WASHINGTON STATE DEPARTMENT OF ECOLOGY

PCB Levels in Bottom Sediments from Lower Sinclair Inlet

Abstract

Sediment from 18 sites in lower Sinclair Inlet was collected in November 1999 and analyzed for PCBs (Arochlors). These data were needed to supplement existing information on the area to evaluate spatial distribution and range of PCBs concentrations in the southern portion of Sinclair Inlet adjacent to the Puget Sound Naval Shipyard (PSNS). Information on spatial distribution of PCBs in this area of the inlet will support development of a long-term compliance monitoring program for the PSNS.

PCB levels were relatively low in all samples analyzed. Arochlors 1254 and 1260 were the only PCBs detected above the practical quantitation limit. Total PCB levels on a dry weight basis ranged from 39 – 190 ug/kg with a mean of 110 ug/kg. The highest PCB levels were measured at stations S-9 (190 ug/kg) and S-14 (170 ug/kg), the stations nearest to the PSNS. The lowest PCB levels were measured at stations S-17 (39 ug/kg) and S-16 (46 ug/kg), located in the southeastern portion of the study area. These stations were also some of the deepest areas sampled.

None of the total PCB concentrations measured exceeded Ecology Sediment Quality Standard (Marine Criteria) of 12 mgTPCB/kg, organic carbon. The highest total PCB concentration measured (5.9 mgTPCB/Kg, OC) was approximately one-half of the marine criterion.

Introduction

The Puget Sound Naval Shipyard (PSNS) has been the focus of several studies in recent years evaluating the extent and magnitude of environmental contamination in Sinclair Inlet. High concentrations of polychlorinated biphenyls (PCBs) have been documented in sediments within the PSNS boundary (U.S. Navy, 1996, 1999). Results of a remedial investigation conducted between 1990 and 1995 indicated subsistence seafood harvesters could be at risk from consumption of PCB-contaminated tissues collected from the area. Based on these findings, remediation of PCB-contaminated sediments, believed to be a potential source of the PCBs accumulating in marine tissues, was identified as a high priority for any sediment cleanup activities in the area.

By Dale Norton
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A review of the sediment data for Sinclair Inlet contained in Ecology's sediment management database (SEDQUAL) indicates sparse coverage for PCB information in the lower and western portion of Sinclair Inlet. These data gaps on PCB levels in the area outside the PSNS boundary make it difficult to evaluate the extent of PCB contamination emanating from the PSNS facility. The data density is also inadequate to fully support development of a long-term compliance monitoring program. Collection of low level (≤36 ug/kg, dry weight) sediment PCB data in the southern portion of Sinclair Inlet outside the PSNS boundary is the focus of the present study (Figure 1). These data were needed to fill data gaps so that a comprehensive evaluation of the extent and magnitude of PCB contamination in the southern portion of Sinclair Inlet can be performed.

The primary objectives of the lower Sinclair Inlet sediment PCB survey were as follows:

- Determine PCB levels in the southern portion of Sinclair Inlet outside the PSNS boundary. The data collected will be used to supplement existing information on the area to evaluate spatial distribution and range of PCBs concentrations in lower Sinclair Inlet adjacent to the PSNS. Information on the spatial distribution of PCBs in this area of the inlet will support development of a long-term compliance monitoring program.

- Compare sediment PCB concentrations obtained with Ecology's Sediment Management Standards Chemical Criteria (Chapter 173-204 WAC) to evaluate the potential for adverse biological impacts.

The data generated from this study have been entered into Ecology's Environmental Information Management System (EIM), as well as the latest version of SEDQUAL which is maintained by the Toxics Cleanup Programs Sediment Management Unit.

Methods

Site Selection

Surface sediments (top 10cm) were collected at 18 locations in the southern portion of Sinclair Inlet to fill data gaps in historical data sets from the area. In this study, the southern portion of Sinclair Inlet refers to that part of the inlet west of the entrance to Port Washington Narrows and south of the PSNS. Stations were mostly located in areas that had not been previously sampled for PCBs or had inadequate detection limits (>36 ug/kg, dry weight) in earlier studies.

Existing data reviewed included PCB stations contained in Ecology's SEDQUAL (version 3.0d, August 1999). The location of existing PCB stations and new stations sampled as part of the present study are shown in Figure 1. A detailed list of station locations is included in Appendix A, Table A1.

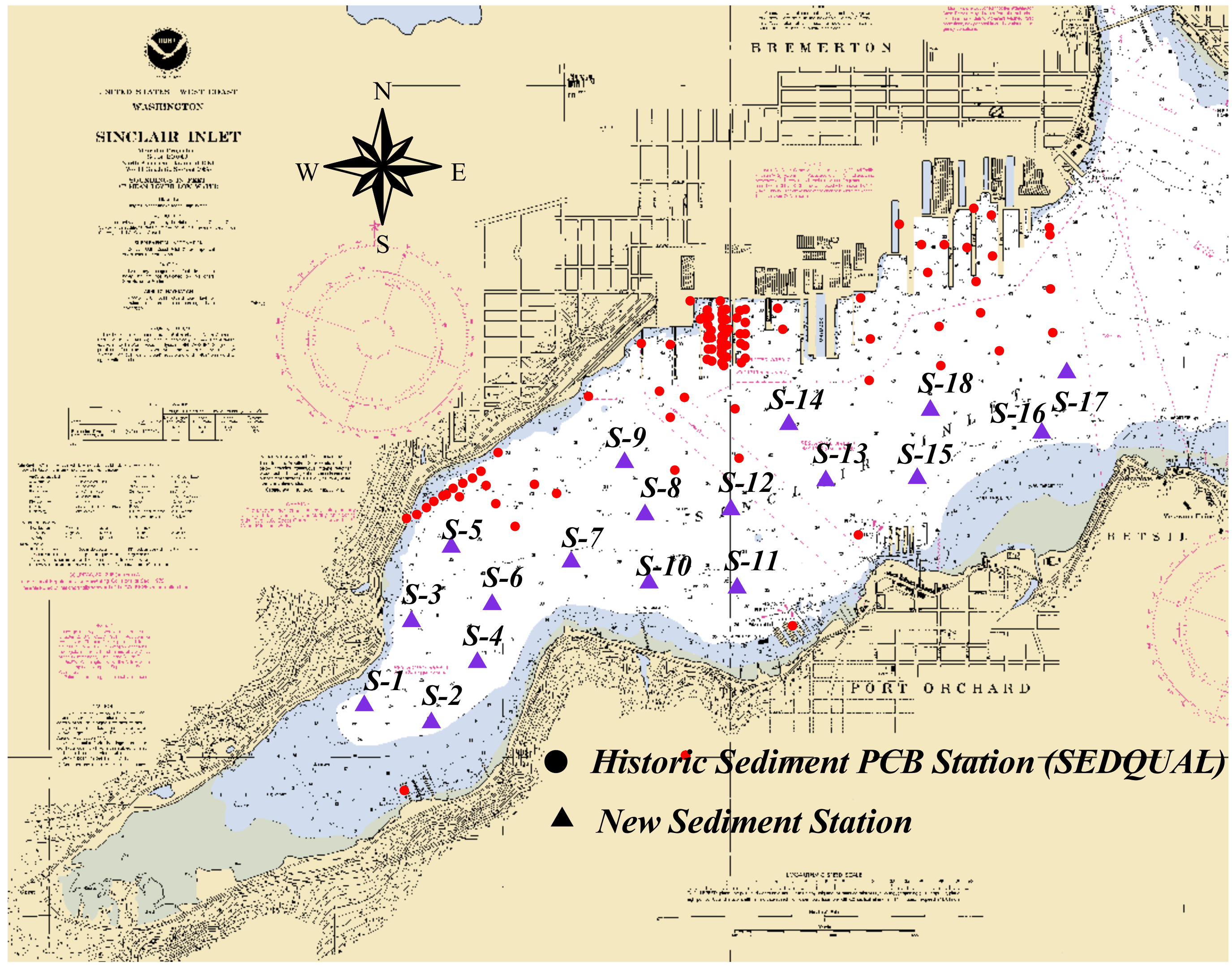

Figure 1: Station Location for Lower Sinclair Inlet Sediment PCB Study.

Sampling Procedures

Where applicable, Puget Sound Estuary Protocols (PSEP) were used for collection, preservation, transportation, storage, and analysis of samples (PSEP, 1996). Requirements of the Sediment Management Standards (Ecology, 1995a,b) were followed in an effort to limit sources of bias.

All samples were collected from Ecology's 20' skiff using a 0.1 m^2 stainless steel van Veen grab. At each station, three individual grabs were collected and composited for an individual sample.

A grab was considered acceptable if it was not over-filled with sediment, overlying water was present and not excessively turbid, the sediment surface was relatively flat, and the desired depth of penetration (>10cm) was achieved. After siphoning off overlying water, the top 10-cm of sediment from each grab was removed with stainless steel scoops, placed in stainless steel bowls, and homogenized by stirring. Material in contact with the side walls of the grab was not retained for analysis. Sub-samples of the homogenized sediment were placed in glass jars (Teflon lid liners) and cleaned to EPA QA/QC specifications (EPA, 1990). Separate 4-oz. jars were used for percent solids, PCB, and excess samples; 2-oz. jars were used for TOC. Grain size samples were placed in 8-oz. glass jars.

Pre-cleaned sampling equipment and sample containers were used to collect, manipulate, and store the sediments. Sampling equipment was pre-cleaned by washing with Liquinox detergent, followed by sequential rinses with hot tap water, de-ionized water, and pesticide-grade acetone, allowed to air dry, and wrapped in aluminum foil until used in the field. Between stations cleaning of the grab consisted of thoroughly brushing with on-site water. If oil or visible contamination was encountered, the grab was cleaned between stations with a detergent wash followed by a rinse with on-site water.

During sampling, engine exhaust from the vessel was directed downwind to avoid contamination. To minimize the risk of cross-contamination, the sampling sequence began with the lowest expected concentration samples and finished with the highest expected concentration samples. Sample containers were placed in polyethylene bags to further reduce the possibility of cross-contamination.

After collection, all samples were placed in coolers on ice and transported to the Ecology Manchester Environmental Laboratory (MEL) for analysis. Chain-of-custody was maintained throughout the study.

Station positions were located and recorded using a differentially corrected Northstar™ Global Positioning System (GPS) interfaced with a laptop computer using NobeltecVisual Navigation Suite™ (version 4.1.3) software. A field log describing material collected in each grab was also maintained during the field sampling.

Laboratory Procedures

Analytical methods and laboratories performing analysis for the project are shown in Table 1. All analysis was conducted at MEL, with the exception of grain size which was analyzed by an accredited contract laboratory selected by MEL.

Table 1: Analytical Methods and Laboratories for the Sinclair Inlet Sediment PCB Study.

Analyte	Method	Reference	Laboratory
Percent Solids	Gravimetric (160.3)	PSEP, 1996	MEL
Total Organic Carbon	Combustion/CO2 Measurement @ 70°C (9060)	EPA, 1996	MEL
Grain Size	Sieve and Pipet	PSEP, 1996	Rosa Environmental
PCBs[1]	GC-ECD (8082) rapid solvent extraction (3540) Confirmation by GC/AED (8085)	EPA, 1996	MEL

1= The following Arochlors were reported: 1016, 1221, 1242, 1248, 1254, 1260.

Data Quality

The standard QA/QC procedures used by MEL were used for this project and are documented in MEL's Quality Assurance Manual (Kirchmer et al., 1989). Laboratory quality control samples for PCBs included analysis of surrogate spikes, method blanks, and duplicate matrix spikes. In addition to the laboratory QC samples, a blind field duplicate was prepared at station S-14. A single sample was homogenized and split into two separate aliquots in the field and labeled as separate stations.

Data quality for the project was excellent. Procedural errors were noted in the original analysis of grain size, and all samples were re-analyzed for grain size. The re-analysis produced results that met all QA criteria. No other analytical problems were noted. Copies of the individual case narratives are included in Appendix B.

Overall precision of the data set as measured by the blind field duplicate was excellent. Relative percent differences (range expressed as a percent of the mean) between duplicates were as follows: percent solids= 0.3%, total organic carbon= 0%, grain size= <8% for all fractions except gravel (195%), and PCBs= <13% based on detected values.

One analytical note of interest was that all samples appear to contain relatively low concentrations of Arochlor 1268. Because weathering of Arochlor 1260 in sediments may lead to relative increases in the concentrations of heavier congeners, accurate quantitation of the low levels of Arochlor 1268 would be difficult using the analytical method employed. This would require congener specific testing. The levels of Arochlor 1268 present appear to be low, being at or below the practical quantitation limits reported for the other Arochlors. In an attempt not to bias the total PCB concentration low, the Arochlor 1268 concentrations have been incorporated into the Arochlor 1260 values reported. For a detailed discussion of the PCB analysis, see the PCB case narrative in Appendix B.

Unless otherwise noted, all values are reported on a *dry weight basis*.

Results

The results of conventionals analysis of sediments from the southern portion of Sinclair Inlet are shown in Table 2.

Table 2: Results of Conventionals Analysis of Lower Sinclair Inlet Sediments.

Station ID	Sample No. 46-	% Solids	% TOC @70°C	% TOC @104°C	% Gravel (>2mm)	% Sand (2mm-62.5um)	% Silt (62.5-4um)	% Clay (<4um)
S-1	8105	29.3	3.9	3.9	1.7	20.4	49.7	28.2
S-2	8106	31.6	4.0	4.0	0.1	20.8	51.2	27.9
S-3	8107	28.1	3.6	3.7	0.0	11.9	53.2	34.9
S-4	8108	29.9	3.9	3.9	0.0	23.4	49.2	27.4
S-5	8109	30.1	3.5	3.5	0.0	6.9	53.3	39.7
S-6	8110	29.5	3.6	3.6	0.0	14.2	53.0	32.8
S-7	8111	29.0	3.7	3.8	1.1	9.8	50.0	39.1
S-8	8112	26.8	3.5	3.6	0.5	9.1	56.7	33.7
S-9	8113	28.9	3.2	3.3	0.0	11.1	57.4	31.5
S-10	8114	27.5	3.8	3.8	0.0	23.7	47.9	28.5
S-11	8115	24.2	3.6	3.6	0.0	24.6	46.7	28.7
S-12	8116	28.3	3.3	3.4	0.2	12.3	55.3	32.1
S-13	8117	30.4	3.1	3.1	0.0	16.8	55.2	28.0
S-14	8118	32.7	2.8	2.8	0.6	17.4	52.2	29.8
S-14 (dup)	8123	32.6	2.8	2.8	5.1	18.5	48.8	27.6
S-15	8119	34.9	2.8	2.8	0.0	23.1	51.5	25.4
S-16	8120	42.2	2.2	2.2	1.3	37.1	41.4	20.2
S-17	8121	41.1	2.4	2.6	1.1	34.9	41.6	22.4
S-18	8122	35.1	2.8	2.8	1.5	29.8	46.8	22.0

Total organic carbon (TOC) levels ranged from 2.2 – 4.0% with a mean of 3.3%.

Grain size analysis indicated that all sediments collected were composed of primarily silt and clay size material.

Percent fines (silt + clay) ranged from 62 – 93% with a mean of 80%.

The results of PCB analysis of sediments from lower Sinclair Inlet are shown in Table 3.

Table 3: Results of PCB Analysis (Arochlors) of Lower Sinclair Inlet Sediments (ug/kg, dry).

Station ID	Sample No. 46-	PCB 1016		PCB 1221		PCB 1232		PCB 1242		PCB 1248		PCB 1254	PCB 1260	Total PCBs (ug/kg, dry)	Total PCBs (mgPCB/kg, OC)
S-1	8105	16	u	16	u	16	u	16	u	16	u	52	67	120	3.1
S-2	8106	16	u	16	u	16	u	16	u	16	u	58	72	130	3.3
S-3	8107	17	u	17	u	17	u	17	u	17	u	67	95	160	4.4
S-4	8108	16	u	16	u	16	u	16	u	16	u	46	57	100	2.6
S-5	8109	16	u	16	u	16	u	16	u	16	u	61	87	150	4.3
S-6	8110	16	u	16	u	16	u	16	u	16	u	55	77	130	3.6
S-7	8111	16	u	16	u	16	u	16	u	16	u	42	54	96	2.6
S-8	8112	19	u	19	u	19	u	19	u	19	u	45	64	110	3.1
S-9	8113	17	u	17	u	17	u	17	u	17	u	74	120	190	5.9
S-10	8114	18	u	18	u	18	u	18	u	18	u	46	57	100	2.6
S-11	8115	20	u	20	u	20	u	20	u	20	u	38	49	87	2.4
S-12	8116	18	u	18	u	18	u	18	u	18	u	50	69	120	3.6
S-13	8117	16	u	16	u	16	u	16	u	16	u	33	44	77	2.5
S-14	8118	14	u	14	u	14	u	14	u	14	u	71	99	170	6.1
S-14 (dup)	8123	14	u	14	u	14	u	14	u	14	u	64	87	150	5.4
S-15	8119	14	u	14	u	14	u	14	u	14	u	29	35	64	2.3
S-16	8120	11	u	11	u	11	u	11	u	11	u	19	27	46	2.1
S-17	8121	12	u	12	u	12	u	12	u	12	u	19	20	39	1.6
S-18	8122	14	u	14	u	14	u	14	u	14	u	30	45	75	2.7

u= Not detected at detection limit shown

PCB levels were relatively low in all samples analyzed. Arochlor 1254 and 1260 were the only PCBs detected above the practical quantitation limit. Total PCB levels on a dry weight basis range from 39 – 190 ug/kg with a mean of 110 ug/kg. The highest PCB levels were measured at stations S-9 (190 ug/kg) and S-14 (170 ug/kg), the stations nearest to the PSNS. The lowest PCB levels were measured at stations S-17 (39 ug/kg) and S-16 (46 ug/kg), located in the southeastern portion of the study area. These stations were also some of the deepest areas sampled.

In 1991, Ecology adopted the Sediment Management Standards (SMS), (Ecology, 1995a). The standards include chemical concentrations criteria, biological effects criteria, and human health criteria which are used to identify sediments that have no adverse effect on biological resources and pose no significant risks to human health. The Sediment Quality Standards (SQS) represent the level below which no adverse effects would be observed in benthic communities. The standards also establish Cleanup Screening Levels (CSL) which represent the upper limit of allowable minor adverse effects on biological resources. Contaminant concentrations above the CSL are a high priority for remediation activities. The SQS level for total PCBs is 12 mgTPCB/kg, organic carbon.

Total PCB levels in lower Sinclair Inlet sediments are compared to the SQS in Figure 2. None of the samples collected exceeded the total PCB standard of 12 mgTPCB/kg, OC. The highest concentrations measured was 5.9 mgTPCB/kg, OC at station S-9, which is 49% of the SQS.

Conclusions

Sediment from 18 sites in the southern portion of Sinclair Inlet was collected in November 1999 and analyzed for PCBs (Arochlors). These data were needed to supplement existing information on the area to evaluate spatial distribution and range of PCBs concentrations in lower Sinclair Inlet adjacent to the Puget Sound Naval Shipyard (PSNS). Information on spatial distribution of PCBs in this area of the inlet will support development of a long-term compliance monitoring program for the PSNS.

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None of the total PCB concentrations measured exceeded the Ecology Sediment Quality Standard (Marine Criteria) of 12 mgTPCB/kg, organic carbon. The highest total PCB concentration measured (5.9 mgTPCB/Kg, OC) was approximately one-half of the marine criterion.

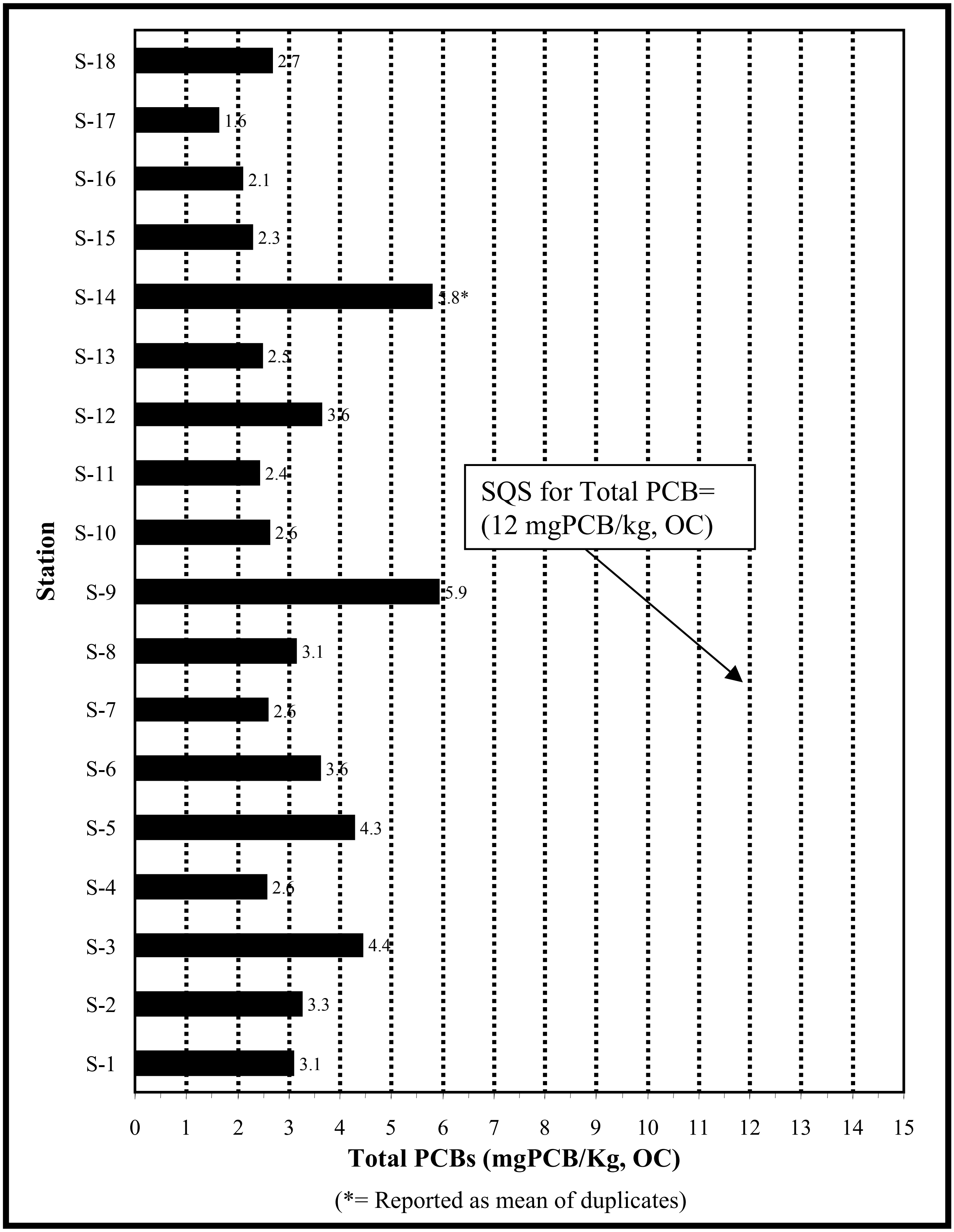

Figure 2: Total PCB Concentrations in Sinclair Inlet Sediments Normalized to Organic Carbon.

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Appendix A

Field Data
Station Position Data
Sediment Sample Descriptions

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Table A1: Station Locations for Lower Sinclair Inlet Sediment PCB Study.

Station ID	Latitude (Deg/Min)	Longitude (Deg/Min)	Depth (ft) @ MLLW
S-1	47 32.143	122 40.661	20
S-2	47 32.127	122 40.268	18
S-3	47 32.414	122 40.392	31
S-4	47 32.287	122 40.112	21
S-5	47 32.631	122 40.227	33
S-6	47 32.459	122 40.046	29
S-7	47 32.586	122 39.698	28
S-8	47 32.728	122 39.372	34
S-9	47 32.883	122 39.463	32
S-10	47 32.475	122 39.285	27
S-11	47 32.509	122 38.968	31
S-12	47 32.742	122 38.994	33
S-13	47 32.829	122 38.576	38
S-14	47 32.965	122 38.740	42
S-15	47 32.834	122 38.173	37
S-16	47 32.971	122 37.623	31
S-17	47 33.150	122 37.515	50
S-18	47 33.038	122 38.115	40

Datum= WSG84 (All positions differentially corrected)

Table A2: Sample Descriptions for Sinclair Inlet PCB Study.

Station ID	Grab No.	Depth (ft)	Date 1999	Time	Sediment Penetration (cm)	Sample Description
S-1	1	36'	11/17	1340	17	Brown to gray silt, anaerobic below 5cm. Some shells
S-1	2	36'	11/17	1345	17	Brown to gray silt
S-1	3	36'	11/17	1355	16	Brown to gray silt, some shell fragments, welks, and amphipods present
S-2	1	35'	11/17	1300	16	Gray to brown silt, soft. Small tube worms along surface
S-2	2	32'	11/17	1310	16	Brown to gray silt
S-2	3	32'	11/17	1325	17	Brown to gray silt
S-3	1	45'	11/17	1125	16	Gray to brown soft silt, darker at depth. No shells or debris
S-3	2	45'	11/17	1140	17	Same as grab #1
S-3	3	45'	11/17	1150	16	Same as grab #1
S-4	1	36'	11/17	1235	17	Green to gray silt, soft uniform color. No debris
S-4	2	35'	11/17	1240	17	Green to gray silt, soft uniform color. No debris
S-4	3	36'	11/17	1250	17	Green to gray silt, soft uniform color. No debris
S-5	1	44'	11/17	1040	14	Gray to brown, soft silt, some shell debris
S-5	2	44'	11/17	1055	14	Same as grab 1
S-5	3	44'	11/17	1105	13	Gray silt over black. Thin aerobic layer, no shells
S-6	1	38'	11/17	1010	15	Brown to gray silt, some shell fragments, dark brown below 10cm
S-6	2	39'	11/17	1020	16	Similar to 1 except no shells
S-6	3	39'	11/17	1030	15	Same as grab #2
S-7	1	40'	11/17	930	16	Brown to gray silt, black below 10cm, some sand
S-7	2	41'	11/17	940	16	Brown to gray silt. Heavy oil sheen on surface. Some shell fragments
S-7	3	42'	11/17	950	16	Similar in texture to grab 1 and 2, but no oil sheen
S-8	1	47'	11/16	1540	17	Brown to black silt, black belowm10cm, anaerobic. H2S odor, no critters
S-8	2	46'	11/16	1545	17	Brown to black silt, black below, anaerobic. H2S odor, no critters
S-8	3	45'	11/16	1600	17	Brown to black silt, black below, anaerobic. H2S odor, no critters
S-9	1	44'	11/17	900	16	Green to brown silt, soft w/ some shell fragments, aerobic
S-9	2	45'	11/17	910	16	Green to brown silt, soft w/ some shell fragments, aerobic
S-9	3	45'	11/17	920	17	Similar to grab 1 and 2, soft seawhip fragments, some shell
S-10	1	37'	11/16	1515	17	Very soft black silt, no organisms, H2S odor
S-10	2	36'	11/16	1520	17	Very soft black silt, no organisms, H2S odor
S-10	3	36'	11/16	1530	17	Very soft black silt, no organisms, H2S odor

Table A2 (cont.): Sample Descriptions for Sinclair Inlet PCB Study.

Station ID	Grab No.	Depth (ft)	Date 1999	Time	Sediment Penetration (cm)	Sample Description
S-11	1	41'	11/16	1445	17	Soft black to brown silt, anaerobic H2S smell, no organisms
S-11	2	44'	11/16	1450	17	Very soft black silt, high water content. H2S odor
S-11	3	41'	11/16	1500	17	Very soft black silt, high water content. H2S odor
S-12	1	47'	11/16	1400	16	Gray to brown silt, soft, some shell, no worms
S-12	2	47'	11/16	1415	16	Gray to brown silt, soft, some shell, no worms
S-12	3	47'	11/16	1420	16	Gray to brown silt w/seawhip fragments, nutabranch, anaerobic at depth
S-13	1	51'	11/16	1325	17	Brown to gray silt w/net fragments, deep aerobic layer
S-13	2	50'	11/16	1340	16	Brown to gray silt, black below 10cm
S-13	3	50'	11/16	1350	16	Brown to gray silt, black below 10cm
S-14	1	55'	11/16	1211	17	Brown and gray silt, some algae. Black below 10cm
S-14	2	55'	11/16	1220	17	Brown and gray silt, some algae. Black below 10cm
S-14	3	55'	11/16	1230	17	Brown and gray aerobic material, some white flecks (organism?) on surface
S-15	1	48'	11/16	1140	16	Brown to gray silt w/ some sand. Bryozoans and tube worms, aerobic
S-15	2	47'	11/16	1145	17	Brown to gray silt w/ some sand, aerobic
S-15	3	48'	11/16	1155	17	Brown to gray silt w/ some sand, aerobic
S-16	1	52'	11/16	1030	17	Gray to brown silt, deep aerobic layer, some tube worms
S-16	2	50'	11/16	1040	16	Gray to brown silt, deep aerobic layer, some tube worms
S-16	3	50'	11/16	1049	15	Gray to brown silty sand, some ulva on sediment surface
S-17	1	65'	11/16	952	15	Gray to brown silt w/ some shell fragments, tube worms
S-17	2	65'	11/16	1004	17	Gray to brown silt w/ some sand. No shells, deep aerobic layer
S-17	3	65'	11/16	1014	16	Gray to brown silt w/ some sand and shells, aerobic
S-18	1	55'	11/16	1105	17	Gray to brown silt w/ some sand. Deep aerobic layer
S-18	2	55'	11/16	1114	17	Gray to brown silty sand, some tube worms, aerobic
S-18	3	55'	11/16	1125	17	Gray to brown silty sand, some tube worms, aerobic

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Appendix B

Case Narratives
for
Physical and Chemical Analysis

Appendix B is available only in printed copies of this report.
See page 11 for ordering information.