, and Fibreboard. The cause of toxicity was determined to be sulfides originating from significant sludge deposits in these areas. In 1973, M&R Timber purchased a former Fibreboard dock and wanted to dredge the area around the dock. Prior to dredging, significant sludge beds and abnormal biological activity (i.e. invertebrate kills) around the dock were noted by divers (Ecology 1973). The beds were further investigated by Ecology and consolidated sludge beds were noted as being void of fish activity, lacking benthic burrowers, and having a slow fanning rate of barnacles on pilings. Volatile solids were also found in the sludge, and measured 14% above EPA dredging standards (Ecology 1973). As previously mentioned in Section 3.1.2, tissue and toxicity sampling conducted as part of the investigations associated with the Rayonier Mill site have shown indications of potential biota impacts from sediment COPCs.

4.1 Chemicals of Concern

Sulfides generated from the decomposition of consolidated sludge beds and wood waste accumulations within the Harbor may be impacting biota. Dioxins/furans, PCBs, heavy metals, TBT, resins/guaiacols, and PAHs are all sediment PBTs potentially generated by sources throughout the Harbor. These PBTs have a higher likelihood of impacting biological communities.

4.2 Potential Contaminant Pathways to Aquatic Environment

Marine biota in Port Angeles Harbor may be at risk for bioaccumulation of contaminants found in sediments either through direct uptake of contaminants by benthic organisms, or by indirect biomagnification of chemicals up the food web.

4.3 Data gaps

There have been recent contrasts in contamination assessment of biota. Some studies found no significant risk of bioaccumulative concentrations in crabs and clams, and thereby human consumption of those species (WADOH 2005). Data from other studies (i.e. ESI, Rayonier RI, and early 1970's toxicity-based studies) found indicators that biota may be at potential risk from sediment contaminants in the vicinity of Port Angeles Harbor. Further bioassays and biological tissue analysis for the suite of COPCs in areas of concern are needed.

5 Summary of Data Gaps

Analysis of existing information for Port Angeles Harbor has included a review of the historical and current industrial, commercial, municipal, and residential activities prevalent around the waterfront. This review has also used data from prior marine sediment and biological investigations throughout the Harbor. Based on the available information, the most important data gaps and areas of concern include the following (Figure 4):

- The spatial extent and contaminant concentration of wood waste debris and by-products found in specific areas of the Harbor as identified by the SAIC 1999 study. These areas of wood waste are directly associated with log rafting, pulp, paper, and lumber mill activities, and COPCs include dioxins/furans, resin and fatty acids, guaiacols, ammonia, sulfides, and TOC. Sediments, bioassays, and tissue analyses are needed. The lagoon located at the western crook of Ediz Hook and the Harbor needs to be sampled as well to characterize potential sediment contamination associated with pulp and paper mill activities.

- Dioxin/furan contaminant signatures associated with possible penta use by lumber and wood product mills at likely locations, i.e. K-Ply, M&R Timber, and Fibreboard properties.

- Petroleum contamination of sediment needs to be assessed in likely areas of concern that have been associated with petroleum-based industry, shipping/boating, and stormwater runoff from major roads. Areas of concern are the Boathaven Marina, Port of Port Angeles MTA and specific terminals (Boat Launch/Standard Oil Pier/Terminal 1), Barge Area, Landings Pier, Rayonier site, Ediz Hook and Inner Hook areas.

- Further characterization and delineation of COPC concentrations in sediment and biota around the Rayonier site is needed. Specifically, dioxins/furans need further spatial and vertical extent delineation throughout the site, while other COPC characterization needs to occur at only specific locations around the site, such as at the old nearshore outfalls, the deepwater outfall, the mouth of Ennis Creek, east of the creek, and the mill dock area.

- Sediment and biota contamination characterization and delineation of areas of the Harbor that receive input from the various direct surface flows, specifically at the mouths of creeks (Tumwater, Valley, Ennis, Lees and Morse Creeks), near the outfall discharges of CSOs, and major stormwater and sewer outfalls. These areas receive point and non-point source influences that may carry COPCs (SVOCs, pesticides, PCBs, metals, dioxins/furans) into the Harbor.

- TBT, heavy metal, and PCB characterization in sediments and biota from areas of concern directly influenced by marine services/shipping facilities and marinas. These areas include the Inner Harbor (specifically near the former shipyard location south of M&R Timber), Boathaven Marina, the Boat Launch/Standard Oil area, and the K-Ply/Valley Creek area.

- Characterization of sediments in association with dense areas of intact, degrading, and/or submerged creosote pilings. PAHs and methylphenols are of particular concern with regard to creosote pilings.

- Sediment and biota characterization is needed where significant intertidal and shallow subtidal beaches are present, and where contact with human populations is increased. For example, beaches commonly used for recreation and recreational shellfish harvesting located in the Red Lion Area and beaches at the spit of Ediz Hook.

- Further characterization is needed of biological impacts from COPCs that are potentially bioaccumulative (pesticides/PCBs, dioxins/furans, TBT, heavy metals, and PAHs). Bioassays for PBTs in areas of concern are needed, as well as biological tissue analysis of likely ecological receptors.

The data gaps identified in this report will help guide the development of the SAP for the Port Angeles Harbor Sediment Characterization Study.

6 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2008. Toxicity Training: Module for Survey of Toxic Substances. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/training/toxmanual/pdf/powerpoint-module-4.pdf

___________. 2006. Toxicological Profile for Phenol (Draft for Public Comment). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

___________. 2002. Toxicological Profile for DDT, DDE, and DDD. *Update*. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

___________. 2000a. Public Health Assessment Rayonier Mill (aka ITT Rayonier Mill) Port Angeles, Clallam County, Washington Agency for Toxic Substances and Disease Registry. CERCLIS No. WAD000490169.

___________. 2000b. Toxicological Profile for Polychlorinated Biphenyls (PCBs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

___________. 1996. Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Anchor Environmental L.L.C. (Anchor). 2005. Sampling and Analysis Report, Sediment Grab Sampling and Log Density Survey, Nippon Paper Industries USA Pulp and Paper Mill Port Angeles Facility. Prepared for Nippon Paper Industries, Port Angeles, Washington. June 2005.

Beaverson, C.A. July 13, 1998. Coastal Resource Coordinator, National Oceanic and Atmospheric Administration, letter to Mark Ader, EPA, Seattle, WA.

Bishop, R.A. and R. Devitt. 1970. A report on the Port Angeles Harbor intertidal clam and biological survey. Tech. Rpt. NO. 70-4. WDOE. 30-43.

California Environmental Protection Agency (CA EPA). August 31, 2007. Air Resources Board definition of bulk plants, website. http://www.arb.ca.gov/vapor/bplants/bplants.htm

City of Port Angeles Public Works Department (CPAPWD). 2006. Maps of Stormwater System and Historic and Current Combined Sewer Outfalls. Port Angeles, WA. http://www.ci.port-angeles.wa.us/PDFs/Stormwater/System%20Map1.pdf. http://www.ci.port-angeles.wa.us/PDFs/PWorks/CSOMap.pdf

City of Port Angeles. Feb 24, 1998. NPDES Permit No WA0023973.

City of Port Angeles. 1989. Port Angeles Harbor Resource Management Plan, Phase III. Prepared for City of Port Angeles and Port of Port Angeles, Port Angeles, Washington. July 1, 1989.

Clallam County Department of Community Development (CCDCD). 2004a. State of the Waters of Clallam County. A report on the health of our streams and watersheds, Streamkeepers of Clallam County, WA.

__________. 2004b. Waters of Clallam County, 2004: A report on the health of our streams & watersheds. Port Angeles, WA

Clallam County Department of Health and Human Services (CCDHHS). June 1, 2006. Press Release, Beaches Reopen after Sewage Spill. Port Angeles, WA.

__________. May 11, 2007. Interim Public Health Advisory Regarding Consumption of Crabs Caught in Port Angeles Harbor. Port Angeles, WA.

Clallam County Marine Resources Committee (CCMRC). 2001. Summary Report on the Clallam County Marine Resources Committee Interactive Public Workshop Series. http://www.clallammrc.org/CCMRC/allframes.html

Dickerson, P. March 3, 2008. Longtime KPly employees wonder about next step, Peninsula Daily News, Port Angeles, WA.

Ecology. March 2008a. Site-Specific Proposal for Modifying the Default MTCA Fish Consumption Exposure Parameters: Questions and Background Information. Prepared for MTCA Science Advisory Board.

__________. 2008b. MTA Work Plan Addendum, Feasibility Study Data Gap Investigation, Westport Marine/Bulkhead Area. Washington State Department of Ecology. January 4, 2008.

__________. 2008c. Report of Transformer Vandalism/Oil Spill Incident ERTS#859343: oil spill by the Port Angels Light Operations Transformer Yard. January 2008.

__________. 2008d. Harbor tour photographs and personal communication with Cynthia Erickson on January 14, 2008.

__________. 2008e. Further Action Determination under WAC 173-340-515(5) for the Ediz Hook Coast Guard Station. Certified letter from Washington Department of Ecology, dated February 15, 2008.

__________. 2007a. 2007 First Quarter Monitoring Report: K-Ply Mill. Washington Department of Ecology. January 2007.

__________. 2007b. Agreed Order No. DE 4086, Union Oil Company of California (Unocal). Prepared by Washington State Department of Ecology, Olympia, Washington. April 2007.

__________. 2005. Agreed Order No. ED 03TCPSR-2738, the Port of Port Angeles and ChevronTexaco Products Company. Prepared by Washington State Department of Ecology, Olympia, Washington.

__________. 2004. General Industrial Storm Water Compliance Inspection Report for K-Ply Inc. May 5, 2004.

__________. 2001. Model Toxics Control Act Clean-Up Regulation Chapter 173-340 (Amended February 12, 2001). Publication No. 94-06, Washington State Department of Ecology, Toxics Cleanup Program, Olympia, Washington. February 2001.

__________. 1998a. Washington State Dioxin Source Assessment. Washington State Department of Ecology Publication No. 98-320.

__________. 1998b. Marine Sediment Sampling Program, I. Chemistry, and Toxicity Testing 1989-1995. Prepared by Washington State Department of Ecology, Olympia, Washington. August 1998.

__________. 1998c. Marine Sediment Sampling Program, II. Distribution and Structure of Benthic Communities in Puget Sound. Prepared by Washington State Department of Ecology, Olympia, Washington. September 1998.

__________. 1995. Sediment Management Standards. Chapter 173-204 WAC. Olympia, WA, 106pp.

__________. 1990. Sediment Management Standards: Chapter 173-204 WAC. Olympia, Washington. Ecology Publication No. 96-252. 106pp.

__________. 1976. Memorandum on Port Angeles STP Class II Inspection. Publication No76-e17, Washington Dept of Ecology, Olympia, WA.

__________. 1973. Memorandum: Investigation of Reported Marine Invertebrate Kill at Old Fibreboard Dock, Port Angeles, Washington. Washington Department of Ecology Publication No.73-e72.

Ecology & Environment, Inc. (E & E). January 1999, Rayonier Pulp Mill Expanded Site Investigation Report for Phase III Tissue Sampling, Prepared for EPA Region10 – Superfund Technical Assessment and Response Team (START), TDD: 97-06-0010.

__________. October 1998, Rayonier Pulp Mill Expanded Site Investigation, Prepared for EPA Region10 – Superfund Technical Assessment and Response Team (START), TDD: 97-06-0010.

Edirveerasingam, V., C. Sandra, and G.C. Miller. 2006. Presence of Polycyclic Aromatic Hydrocarbons (PAH) in the Lake Tahoe Basin. Abstract presented at the American Chemical Society 61st Northwest Regional Meeting. June 25-28, 2006.

Floyd Snider. 2007. Marine Trades Area Site, Port Angeles, Washington, Remedial Investigation. Prepared for Marine Trades Area Group. September 18, 2007.

Foster Wheeler. 2001. Technical Memo: Summary of Log Pond Survey Scoping Effort for the Remedial Investigations. Prepared for Rayonier Inc., Port Angeles, Washington. January 2001.

Foster Wheeler. 1997. Current Situation/Site Conceptual Site Model Report, Rayonier Port Angeles Mill Site. Prepared for Rayonier Inc., Port Angeles, Washington.

GeoEngineers. 2003. Report Dredged Material Characterization for the Proposed Port Angeles Graving Dock. For Washington State Department of Transportation. January 31, 2003.

Goodwin, L.C. and R.E.Westley. 1969. Supplemental Progress Report – Port Angeles subtidal clam survey. 5 pages plus appendices.

Goodwin, L.C. 1973. Subtidal geoducks of Puget Sound, Washington. WDFW. Tech. Rpt. No.13. 64 pages.

Gunther, A.J., Davis, J.A., Hardin, D.D., Gold, J., Bell, D., Crick, J.R., Scelfo, G.M., Sericano, J., Stephenson, M., 1999. Long-term bioaccumulation monitoring with transplanted bivalves in the San Francisco Estuary. Mar. Pollut. Bull. 38, 170–181.

Integral. 2006. Remedial Investigation for the Uplands Environment of the Former Rayonier Mill Site. Public Review Draft submitted to Washington State Department of Ecology. Prepared for Rayonier, Jacksonville, FL.

Kay, J. 2004. Toxic risks in farmed salmon - consumers told to be wary, Study finds PCBs, dioxins, pesticides, probably from diet. San Francisco Gate Article, San Francisco, California. January 9, 2004.

Kinney, K. 2005. Screening Survey for Petroleum Contamination at Cornet Bay Marina (Island County). Washington Department of Ecology Publication No. 05-03-033. September 2005.

K-Ply Inc. September 2007, Fact Sheet for NPDES Permit WA 0038059.

Li, K., T. Chen, P. Bicho, C. Breuil and J. N. Saddler. 1996. A Comparison of Gas Chromatographic and Immunochemical Methods for Quantifying Resin Acids. In M. Servos, K. Munkittrick, J. Carey & G. Kraak (eds.), Environmental Fate and Effects of Pulp and Paper Mill Effluents. St. Lucie Press, FL. Pp: 119-127.

Long, E.R., and Morgan, L.G. 1991. The potential for biological effects on sediment-sorbed contaminants tested in the National Status and Trends Program: National Oceanic and Atmospheric Administration, Technical Memorandum NOS/OMA 52.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management 19(1), 81-97.

Malcolm Pirnie. 2007. Phase 2 Addendum Remedial Investigation For The Marine Environment Near The Former Rayonier Mill Site, Prepared for Rayonier – Jacksonville, Florida. February 2007.

Malcolm Pirnie. 2006. Remedial Investigation for the Marine Environment near The Former Rayonier Mill Site, Prepared for Rayonier – Jacksonville, Florida. April 2006.

Marine Resources Committee (MRC). 2008. Whatcom County MRC Projects – Marine Creosote Log Remediation Project. http://whatcom-mrc.wsu.edu/MRC/projects/restoration_creosote.htm

Nalder, E. and Phuong Cat Le. October 15, 2004. How investigators track oil culprits Chemists employ 'fingerprinting' -- but sometimes more is needed. SEATTLE POST-INTELLIGENCE, Seattle, Washington.

National Oceanic and Atmospheric Administration (NOAA). 2007. Mussel Watch Status and Trends: Sampling for Coastal Trends, Contaminants Monitored List. January 30, 2007. http://celebrating200years.noaa.gov/datasets/mussel/welcome.html#con

__________. 2006. United States-West Coast, Washington, Port Angeles Coastal Survey Map. National Oceanic and Atmospheric Administration, Seattle, WA. March 2006.

O'Connor, T.P., 1991. Concentrations of organic contaminants in mollusks and sediments at NOAA National Status and Trend sites in the coastal and estuarine United States. Environ. Health Perspect. 90, 69–73.

Oldham, K. July 8, 2007. Port Angeles Thumbnail History, HistoryLink.org Essay 8210.

PAN Pesticides Database. 2008. Guaiacol - Identification, toxicity, use, water pollution potential, ecological toxicity and regulatory information. http://www.pesticideinfo.org/Detail_Chemical.jsp?Rec_Id=PC36579

Pentec Environmental. 2001. Port Angeles Harbor Shoreline Habitat Assessment. Prepared for City of Port Angeles. December 19, 2001.

Personal communication with Larry Dunn, LEKT Tribal Lead for Rayonier Cleanup Project. February 27, 2008.

Personal Communication with Kurt Fresh, NOAA. March 3, 2008.

Personal communication with Dr. Teresa Michelsen, Avocet Consulting. April 1, 2008.

Personal communication with Clay Patmont, Anchor Environmental. March 19, 2008.

Personal communication with Doug Stolz, Washington Department of Ecology, Spill Prevention, Preparedness & Response Unit. March 31, 2008.

Personal Communication with Jeff Young, City of Port Angeles Public Works Wastewater Department. February 28, 2008.

Port of Port Angeles. 2006. Level Response Letters to Washington Department of Ecology, Industrial Stormwater Permit Section. Port Angeles, Washington. June 19 and December 1, 2006.

PTI Environmental Services. 1991. Puget Sound Estuarine Studies, Procedures for Monitoring Salmon Marine Net-Pens. US EPA Contract No. 68-D8-0085. September 1991.

Rossiter, T. November 6, 2003. Shipping company fined for spilling oil into Port Angeles Harbor. Washington Department of Ecology News Archives. http://listserv.wa.gov/cgi-bin/wa?A2=ind0311A&L=ecology-news&T=0&F=&S=&P=510

Science Applications International Corporation (SAIC). 1999. Port Angeles Harbor Wood Waste Study, Port Angeles, Washington, Final. February 5, 1999.

Shaffer, A. 2001. "Nearshore Marine Habitats", Summary Report: Clallam County Marine Resources Committee Interactive Workshop #5. http://www.clallammrc.org/CCMRC/InteractiveWorkshops_files/keyelements.htm

Shannon and Wilson, Inc. 1996. Phase II Source Investigation Results Marine Terminal Log Sort Yard, Port Angeles, Washington. Prepared for Port of Port Angeles, Port Angeles, WA. March 1996.

Shea, G.B., C.C. Ebbesmeyer, Q.J. Stober, H. Pazera, J.M. Cox, H.M. Helseth, and Hemingway, 1981. History, Dispersion and Effects of Pulpmill Effluents on Receiving Waters: Port Angeles, Washington. Submitted to US Dept of Justice and USEPA.

Strand, J. 2000. Letter to Ms. Darlene Schanfald, Project Director, Rayonier Hazardous Waste Cleanup Project, Olympic Environmental Council: Evaluation of Chemical Analyses of Influent, Biosolids, and Final Effluent Samples Collected by the City of Port Angeles Waste Water Treatment Plant in 1999 and 2000. October 10, 2000.

Stratus Consulting, Inc. 2006. Creosote-Treated Wood in Aquatic Environments: Technical Review and Use Recommendations. Prepared for NOAA Fisheries, Southwest Division. http://swr.nmfs.noaa.gov/wood/Creosote_Report-final.pdf

Tank Services Northwest, Inc. 1996. Underground Storage Tank Site Characterization & Cleanup Report, Ediz Hook Salmon Club Property. Prepared for Public Works Department City of Port Angeles. April 18, 1996.

US Coast Guard. Feb 21, 2006. Groundwater monitoring report, Submitted to Washington State Department of Ecology, Olympia, WA.

__________. March 2005. Remedial Implementation Report, Submitted to Submitted to Washington State Department of Ecology, Olympia, WA.

__________. Jan 2002. Final 2001 Annual Groundwater Monitoring Report, Submitted to Washington State Department of Ecology, Olympia, WA.

U.S. Environmental Protection Agency (EPA). 2006. An inventory of sources and environmental releases of dioxin-like compounds in the United States for the years 1987, 1995, and 2000. National Center for Environmental Assessment, Washington, DC; EPA/600/P-03/002F. (http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=159286)

__________. 2004. Washington State 303(d) list for Port Angeles Harbor. http://oaspub.epa.gov/tmdl/enviro.control?p_list_id=WA48123B4D6&p_cycle=

__________. 1998. Risk-Based Concentration Table, Region III. Office of RCRA, Technical, and Program Support Branch.

__________. 1993. Multimedia Compliance Investigation, ITT Rayonier, Inc., Port Angeles, Washington. National Enforcement Investigations Center, Office of Enforcement, Denver, CO.

__________. 1991. Puget Sound Estuarine Studies: Dioxin and Furan Concentrations in Puget Sound Crabs. EPA 910/9-040.

Washington Department of Fish and Wildlife (WDFW). 2008. Strait of Juan de Fuca Commercial Geoduck Tracts. Commercial Fishing Section, Washington Department of Fish and Wildlife. March 2008. http://wdfw.wa.gov/fish/shelfish/geoduck/strait7.htm

Washington Department of Health (WADOH). 2008a. Shellfish Safety Information, Marine Biotoxin Closure Zones. March 2008. http://ww4.doh.wa.gov/scripts/esrimap.dll?name=BIOVIEW&Left=602000&Bottom=738321&Right=1058000&Top=1360679&Step=2&click.x=217&click.y=220

__________. 2008b. Fish Consumption Advisories. March 2008. http://www.doh.wa.gov/ehp/oehas/fish/fishconadvice.htm#Port_Angeles_Harbor

__________. 2005. Health Consultation: Rayonier Mill Site Exposure Investigation. DOH Publication No. 333-071. Washington State Department of Health.

Ziebel, C., R. Pine, A. Mills, and R. Cunningham. 1968. Field Toxicity Studies and Juvenile Salmon Distribution in Port Angeles Harbor, Washington. Technical Services Division, Washington Pollution Control Commission. October 16, 1968.

A Tables

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Table 1 Timeline of Historical and Recent Major Industrial/Municipal Activities at Port Angeles Harbor

Year	Event/Facility	Description
Appx 400 yrs ago	Port Angeles/Ediz Hook area settled	Settled by Tse-whit-zen and I'e'nis native Americans
mid-1800's	Port Angeles	Settled by European settlers
1914	Big Mill	1st saw mill constructed in Port Angeles, at base of Ediz Hook. Closed in 1930s
1917	Rayonier Mill	US Spruce Production Company constructed a sawmill onsite east of Port Angeles, unused between 1918 to 1929. Olympic Forest Products purchase mill in 1929 and build pulp mill.
1918	Crescent Boxboard Co.	West side of Port Angeles. Later named Fibreboard Products, closed in the 1970s. Dock/land bought by M&R Timber in the 1970s
1921	Washington Pulp and Paper Corp.	Pulp mill constructed at Ediz Hook near Cresent Boxboard. Later named Crown Zellerbach. Then passed to Daishowa, then Georgia Pacific, then Nippon. Still operating.
1922	Chevron Bulk Plant	Begins operations. Name changes to Unocal at unknown point.
1930	Rayonier Mill	Start production of dissolving-grade pulps using an acid sulfite process. In 1937, Olympic Forest Products and two other companies form Rayonier, Inc.
1930-1972	Rayonier Mill	Wastewater and stormwater were discharged from nearshore outfalls
1935	US Coast Guard Station	Built on Ediz Hook
1941	Penisula Plywood Company	Built on center of Port Angeles waterfront. Sold to ITT Rayonier in 1971, then became K-Ply. Closed down March 2008.
1914-1941	Mills backbone of economy	Five major mills operating along the Port Angeles waterfront Big Mill, Crown Zellerbach, Crescent Boxboard Co., Peninsula Plywood, and Rayonier
1921-1960s	Diashowa/Nippon Mill	Discharges effluent from processes into Harbor. Sometime in 60's, closed down outfall to harbor and redirected discharge to Strait of Juan De Fuca
1968	Rayonier Mill	ITT buys Rayonier and name changes to ITT Rayonier, Inc
1969	Port Angeles STP	Comes online and begins municipal discharge.
1972	Rayonier Mill	Construction of primary treatment plant and sewer system
1979	Rayonier Mill	Construction of secondary treatment system
1974-1997	Rayonier Mill	Air emissions monitored for particulates, VOCs, sulfur compounds, chlorine, carbon monoxide, nitrogen oxides

Table 1 Timeline of Historical and Recent Major Industrial/Municipal Activities at Port Angeles Harbor

Year	Event/Facility	Description
1972-1997	Deep-water Outfall for Rayonier	Wastewater and stormwater were discharged (average of 39 million gals/day effluent discharged during operations)
1980s	Petroleum Bulk Plants	8 bulk plants operating on or near the Port of Port Angeles. 5 closed in early 1980s.
1984	Unocal Bulk Plant	LUSTs- found contaminated soil and groundwater. Site assigned Hazard 1 ranking.
1985	Arco Anchorage Tanker	Ran aground, spilling crude oil into harbor
1989-2003	Ennis Creek	Hydraulic fluid from the finishing room presses (soil beneath building) noted on creek. Remedial actions to remove soil adjacent to creek were completed.
1990	Port of Port Angeles Terminal 1	WW2 Aircraft decommissioned over water. Divers retrieve propeller dropped through the sediment.
1990	Port of Port Angeles Marine Trade Areas (includes K-Ply)	Hydraulic oil leaked into soil & groundwater beneath mill (K-Ply). Benzene into soil and groundwater at MTA portion of sites (Chevron Bulk Plant, Pettit Oil, Standard Oil).
1992-1993	Port of Port Angeles Marine Trade Areas (includes K-Ply)	Groundwater monitoring 1992-1993. Ecology ranks MTA a hazard 1 (high priority cleanup)
1994	Rayonier Mill	ITT spins off Rayonier name changed back to Rayonier, Inc.
1997	Rayonier Mill	Rayonier Mill ceases production, start deconstruction process completed in 1999.
1997	Port of Port Angeles Marine Terminal Log Yard	Last scheduled groundwater monitoring for historic diesel, gas, and BTEX.
1997	Rayonier Mill	EPA (E & E) Expanded Site Investigation
1998-2002	K-Ply	Groundwater monitoring reveals benzene and gas
1999	Harbor wood waste mapping	Wood waste study conducted within entire Harbor by Ecology (SAIC 1999)
2000	Rayonier Mill	Approximately 2500 logs, 200 creosoted dolphins, and sunken rock removed from log pond area.
2002 & 2003	Gaz Diamond Tanker	Spills refined fuel - eel grass beds along intertidal areas affected
2003	Port of Port Angeles Marine Trade Areas (includes K-Ply)	Draft Site Characterization Report confirms soil and groundwater contamination - Ecology Agreed Order in 2005.

Table 1 Timeline of Historical and Recent Major Industrial/Municipal Activities at Port Angeles Harbor

Year	Event/Facility	Description
2006	Port Angeles STP	Major sewage spill into harbor that prompts shellfish consumption advisory
2007	Unocal Bulk Plant	Agreed Order signed; formal cleanup process to begin
2007	Port of Port Angeles Marine Trade Areas (includes K-Ply)	RI completed; Currently developing feasibility study for cleanup.
2008	Port Angeles	Four CSOs still in operation with occasional discharge to harbor
2008	Pacific Pride off Tumwater Road	Petroleum leaks from stormwater retention pond discharged into Tumwater Creek. Current ongoing remedial actions.
2008	Port Angeles Light Operations Transformer Yard	Vandalism spill of oil that may have reached Tumwater Creek. Awaiting soil test results

Table 2 Current and Historical Dischargers in the Port Angeles Harbor Area

Harbor Area	Facility	Began Discharge	Ceased Discharge	Principal Discharge Type	Receiving Waters	
					Previous	Present
Ediz Hook						
	U.S. Coast Guard Air Station	1970	N/A	Oil Wastewater	Harbor	Harbor
	Cypress Island Inc			Water Discharge	Harbor	Harbor
	BP America	November 2001	N/A	Stormwater	Harbor	Harbor
	Crown Zellerbach Corp. (Currently Nippon Paper Industries)	1821	N/A	Industrial Wastewater Stormwater	Harbor/Straits	Straits
Western Inner Harbor						
	M&R Timber, Inc.	1958 (b)	N/A	Non-contact cooling water	Harbor	Harbor
	Green Crow Terminal 5	April 2004	N/A	Stormwater	Harbor	Harbor
	Green Crow Terminal 5 Log Yard	March 2004	N/A	Stormwater	Harbor	Harbor
	WA DOT Port Angeles Graving Dock	August 2003	N/A	Stormwater	Harbor	Harbor
	Marine Drive Chip Yard			Water Discharge	Harbor	Harbor
Port of Port Angeles						
	Port Angeles Marine Terminal 7	September 2002	N/A	Stormwater	Harbor	Harbor
	Port Angeles Port Marine Terminal Log Yard	September 2002	N/A	Stormwater	Harbor	Harbor
	Port of Port Angeles Terminal 5	August 2003	N/A	Stormwater	Harbor	Harbor
	Fred Hills Materials			Water Discharge		
	Port Angeles Marine Inc			Stormwater	Harbor	Harbor
	Port of Port Angeles	March 1998	N/A	Stormwater	Harbor	Harbor
	Port of Port Angeles Marine Trades Area (Chevron, Texaco, Standard Oil, Arco bulk plants)			Stormwater	Harbor	Harbor

Table 2 Current and Historical Dischargers in the Port Angeles Harbor Area

Harbor Area	Facility	Began Discharge	Ceased Discharge	Principal Discharge Type	Receiving Waters: Previous	Receiving Waters: Present
	Atlantic Richfield Co. (ARCO)	1952	November 1976	Oil Wastewater	Tumwater Creek	N/A
	ITT Peninsula Plywood Corp.			Stormwater	Harbor	Harbor
Central Harbor						
	Admiral Marine Construction			Water Discharge		
	Platypus Marine Inc.			Water Discharge		
	Fibreboard Paper Products	1917	November 1970	Industrial Wastewater	Harbor	N/A
	Peninsula Plywood Corp. (Currently K-Ply)	1941 (b)	2008	Industrial Wastewater Non-contact cooling water Stormwater	Harbor	Harbor
	City of Port Angeles	February 1998		Stormwater	Harbor	Harbor
	Port Angeles Car Wash	1972	1977	Industrial Wastewater	Harbor	N/A
	Pres-Sure-Matic, Inc.	1974 (a)	N/A	Industrial Wastewater	Tumwater Creek	Ground
	Delhur Place Road Pit			Water Discharge	Harbor	Harbor
Rayonier						
	Port Angeles STP	1969	N/A	Municipal	Harbor	Harbor
	Rayonier, Inc.	1930	1997	Industrial Wastewater Stormwater	Harbor/Straits	Straits
	Rayonier Mt. Pleasant Landfill	September 2002		Stormwater		

Sources:
- Northwest Environmental Consultants, Inc. 1981. History, Dispersion, and Effects of Pulpmill Effluents on Receiving Waters: Port Angeles, Washington Final Report. Prepared by Northwest Environmental Consultants, Inc. for the U.S. Department of Justice and the U.S. Environmental Protection Agency.
- U.S. Environmental Protection Agency. 2008. Enviromapper for Envirofacts. Accessed online at http://www.epa.gov/enviro/emef/. March 10, 2008.
- Washington State Department of Ecology. 2008. Facility/Site Database. Accessed online at http://www.ecy.wa.gov/fs/. March 10, 2008.

Notes:
(a) Earliest permit and/or application on file.
(b) Date most recent discharging source began operation.

Table 3 Sediment SMS Analyte List Summary

Analyte	Sediment RL 1,2	SQS	CSL
Conventional Parameters			
Total Solids (%)	0.1	--	--
Total Organic Carbon (%)	0.1	--	--
Total Sulfides (mg/kg)	1	--	--
Ammonia (mg/kg)	1	--	--
Grain Size	--	--	--
Metals	**mg/kg**	**mg/kg**	
Arsenic	3	57	93
Cadmium	0.5	5.1	6.7
Chromium	1.3	260	270
Copper	1.0	390	390
Lead	1.5	450	530
Mercury	0.02	0.41	0.59
Silver	1.0	6.1	6.1
Zinc	2.5	410	960
Low Molecular Polycyclic Aromatic Hydrocarbons (LPAH)	**µg/kg**	**mg/kg OC**	
Naphthalene	20	99	170
Acenaphthylene	20	66	66
Acenaphthene	20	16	57
Fluorene	20	23	79
Phenanthrene	20	100	480
Anthracene	20	220	1200
2-Methylnaphthalene	20	38	64
Total LPAH	20	370	780
High Molecular Polycyclic Aromatic Hydrocarbons (HPAH)	**µg/kg**	**mg/kg OC**	
Fluoranthene	20	160	1200
Pyrene	20	1000	1400
Benzo(a)anthracene	20	110	270
Chrysene	20	110	460
Benzofluoranthenes	20	230	450
Benzo(a)pyrene	20	99	210
Indeno(1,2,3-c,d)pyrene	20	34	88
Dibenzo(a,h)anthracene	20	12	33
Benzo(g,h,i)perylene	20	31	78
Total HPAH	20	960	5300
Chlorinated Benzenes	**µg/kg**	**mg/kg OC**	
1,2-Dichlorobenzene	20	2.3	2.3
1,4-Dichlorobenzene	20	3.1	9
1,2,4-Trichlorobenzene	20	0.81	1.8
Hexachlorobenzene	20	0.38	2.3

Table 3 Sediment SMS Analyte List Summary

Analyte	Sediment RL 1,2	SQS	CSL
Phthalate Esters	**µg/kg**	**mg/kg OC**	
Dimethyl phthalate	20	53	53
Diethyl phthalate	20	61	110
Di-n-butyl phthalate	20	220	1700
Butyl benzyl phthalate	20	4.9	64
Bis(2-ethylhexyl)phthalate	20	47	78
Di-n-octyl phthalate	20	58	4500
Ionizable Organic Compounds	**µg/kg**	**µg/kg**	
Phenol	20	420	1200
2 Methylphenol	20	63	63
4 Methylphenol	20	670	670
2,4-Dimethylphenol	20	29	29
Pentachlorophenol	100	360	690
Benzyl alcohol	20	57	73
Benzoic acid	200	650	650
Miscellaneous Compounds	**µg/kg**	**mg/kg OC**	
Dibenzofuran	20	15	58
Hexachlorobutadiene	20	3.9	6.2
N-Nitrosodiphenylamine	20	11	11
Total PCBs	**10**	**12**	**65**

Table 4 Port Angeles Harbor Nearshore Facilities Currently Regulated by Ecology and EPA

Facility	Address	Facility Regulatory Information
Toxic Release		
Admiral Marine Construction	102 Cedar St	Air, Hazardous waste, Stormwater
BP America Inc.	1902 Marine Dr	Air, Enforcement, Hazardous waste, Stormwater, UST
Nippon Paper Industries USA CO	Marine Dr at Ediz Hook	Air, Hazardous waste, Stormwater, UST
K PLY Inc	439 Marine Dr	Air, Hazardous Waste, Stormwater
Rayonier	700 North Ennis Street	Air, Enforcement, Hazardous Waste, Stormwater
Air Emissions		
Admiral Marine Construction	102 Cedar St	Air, Hazardous waste, Stormwater
BP America Inc.	1902 Marine Dr	Air, Enforcement, Hazardous waste, Stormwater, UST
Nippon Paper Industries USA	Marine Dr at Ediz Hook	Air, Hazardous waste, Stormwater, UST
K PLY Inc	439 Marine Dr	Air, Hazardous Waste, Stormwater
Westport Shipyard Inc Port Angeles	637 Marine Dr	Hazardous Waste
Hazardous Waste		
436 Marine Drive Property	436 Marine Drive	LUST/UST
AT&T Port Angeles	W Front Street	Independent/State Cleanup
City Light Utility	Front St and Cherry	UST
Ediz Hook Boat Launch	N/A	Enforcement, Hazardous waste
Ediz Hook Drum II	Ediz Hood Coast Guard Station	Voluntary Cleanup
Ediz Hook Salmon Club	Ediz hook rd	Independent Remedial Action, LUST/UST
Ferrellgas Port Angeles	704 Marine Dr	Hazardous Waste
Fuds Port Angeles AAF	338 W 1st St	Independent Cleanup
ITT Peninsula Plywood Corp.	200 Block Tumwater Truck rte	LUST/UST
ITT Port Angeles Oil Tank site	700 N Ennis	Voluntary Cleanup
ITT Rayonier PA Finish RM Site	700 N Ennis	State Cleanup, Sediments
Jackpot food mart 356	331 1st St W	LUST/UST, Voluntary Cleanup

Table 4 Port Angeles Harbor Nearshore Facilities Currently Regulated by Ecology and EPA

Facility	Address	Facility Regulatory Information
Levaque Co Inc Port Angeles Shingle		LUST/UST
Marine Drive Exxon and Grocery	402 Marine Dr	Hazardous Waste, LUST/UST
Midas Muffler Firestone 31A2	1960 1st St	Independent Remedial Action, LUST/UST
Naftomar shipping port Angeles harbor	NA	Enforcement
Nippon Paper Industries USA Co ltd	1902 Marine Dr	Hazardous Waste
Peninsula Daily News	305 West 1st St	UST
Pettit Oil Co Port Angeles Bulk Plant	727 Marine Dr	Hazardous waste
Pettit Oil Co Port Angeles Warehouse	637 Marine View Dr	Hazardous Waste, State Cleanup
Port Angeles Marine Drive	639 Marine Dr.	Hazardous waste
Port Angeles Marine Inc	832 Boathaven Dr	UST
Port Angeles STP	1509 E Columbia St	Enforcement, Stormwater
Port Angels Port	Marine Dr & B	LUST/UST
Port of Port Angeles Marine Trades Area (Chevron Texaco)	Marine View Dr & Tumwater St	Hazardous Waste, State Cleanup, Sediments
Rayonier Inc Mt Pleasant Landfill	Mt Pleasant access re, approx 0.6 MI	Stormwater
SeaPacific Transmission Line	NA	ORA Project
Tire Town Kolk	501 Marine Dr	LUST/UST
Transoceanic Cable	620 W Front St	Hazardous Waste
Unocal Bulk Plant #0601	738 West Marine Drive	Hazardous Waste
US CG Air Station Port Angeles	Lat 48 08 24 N Long 123 21 30 W	LUST/UST
US CG Group Port Angeles	Marine Dr Ediz Hook Rd	Hazardous Waste
Vessel Alaska Frontier	832 Boathaven Dr	Hazardous Waste
Vessel BT Alaska	832 Boathaven Dr BT Alaska	Hazardous Waste
Vessel Denali	832 Boathaven Dr Denali	Hazardous Waste
Vessel Kenai	832 Boathaven Dr	Hazardous Waste
Vessel Marine Columbia	832 Boathaven Dr	Hazardous Waste
Vessel Overseas Boston	832 Boathaven Dr Boston	Hazardous Waste
Vessel Overseas Chicago	832 Boathaven Dr	Hazardous Waste
Vessel Overseas New York	832 Boathaven Dr	Hazardous Waste
Vessel Overseas Washington	832 Boathaven Dr	Hazardous Waste
Vessel Prince William Sound	832 Boathaven Dr Prince William Sound	Hazardous Waste

Table 4 Port Angeles Harbor Nearshore Facilities Currently Regulated by Ecology and EPA

Facility	Address	Facility Regulatory Information
Vessel Prince William Sound	832 Boathaven Dr Prince William Sound	Hazardous Waste
Vessel Tosina	832 Boathaven Dr Tosina	Hazardous Waste
Westport Shipyard Inc Port Angeles	637 Marine Dr	Hazardous Waste
Westport Shipyard Port Angeles Waterfront	Marine Dr & Tumwater St	Hazardous Waste

Table 5 Biological Studies in Port Angeles Harbor Area

Study	Sampling Conducted	Harbor Area	Toxicity/ Chemical Samples?	Biological Collection: Species	Biological Collection: Sample Analysis
Juvenile Salmon Toxicity and Distribution in Port Angeles Harbor (Ziebell et al. 1968)	Beach seining and live box tests with juvenile salmon	Seining at Ediz Hook, Boathaven Marina, Red Lion area, Eastern subtidal beaches; toxicity testing at Crown Zellerbach, Rayonier, Fibreboard	Field toxicity and water quality (including sulfides)	Pink (*Oncorhynchus gorbuscha*) and Chum (*Oncorhynchus keta*)Salmon	NA
Port Angeles Harbor Clam Populations (Goodwin & Westley 1969, and Bishop & Devitt 1970)	Field surveys for clam populations	Intertidal and subtidal areas in Harbor: Ediz Hook, beaches east of Rayonier, Red Lion area	NA	Various clams, crustaceans, annelids, kelp	NA
Port Angeles Harbor Geoduck Populations (Goodwin 1973)	Field surveys for geoduck populations	Intertidal and subtidal areas in Harbor: Ediz Hook, beaches east of Rayonier, Red Lion area	NA	Geoduck (*Panopea generosa*)	NA
Fibreboard Dock Investigation (Ecology 1973)	Dive observations of invertebrate and fish populations at dock and associated sludge beds	Fibreboard dock	Sediment chemistry: pH, COD, sulfides, volatile solids	Mussels, anemones, barnacles, crustaceans, sea urchins	NA

Table 5 Biological Studies in Port Angeles Harbor Area

Study	Sampling Conducted	Harbor Area	Toxicity/ Chemical Samples?	Biological Collection	
				Species	Sample Analysis
History, Dispersion and Effects of Pulpmill Effluents on Receiving Waters: Port Angeles (Shea et al. 1981)	Field surveys of observed marine wildlife	Throughout Harbor	NA	Marine fish, invertebrates, birds, and mammals (see report)	NA
Marine Sediment Monitoring Program 1989-1995 (Ecology 1998)	Annual sediment and benthic community analysis for baseline characteriza tion	One station in subtidal central Harbor, one in Dungeness Bay	Sediment chemistry: metals, SVOCs, pesticides, PCBs, resin acids, TOC, sulfides. Amphipod bioassays.	Annelids, mussels/clams, crustaceans	NA
Dioxin in Puget Sound Crabs (EPA 1991)	Dioxin/fura n concentratio ns in Puget Sound Crabs	Crab pots near Rayonier property, and in Dungeness Bay	Tissue chemistry: dioxin/furan	Red rock crab (*Cancer productus*)	Composite of 3 crab hepatopancr eas
Wood Waste Study in Port Angeles Harbor (SAIC 1999)	Underwater video surveys for wood debris and benthic community analysis	Throughout Harbor	NA	Annelids, crustaceans, fish	NA

Table 5 Biological Studies in Port Angeles Harbor Area

Study	Sampling Conducted	Harbor Area	Toxicity/ Chemical Samples?	Biological Collection	
				Species	Sample Analysis
EPA Rayonier ESI Investigation; Tissue Sampling (E & E 1999)	ESI tissue and sediment investigation for COPCs	Ediz Hook, Red Lion subtidal area, subtidal areas east of Rayonier, Dungeness Bay	Tissue and sediment chemistry: metals, SVOCs, pesticide/PCBs, dioxin/furan	Red rock crab and geoduck	Composite of crab muscle tissue (6/location); composite of edible geoduck tissue (2/location)
Rayonier RI (Malcolm Pirnie 2005 & 2007)		N/A	Stormwater	Harbor	Harbor
Health Consultation: Rayonier Site Exposure Investigation (WDOH 2005)	Health exposure investigation of shellfish consumption	Subtidal areas east of Rayonier, Dungeness Bay	Tissue chemistry: dioxin/furan	Dungeness (*Cancer magister*) and red rock crab and geoduck	Composites of crab muscle, and edible geoduck tissue
NOAA Fish Surveys in Port Angeles Harbor (Pers. Comm. With K. Fresh 2008)	Fish abundance and distribution in Harbor	Intertidal and subtidal beaches at Ediz Hook and Eastern area beaches	NA	Juvenile salmonids, forage fish, flatfish, rockfish, crabs	NA

B Figures

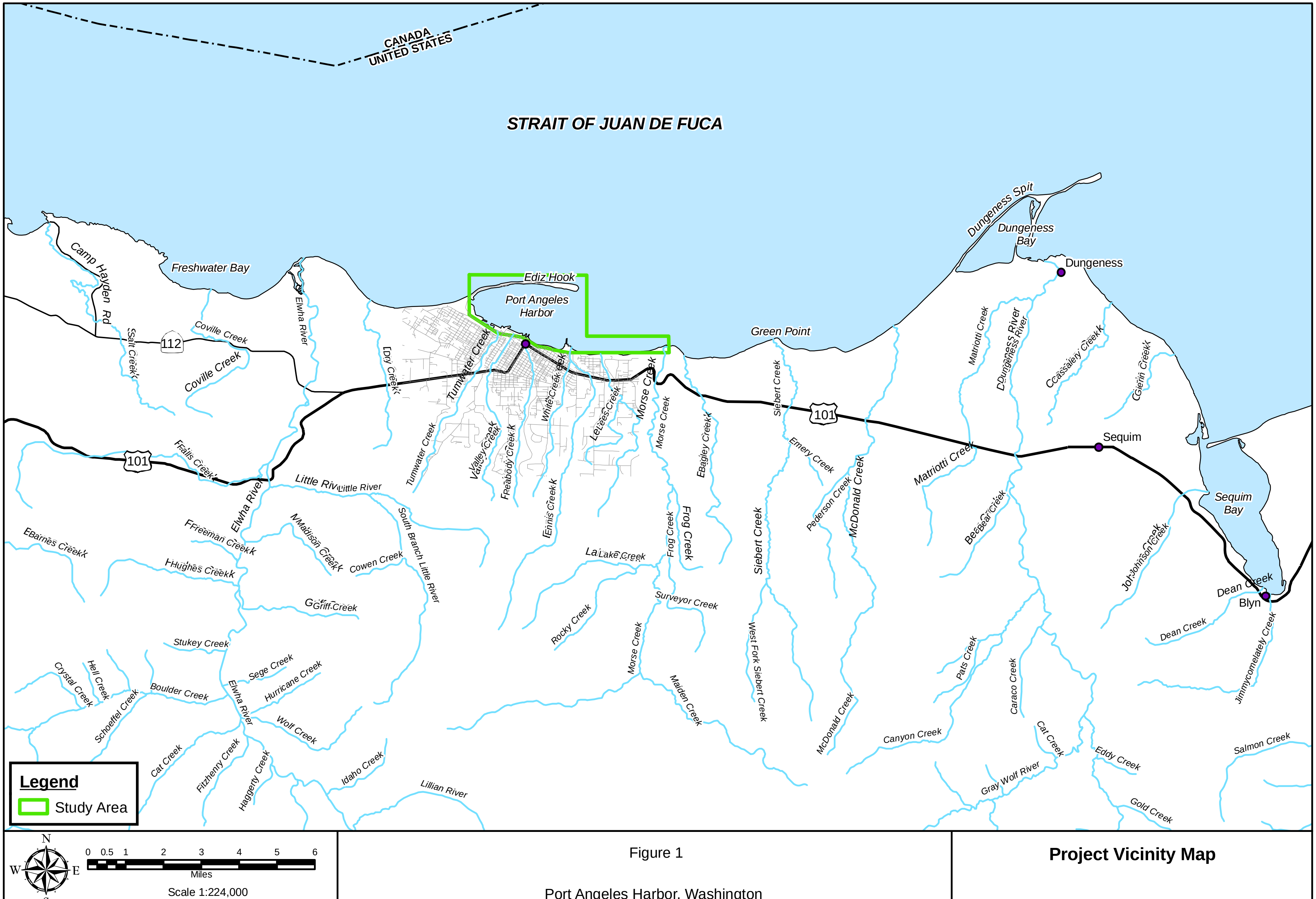

Figure 1

Port Angeles Harbor, Washington

Project Vicinity Map

source: ecology & environment, inc., 3/10/2008 ...\port_angeles_sta\figure x regional vicinity map.mxd

N W E S

0 500 1,000 2,000 3,000 4,000 5,000
Feet

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Figure 2

Port Angeles Harbor, Washington

CSOs, Outfalls, & Woodwaste Location Map

source: ecology & environment, inc., 3/10/2008 ...\port_angeles_sta\figure x log boom locs.mxd

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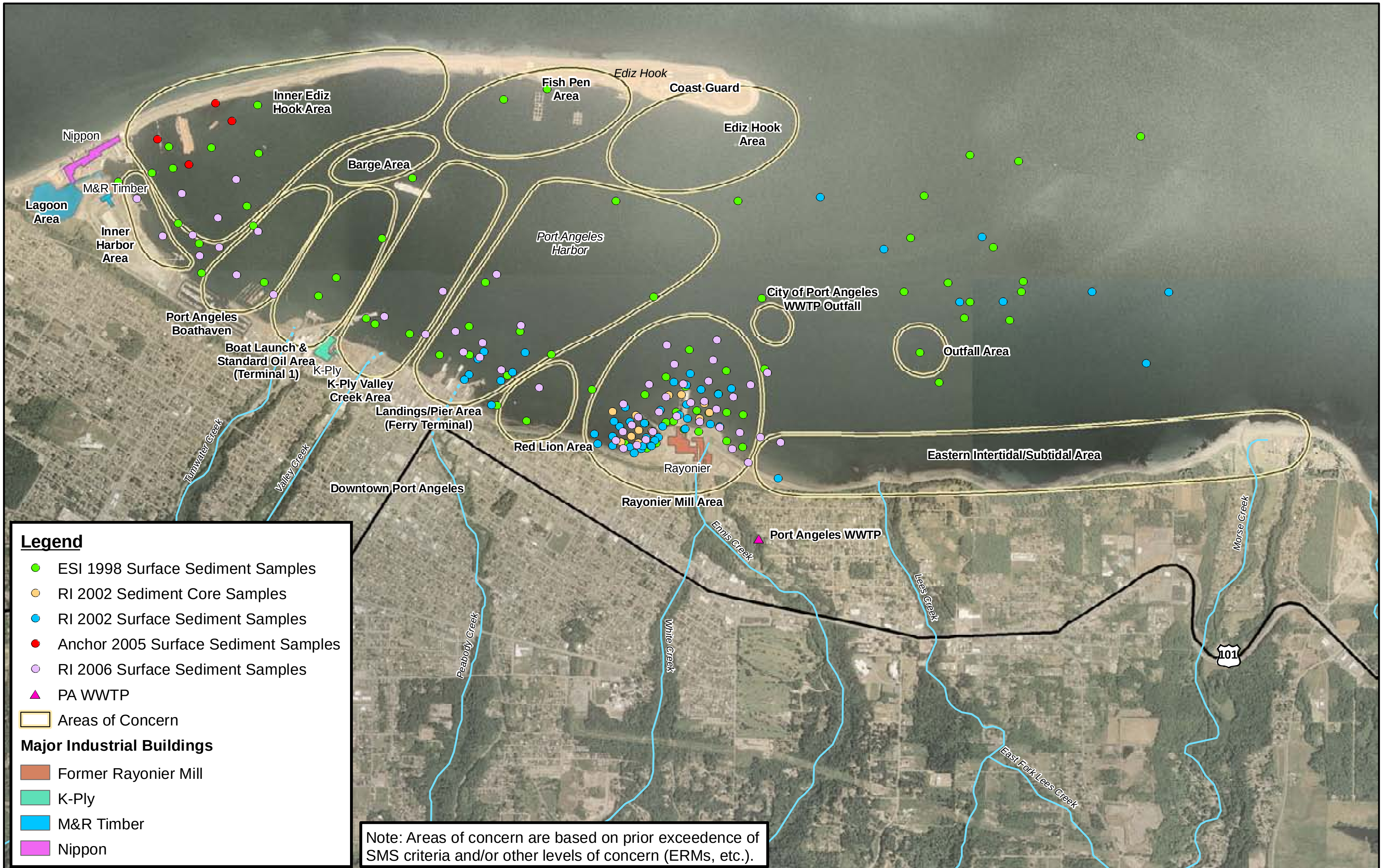
Figure 3

Port Angeles Harbor, Washington

Former Mill Site Features
Rayonier, Inc.

source: ecology & environment, inc., 3/10/2008 ...\port_angeles_sta\figure rayonier layout historical.mxd



N W E S

0 500 1,000 2,000 3,000 4,000 5,000
Feet
Scale 1:40,000

Figure 4

Port Angeles Harbor, Washington

Historical Sample Location Map from EPA & Rayonier Marine Investigations

source: ecology & environment, inc., 3/10/2008 ...\port_angeles_sta\figure x historical samp loc map.mxd

N
W E
S

0 250 500 1,000 1,500
Feet
Scale 1:11,000

Figure 5

Port Angeles Harbor, Washington

Industrial Areas along Port Angeles Southern Harbor

source: ecology & environment, inc., 4/1/2008 ...\port_angeles_sta\figure 5 industry along innner harbor.mxd