10

Puget Sound Naval Shipyard

Bremerton, Washington
CERCLIS #WA2170023418

Site Exposure Potential

Puget Sound Naval Shipyard (PSNS) was established in Bremerton, Washington in 1891. The site is on 143 hectares of dry land and 137 hectares of submerged land along the northern shore of Sinclair Inlet (Figures 1 and 2; U.S. Navy 1989). The primary industrial activities at PSNS include the construction, repair, overhaul, and maintenance of ships; mooring, berthing, and dry docking of ships; and staging and supply. As part of the Installation Restoration Program, the U.S. Navy's environmental program, Site Inspections were conducted at eleven sites previously identified as the most important historical sources of contamination (Figure 3; URS 1992). The period of operation, types of waste disposed, and the chemicals of concern at each of these sites are summarized in Table 1.

Surface runoff, direct discharge, and groundwater are the potential pathways of contaminant transport from the site to NOAA trust resources and habitats. The facility maintains little natural vegetation and is dominated by buildings and other impervious surfaces such as asphalt and concrete. Overall, the facility slopes gently toward Sinclair Inlet; the northernmost areas in the shipyard (upland) are 15 to 20 m higher in elevation than the waterfront areas. Overland flow from two basins within the shipyard discharges directly into the inlet (URS 1992).

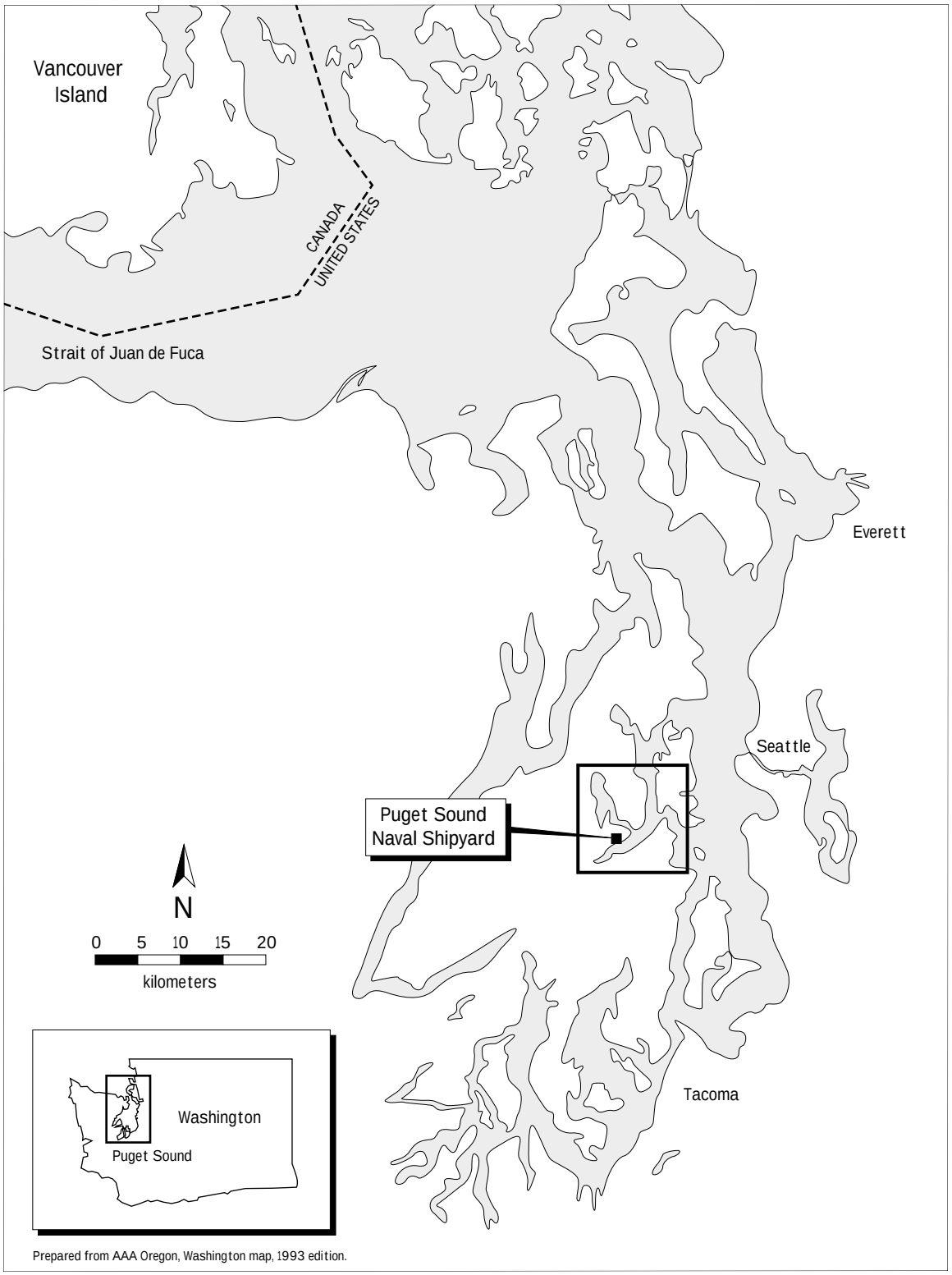

Figure 1. Location of the Puget Sound Naval Shipyard, Bremerton, Washington.

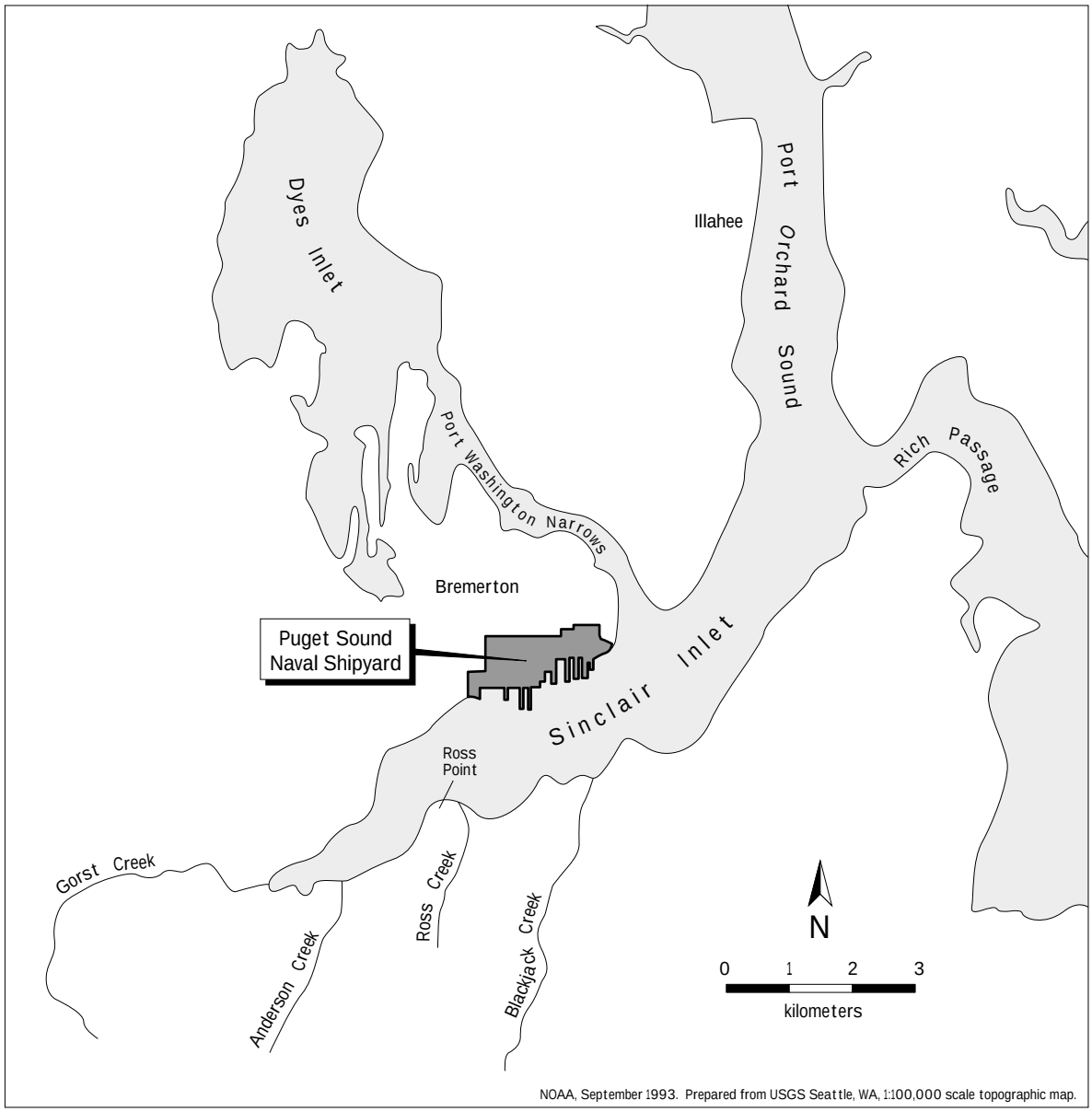

Figure 2. Location of the Puget Sound Naval Shipyard on Sinclair Inlet, Bremerton, Washington.

Surface runoff from these small basins consists primarily of stormwater discharged via storm drain outfalls and natural drainage channels. There is at least one combined sewage overflow (CSO) at PSNS, between Piers 6 and 7. The CSO discharges a mixture of stormwater runoff and raw sewage when the combined sanitary and storm sewer system's hydraulic capacity is exceeded during a heavy rain storm.

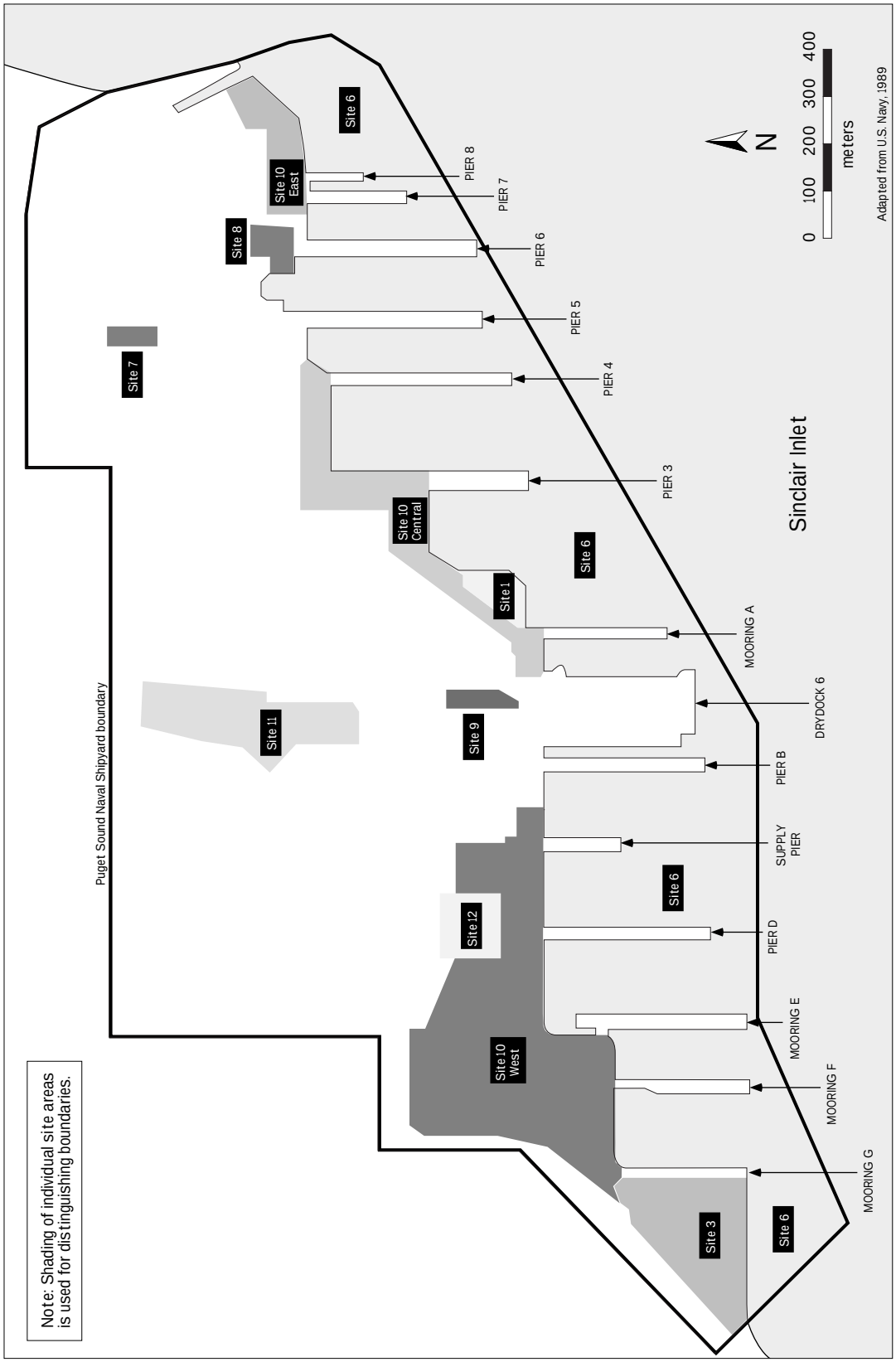

Figure 3. Locations of eleven sites where site inspections were performed at Puget Sound Naval Shipyard.

Two different sand and gravel aquifers have been described near PSNS (URS 1992). The upper aquifer overlies a silt and clay aquitard throughout the area. The base of the aquifer ranges from near sea level to 90 m above sea level. The saturated thickness of the upper aquifer ranges from 6 m to more than 60 m. The lower aquifer occurs at elevations ranging from slightly above mean sea level to approximately 90 m below mean sea level, and ranges in thickness from a few meters to 90 m. Despite the predominance of impervious surfaces, contaminants may have entered the groundwater via leaking underground storage tanks and cracked floors.

Previous investigations at the site indicate that the three fill areas that constitute Site 10 (Figure 3; Table 1) are hydraulically connected to Sinclair Inlet, and that groundwater in both aquifers moves toward Sinclair Inlet (URS 1992). Contaminants from the majority of the sites listed in Table 1 may have entered the groundwater and could subsequently be transported to Sinclair Inlet.

NOAA Trust Habitats and Species

Habitats of concern to NOAA are surface water and associated bottom substrates of Sinclair Inlet. Compared with other regions of Puget Sound, Sinclair Inlet is relatively shallow, an average of 13 to 22 m deep (U.S. Department of Commerce 1979). Substrates are predominantly mud, with areas of sand deposits along the southern shore of Sinclair Inlet (WDNR 1977). Currents near PSNS are weak and variable (average current speed is 0.08 knots; Tetra Tech 1988); tidal amplitude averages 2.5 m. Surface waters are cool (6.6 to 16.6°C), saline (24 to 31 ppt), and well-oxygenated (average 7.9 mg/l; WDNR 1977). Shallow nearshore depths and tidal wetlands combined with deeper, cooler troughs in the center of the inlet provide a diverse habitat.

A variety of anadromous, estuarine, and invertebrate NOAA trust resources use Sinclair Inlet (Table 2: U.S. Fish and Wildlife Service 1981; Freymond personal communication 1991; Fyfe personal communication 1991; WDF 1992; Zichke personal communication 1992). Sinclair Inlet and its drainages support various salmonids, including wild stocks of early and late chum salmon, sea-run cutthroat trout, and steelhead trout (Brooks personal communication 1992). Chum salmon is the most abundant and widely distributed species, followed by coho salmon. Chinook salmon are also present, but not as wild fall stocks. Chinook populations are limited by available upstream spawning habitat. Most upland drainages associated with Sinclair Inlet provide important salmon spawning habitats, especially the Gorst Creek (at the head of the inlet) and Blackjack Creek watersheds (Figure 2). The Anderson and Ross creek systems may occasionally support salmonids as well. Cutthroat trout are suspected to use all salmon habitat, while steelhead are less widely distributed (Freymond personal communication 1991). Several streams are stocked regularly by either the

Table 1. Sites, waste types, and chemicals of concern for eleven sites evaluated at Puget Sound Naval Shipyard as part of Site Inspection (URS 1992).

Site	Period of Operation	Waste Type	Size of Area/Estimated Quantity	Chemicals of Concern
1 Fill Area, Mooring A to Dry Dock 5	1960 - 1974	Construction debris, rubble, spent abrasive grit	1-ha/54,000 m^3 of fill	Trace elements, acids, PCBs
3 Helicopter Pad Area	1963 - 1972	Plating wastes, unopened paint cans, oils, metal parts and shavings	114,000 liters	Trace elements, acids, organic solvents, oil-based formulations, epoxies, organotin compounds
6 Drain Outfalls	Sanitary-until 1957; Storm - until present	Storm and sanitary sewer discharge	Unknown	PCBs, organic compounds, trace elements
7 Building 99, Old Plating Shop	Unknown	Chemical leakage through cracked floor	Unknown	Acids, bases, sodium cyanide, calcium sulfate, trace elements
8 Building 106, Old Power Plant	Unknown	Oil from leaking underground storage tanks	Unknown	PCBs
9 Crane Maintenance Area	Present	Debris from crane maintenance and painting	Unknown	Trace elements
10 Landfill Areas, Waterfront Areas[a]	Unknown	Fill (oily sludge, automobile scrap, construction and shipyard debris, spent abrasive grit)	Unknown	PCBs, trace elements, organic and organotin compounds
11 Oil Tank 316 Area	Until 1988	Fuel from leaking tanks, possibly contaminated soils for fill materials	Unknown	Petroleum hydrocarbons, trace elements, volatile organic and organotin compounds
12 Acid Drain Slab Area	Unknown	Unknown	Unknown	Trace elements, cyanide, PCBs

a: The Waterfront Area Landfills are divided into three separate locations: Site 10 East, Site 10 Central, and Site 10 West.

state or combined tribal/volunteer programs to enhance runs (Brooks personal communication 1992).

Several estuarine fish species use Sinclair Inlet for spawning, nursery, and adult forage habitat (U.S. Fish and Wildlife Service 1981). According to

Table 2. NOAA trust fish and invertebrate resources that use Sinclair Inlet near Bremerton, Washington.

Species		Habitat			Fisheries	
Common Name	Scientific Name	Spawning Ground	Nursery Ground	Adult Forage	Comm. Fishery	Recr. Fishery
ANADROMOUS FISH						
Cutthroat trout	*Oncorhynchus clarki*	♦	♦	♦		♦
Steelhead trout	*Oncorhynchus mykiss*	♦	♦	♦		♦
Chum salmon	*Oncorhynchus keta*	♦	♦	♦	♦	♦
Coho salmon	*Oncorhynchus kisutch*	♦	♦	♦	♦	♦
Chinook salmon	*Oncorhynchus tshawytscha*	♦	♦	♦	♦	♦
MARINE FISH						
Sablefish	*Anoplopoma fimbria*			♦	♦	♦
Arrow goby	*Clevelandia ios*	♦	♦	♦		
Pacific herring	*Clupea harengus pallasi*	♦	♦	♦	♦	♦
Shiner perch	*Cymatogaster aggregata*		♦	♦	♦	♦
Striped sea perch	*Embiotoca lateralis*		♦	♦	♦	♦
Buffalo sculpin	*Enophrys bison*		♦	♦		
Pacific cod	*Gadus macrocephalus*		♦		♦	♦
3-spine stickleback	*Gasterosteus aculeatus*	♦	♦	♦		
Silver smelt	*Hypomesus pretiosus*	♦	♦	♦	♦	♦
Rock sole	*Lepidopsetta bilineata*		♦	♦	♦	♦
Pacific staghorn sculpin	*Leptocottus armatus*		♦	♦		
Pacific hake	*Merluccius productus*			♦	♦	♦
Dover sole	*Microstomus pacificus*		♦	♦	♦	♦
Ling cod	*Ophidon elongatus*			♦	♦	♦
English sole	*Parophyrs vetulus*		♦	♦	♦	♦
Starry flounder	*Platichthys stellatus*		♦	♦	♦	♦
C-O sole	*Pleuronichthys coenosus*		♦	♦	♦	♦
Sand sole	*Psettichthys melanostictus*		♦	♦	♦	♦
Cabezon	*Scorpaenichthys marmoratus*		♦	♦		
Rockfish	*Sebastes* spp.		♦	♦		♦
Pile perch	*Rhacochilus vacca*		♦	♦	♦	♦
INVERTEBRATE SPECIES						
Dungeness crab	*Cancer magister*		♦	♦		
Red rock crab	*Cancer productus*		♦	♦		
Horse clam	*Clinocardium nuttali*	♦	♦	♦		
Pacific oyster	*Crassostrea gigas*	♦	♦	♦		
Kumamoto oyster	*Crassostrea gigas kumamoto*	♦	♦	♦		
Pacific coast squid	*Loligo opalescens*			♦		
Sea cucumber	*Parastichopus californicus*	♦	♦	♦		
Littleneck clam	*Protothaca staminea*	♦	♦	♦		
Kelp crab	*Pugettia gracilis*	♦	♦	♦		
Butter clam	*Saxidomus giganteus*	♦	♦	♦		
Manila clam	*Venerupis japonica*	♦	♦	♦		

the Washington State Department of Fisheries, surf smelt spawn in the intertidal zone of the southern section of Sinclair Inlet and use both Sinclair Inlet and nearby Dyes Inlet as nursery habitat (Zichke personal communication 1991). Herring may spawn near PSNS. Numerous species of demersal fish, including Pacific hake, Dover sole, ling cod, and starry flounder, plus various species of perch, rockfish, and sculpin use Sinclair Inlet for seasonal nursery and adult forage habitat. These species may also congregate near the piers and pilings of PSNS.

Broad intertidal flats and bars provide excellent spawning and nursery substrate for molluscs. Littleneck, Manila, butter, and horse clams are abundant over most intertidal areas, particularly near Gorst Creek. Sea cucumbers are also abundant in Sinclair Inlet (Fyfe personal communication 1991). Oyster and adult crab populations are small. Dungeness crab, rock crab, and kelp crab tend to congregate near Rich Passage (Figure 2). Squid may drift seasonally into Sinclair Inlet and spawn (Zichke personal communication 1991).

Fish and shellfish fisheries in Sinclair Inlet are limited. Commercially harvested salmon make up the majority of landings from Sinclair Inlet. Substantial Suquamish Tribe effort is directed towards salmonid runs in the vicinity of Sinclair Inlet. Most fishing occurs in Port Orchard Sound above Illahee or in Sinclair Inlet (Figure 2). Three principal salmon fisheries occur annually on stocks of Sinclair Inlet origin: an August-September fall chinook tribal gillnet fishery, which targets returning enhanced chinook from the Gorst Creek rearing facility; the fall treaty and non-treaty harvest of chum salmon; and the fall treaty and non-treaty harvest of coho salmon (Zichke personal communication 1992). Small catches of smelt and perch also occur.

Recreational fishing effort in Sinclair Inlet is reported to be light, although catch data were not available. Summer steelhead and cutthroat trout fishing occurs in most streams which discharge to the inlet (Freymond personal communication 1991). In areas off the Bremerton shoreline and in Port Washington Narrows (Figure 2), there is usually moderate sport fishing for salmon from September to late November. The water around Ross Point (Figure 2) supports a recreational surf smelt fishery (Brooks personal communication 1992; WDF 1992). The sandy southern shore of Sinclair Inlet supports a regular demersal sport fishery targeting Pacific cod, starry flounder, and several species of sole (WDNR 1977). There is infrequent sport crabbing for Dungeness crab offshore in Port Orchard Sound (Zichke personal communication 1992).

The commercial harvest of bivalves from Sinclair Inlet has never been certified and is now prohibited by the Washington State Department of Health because of high fecal coliform counts (Melvin personal communication 1991; Nosho personal communication 1991). Although this prohibition does not officially extend to all recreational harvests, the Bremerton-Kitsap County

Health Department has recommended against harvesting bottom-dwelling organisms, including fish, from Sinclair Inlet (Jones personal communication 1993).

Site-Related Contamination

During site investigations 283 soil samples, 239 groundwater samples, 42 surface water samples, and 61 sediment samples were collected (URS 1992). Samples were analyzed for some or all of the following target analytes: VOCs, SVOCs, pesticides / PCBs, trace elements, cyanide, and TPH. Phenols (GeoEngineers 1986; U.S. EPA 1986a) and tributyl tin (Grovhoug et al. 1987) were measured in some studies. Detection limits were not available.

Trace elements and PAHs are the primary contaminants of concern to NOAA. Other contaminants of concern include PCBs and other organic compounds such as phthalate esters and chlorinated benzenes. These contaminants were limited in distribution and were not found at concentrations exceeding screening guidelines in all sampled media. The maximum concentrations of contaminants detected in media collected from the eleven waste sites at PSNS are presented in Table 3.

Ten trace elements were detected at elevated concentrations in soil, sediment, and groundwater (Table 3). Concentrations of all trace elements measured in soil, except silver, exceeded average values for U.S. soil (Lindsay 1979). Similar substances were detected in groundwater at concentrations exceeding their respective marine chronic AWQC by factors greater than ten. All ten trace elements were detected in sediments collected from Sites 3 and 6 at concentrations exceeding their ERL screening guidelines (Long and MacDonald 1992). Arsenic, copper, lead, mercury, nickel, and zinc were detected in sediment samples from these same areas at concentrations exceeding their respective ERM screening guidelines (Long and MacDonald 1992).

Toxicity tests were performed at the Pier D Dredging Project to determine whether the dredged sediment was suitable for open-water disposal in Puget Sound (U.S. Navy 1992). The results indicated that sediments were toxic to the amphipod *Rhepoxynius abronius.* The areal extent of the toxic sediments has not been determined. Comparison of the concentrations of zinc in the sediments with toxicity test data obtained from the scientific literature suggests that most of the sediment within the boundaries of PSNS is potentially toxic to sensitive marine organisms.

In addition, benthic infaunal analyses were performed with the site investigations at 12 locations within PSNS boundaries and two reference locations in Sinclair Inlet (URS 1992). Sediment samples were collected synoptically for chemistry analyses. Two of the on-site stations and one of the reference stations could not be legitimately used in the analyses due to distinctly

Table 3. Maximum concentrations of contaminants of concern at waste sites located at PSNS (GeoEngineers 1986; U.S. EPA 1986a; URS 1992; and U.S. Navy 1992).

	Water (µg/l)			Soils (mg/kg)		Sediment (mg/kg)		
Contaminants	Ground water	Surface Water	AWQC [a]	Soils	Average US Soils [b]	Sediment	ERL [c]	ERM [d]
Inorganic Substances								
Antimony	ND	NR	500**	853	1	13.8	2	25
Arsenic	1,860	NR	36	1,160	5	111	8.2	70
Cadmium	174	NR	9.3	84.3	0.06	6.5	1.2	9.6
Chromium	2,140	NR	50	735	100	102	80	370
Copper	23,400	NR	2.9	10,400	30	1,709	34	270
Lead	18,200	NR	8.5	11,100	10	603	47	220
Mercury	203	NR	0.025	145	0.03	5.2	0.15	0.71
Nickel	3,210	NR	8.3	1,030	40	56.0	21	52
Silver	ND	NR	0.92**	ND	0.05	2.9	1.0	3.7
Zinc	23,900	NR	86	23,600	50	1,950	150	410
Organic Compounds								
PAHs								
Acenaphthene	ND	NR	710*	8	NA	ND	0.160	0.5
Fluorene	ND	NR	NA	63	NA	230	0.019	0.54
Phenanthrene	ND	NR	4.6**	170	NA	2,400	0.24	1.5
Anthracene	ND	NR	NA	3.9	NA	510	0.085	1.1
Fluoranthene	ND	NR	16*	68	NA	2,800	0.600	5.1
Pyrene	ND	NR	NA	60	NA	3,100	0.66	2.6
Benzo(a)anthracene	ND	NR	NA	20	NA	1,600	0.26	1.6
Chrysene	ND	NR	NA	16	NA	1,700	0.38	2.8
Benzofluoranthenes	ND	NR	NA	22	NA	2,700	NA	NA
Benzo(a)pyrene	ND	NR	NA	14	NA	ND	0.43	1.6
Indeno(1,2,3-c,d)pyrene	ND	NR	NA	36	NA	600	NA	NA
Benzo(g,h,i)perylene	ND	NR	NA	6.2	NA	700	NA	NA
Naphthalene	ND	NR	NA	260	NA	ND	0.16	2.1
2-Methylnaphthalene	ND	NR	NA	74	NA	ND	0.07	0.67
Dibenz(a,h)anthracene	ND	NR	NA	1.3	NA	96	0.063	0.26

a: Ambient water quality criteria for the protection of aquatic organisms. Marine chronic criteria are presented (EPA 1986b) because waste sites are located near marine environments.
b: Lindsay (1979).
c: Effects Range-Low (Long and MacDonald 1992).
d: Effects Range-Median (Long and MacDonald 1992).
NA: Screening guidelines not available.
ND: Not detected; detection limit not reported.
NR: Not reported.
+: Hardness-dependent criteria; 100 mg/l $CaCO_3$ assumed.
* Insufficient Data to Develop Criteria. Value Presented is the LOEL. - Lowest Observed Effect Level
** Proposed Criterion

different characteristics in grain size and total organic carbon. Pollution-tolerant taxa represented 56 to 82 percent of the taxa at ten of the twelve PSNS stations as compared to only 28 percent from the reference station. Although the source of the impairment has not yet been determined, the results suggest that benthic communities near PSNS appear stressed on the

basis of richness, Shannon-Weaver Diversity Index, Swartz's Dominance Index, abundance-biomass comparisons, and relative abundance of pollution-sensitive and pollution-tolerant taxa.

Summary

A diverse group of anadromous, estuarine, and marine NOAA trust species use Sinclair Inlet for adult forage, spawning, and nursery habitat. Salmon are fished both commercially and by Indian tribes; there are also several sport fisheries in the Inlet. Puget Sound Naval Shipyard has operated on the north shore of Sinclair Inlet since 1891, resulting in trace element and PAH contamination in soils, groundwater, and sediments. These contaminants are extremely persistent in aquatic systems and may threaten sensitive life stages of NOAA trust species and their habitat.

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