PCBs in Sediments at Selected Sites in Puget Sound

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PCBs in Sediments at Selected Sites in Puget Sound

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Abstract

Sediment from 15 Puget Sound sites was collected during May 2001 and analyzed for polychlorinated biphenyls (PCBs) using EPA methods 8082 and 1668a. This study was conducted to support efforts by the Washington State Department of Ecology and the Washington Department of Fish and Wildlife to compare PCB concentrations in sediment with PCB concentrations in muscle tissue of English sole *(Plueronectes vetulus)*.

Concentrations of PCBs in sediment samples from all sites were generally low, and results were compared to various sediment criteria.

Using method 8082, total PCB concentrations of 3.5-11.2 ug/kg, dry weight (dw) basis, were detected in the Outer Commencement Bay, Port Townsend, and Possession Point sites. These concentrations exceeded the proposed Human Health Cleanup Screening Level of 260 ug/kg, normalized to organic carbon. All 15 sites were at least an order of magnitude lower than the Washington State sediment quality standard of 12,000 ug total PCB/kg, organic carbon. The highest total PCB value in this study, 11.2 ug/kg, dw, was an order of magnitude below the lowest apparent effects threshold of 130 ug/kg, dw.

Three samples from the Vendovi Island and Outer Commencement Bay sites were analyzed by EPA method 1668a, and all showed detectable levels of PCBs. Practical quantitation limits for method 1668a ranged from 0.00003 to 0.004 ug/kg, dw. While method 1668a has the ability to detect PCBs at lower levels than method 8082, the price difference is formidable: $1,100/sample (1668a) vs. $130/sample (8082).

Improvement of correlations between sediment and English sole PCB concentrations using data from this study will be minimal, due to the majority of non-detected values from method 8082. Future PCB studies should use method 1668a to more accurately characterize background levels of PCBs in Puget Sound sediments and to allow development of more meaningful bioaccumulation factors.

Waterbody Numbers:

WA-01-0010	WA-PS-0200
WA-01-0080	WA-PS-0220
WA-10-0010	WA-PS-0230
WA-10-0020	WA-PS-0240
WA-14-0010	WA-PS-0250
WA-15-0060	WA-PS-0260
WA-17-0020	WA-PS-0270
WA-17-0030	WA-PS-0280
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Introduction

Polychlorinated biphenyls (PCBs) were used in Puget Sound and other regions for a range of industrial applications such as additives to hydraulic fluids, insulating fluids, and plasticizers. The U.S. Environmental Protection Agency (EPA) banned the use of PCBs in 1979, once their toxic qualities were documented (EPA, 1999). PCBs are widespread due to their environmental persistence which permits their redistribution in the environment. PCBs may be stored in the tissues of benthic invertebrates and other organisms associated with sediments. When sediment dwelling organisms are consumed by predators, the prey's PCB body burden is transferred to the predator. PCBs are not substantially metabolized by organisms, and consequently, PCB concentrations increase at higher levels of the food chain.

In Puget Sound, PCB levels in sediments and edible muscle tissue of English sole (*Pleuronectes vetulus*) have been monitored by the Puget Sound Ambient Monitoring Program (PSAMP) since 1989, permitting correlation of PCB concentrations in these two media (O'Neill et al., 1995; PSWQAT, 1998). By linking fish tissue to sediment PCB concentrations, it is possible to use analysis of fish consumption-based human health risks to make sediment remedial action decisions.

Adequate sediment data had not been collected from a number of sites in Puget Sound where fish tissue PCB concentrations had been determined. Additionally, previously used PCB analytical methods were not as sensitive as those now available. Historic detection limits were from five to ten times greater than current detection limits of about 3-6 ug/kg, dry weight basis (dw). Previous determinations of sediment PCB concentrations at many sample locations resulted in values below detection limits, which restricts the usefulness of the data.

The primary goal of this project was to provide additional sediment PCB concentration data to support characterization of PCB bioaccumulation in Puget Sound English sole. A secondary goal was to provide background data on sediment PCB concentrations at relatively pristine Puget Sound reference sites. Sediment samples were collected from historically sampled sites where fish tissue samples had been taken but sediment PCB concentration data were either non-existent or were below detection limits. To explore the need for lower analytical detection limits, several samples were analyzed by two methods.

The characteristics of PCBs in the environment and their quantification continue to challenge a fuller understanding of their impacts on biota. There are more than 200 individual forms (congeners) of PCBs, and these vary in their toxicity. Most PCBs have been released into the environment as particular mixtures of congeners, known as Aroclors. These Aroclors experience changes in their congener composition due to varied degradation processes. Highly chlorinated congeners are subject to anaerobic degradation in sediments, while congeners with lower chlorine content are subject to aerobic degradation. Individual congeners also differ in how they partition into water, sediment, or air, thus affecting their bioavailability. Congeners accumulate to differing degrees in the tissues of organisms where they are metabolized to different extents. Because of all these processes, the mixtures of PCBs found in the environment can differ greatly from freshly produced industrial material.

Given the uncertainty in the congener composition of Aroclors present in the environment, recent efforts have focused on measuring concentrations of individual PCB congeners, particularly for the purposes of risk assessment. Information about concentrations of individual congeners in tissue and sediments should allow for more accurate determination of human exposure to PCBs relative to exposure extrapolated from the properties of unaltered Aroclor mixtures. Of particular interest is the characterization of the concentrations of congeners with dioxin-like activity. Unfortunately, congener toxicology research, as well as risk-based regulatory methods, lag behind what is available for Aroclors. This situation should change over time.

In addition to providing better exposure information, an advantage of congener analysis is that congener analytical methods have far lower detection limits than Aroclor methods. However, a disadvantage of collecting congener data is analytical cost. Congener analysis requires specialized gas chromatography/high resolution mass spectroscopy with rigid controls to prevent incidental contamination. The average cost for a full-spectrum congener analysis is approximately $1,100. The cost for Aroclor analysis is approximately $130. Due to budgetary limits, samples from only two sites were analyzed for congeners during this study.

Methods

Site Selection

Surface sediments from the top 2-3 cm were sampled from 15 locations in Puget Sound (Figure 1). Detailed information on site locations are provided in Appendix A. The 15 locations were selected by the Washington State Department of Ecology (Ecology) and the Washington Department of Fish and Wildlife (WDFW) after review of historic sediment and fish tissue PCB data (Seiders and Roose, 2001).

Historic trawl line locations were provided by WDFW staff (West and Lippert, 2001). Efforts were made to sample near the historic fish-trawl track lines but not actually on the disturbed sea bed. Historic track lines were first plotted using Geographic Information System software. A 200-400 meter perimeter target sampling zone was then created around the trawl tracks to account for error due to drift, Global Positioning System (GPS) bias, and wind. The historic trawl lines, target sites, and sampling locations are shown in Appendix A.

Sampling Procedures

Sampling was conducted from two vessels: Ecology's 20' Boston Whaler and the *Kittiwake,* a 42' research vessel owned and operated by Mr. Charles Eaton. Stations were located and positions recorded using differentially corrected GPS. During sampling, the vessel's engine exhaust was directed downwind of the work area to avoid cross-contamination. Care was taken while operating the Boston Whaler in shallow water so as not to disturb the sediments to be sampled.

Sampling methods followed Puget Sound Estuary Program protocols (PSEP, 1996) and requirements of the Sediment Management Standards (Ecology, 1995a,b). A field log was kept describing the material collected in each grab (Appendix A).

All samples were collected using a 0.1 m^2 stainless steel van Veen grab. 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. The overlying water was siphoned off. A sub-sample from the top 2-3 cm of sediment was removed with cleaned, stainless steel scoops and placed in a stainless steel bowl. Material in contact with the side walls of the grab was not retained for analysis. The three individual grabs from each target area were composited and homogenized by stirring to a consistent color and texture.

Sub-samples of the homogenized sediment were placed in glass jars with Teflon lid liners. Sample containers met EPA specifications for cleanliness (EPA, 1990). Separate 4-oz jars were used for PCB and PCB archive samples, 2-oz jars were used for total organic carbon, and 8-oz glass jars were used for grain size samples. Sample containers were placed in polyethylene bags

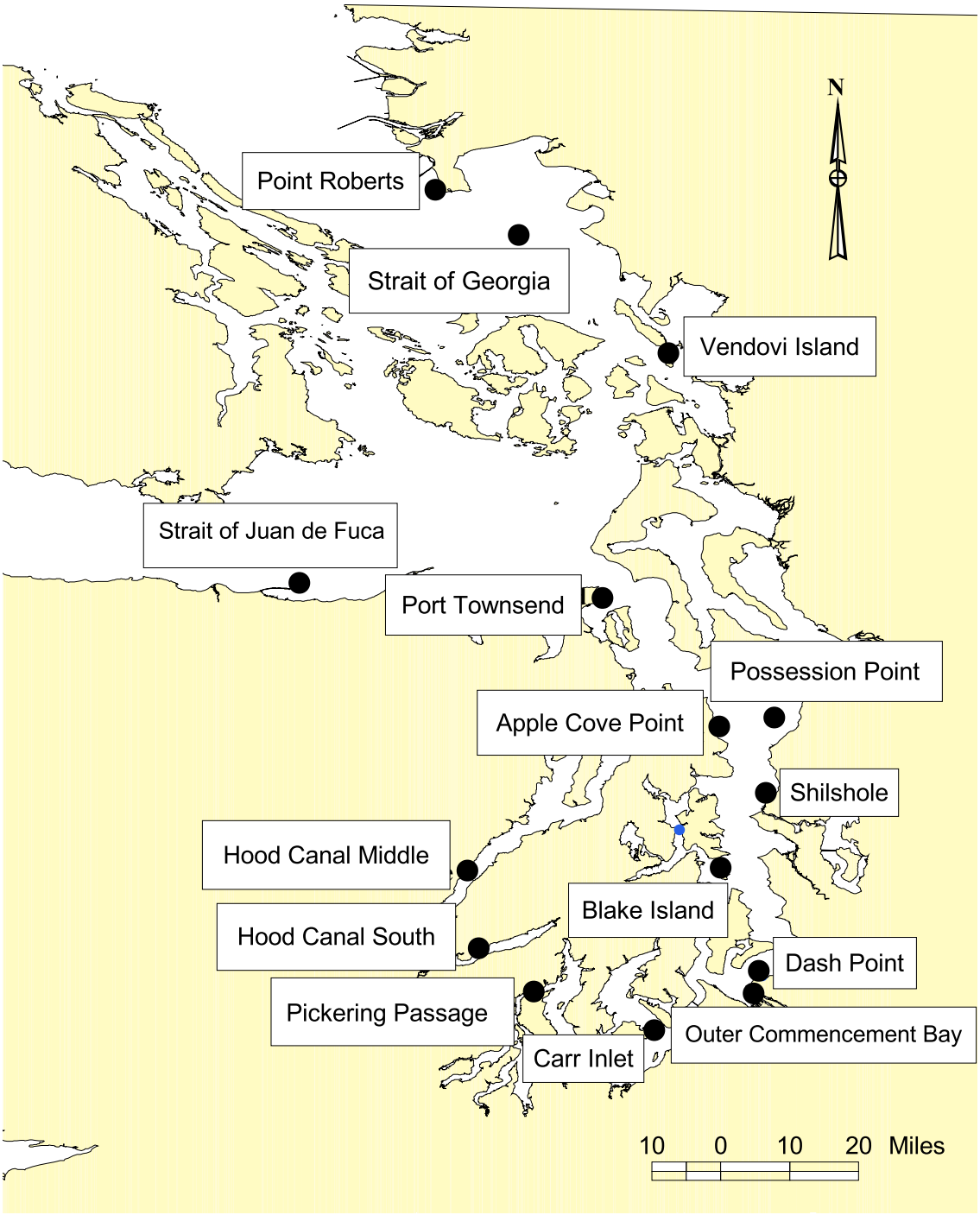

Figure 1: Sediment Sampling Sites in Puget Sound

to reduce the possibility of contamination. All samples were placed on ice immediately after collection, refrigerated, and transported to the Ecology Manchester Environmental Laboratory (Manchester Laboratory) within five days. Chain-of-custody was maintained throughout the study.

Pre-cleaned sampling equipment and sample containers were used to collect, handle, and store the sediment samples. Sampling equipment was cleaned with Liquinox detergent, followed by sequential rinses with hot tap water, deionized water, and pesticide-grade acetone, then air dried and wrapped in aluminum foil until used in the field. The same cleaning procedure was used to pre-clean the grab-sampling device prior to field outings. The grab sampler was cleaned between stations by thoroughly brushing and rinsing with on-site water.

Laboratory Procedures

Laboratory analyses of all samples were coordinated by the Manchester Laboratory. Axys Analytical Services, LTD, performed the analyses for individual congeners while Manchester Laboratory performed analyses to determine Aroclors only. Analytical costs and method sensitivity are important factors in method selection. The cost difference between methods 8082 and 1668a are substantial: the cost for congener analysis using method 1668a (about $1100/sample) is nearly ten times the cost for analysis of Aroclors using method 8082 ($130/sample). Table 1 shows the analytical methods and laboratories employed for this project.

Table 1: Analytical Methods and Laboratories.

Parameter	Method	Reference	Laboratory
Percent Solids	Gravimetric (EPA 160.3)	PSEP, 1996	Manchester
Total Organic Carbon	Combustion/CO2 Measurement @ 104°C and @70°C	PSEP, 1996	Manchester
Grain Size	Sieve and Pipet	PSEP, 1996	Rosa Environmental
PCBs (Aroclors)	(EPA 8082) GC-ECD	EPA, 1996	Manchester
PCBs (150 congeners plus groups)	(EPA 1668a) High Resolution Mass Spectrometry	EPA, 1996	Axys Analytical Services, LTD

Quality Assurance

Manchester Laboratory's standard quality assurance (QA) and quality control (QC) procedures were used for this project and are documented in their QA Manual (Kirchmer et al., 1989). Laboratory QC samples for PCBs included analysis of surrogate spikes, method blanks, duplicate matrix spikes, and laboratory control samples.

Field QA consisted of two blind replicates, one taken at the Vendovi Island site and the other at the Outer Commencement Bay site. The replicates were prepared from three additional grabs at each site. These grab samples were collected from within the 200-400 meter zone around the trawl tracks. These replicate samples were submitted to the laboratory as separate stations with random times.

Results

Data Quality

The case narratives from the laboratory indicate that QC was excellent and all results are usable as qualified (Appendix B). The data quality objectives described in the project plan (Seiders and Roose, 2001) were met in most cases. Practical quantitation limits (PQLs) for method 8082 ranged from 2.7-6.7 ug/kg; the target PQLs were 2-5 ug/kg. The PQLs achieved for method 1668a ranged from 0.00003-0.004 ug/kg; the target PQLs were 0.02-0.10 ug/kg. One hundred percent of all the data were usable while the target was 95%.

Results from the field replicate samples helped to assess sampling precision. The relative percent difference (RPD) between the replicate and original station are shown in Table 2. The RPD is the range of the replicate results expressed as a percent of their mean. Of the two sites where replicates were taken, only the Outer Commencement Bay site had detectable levels of PCBs. The RPD between each sample and its replicate was small, indicating that individual grab sampling locations were representative of the larger perimeter zone established for each site. The RPD for individual congeners analyzed by EPA method 1668a at the Outer Commencement Bay site ranged from 0-46% (Appendix C). For conventionals, the low RPDs suggest that the samples were representative of the sample area. The large RPDs for gravel are due to the natural variability found in these environments.

Table 2: Relative Percent Difference of Blind Field Replicates.

Conventionals

Station	% Gravel	% Sand	% Silt	% Clay	% Solids	TOC @70 °C	TOC @104 °C
ComBay	0.03	16.85	63.12	20.01	50.6	1.45	1.47
ComBay-R1	0.50	22.80	58.90	17.80	54.6	1.42	1.42
RPD	177	30	7	12	8	2	3
Vndovi	15.10	48.40	26.90	9.60	54.5	1.05	1.01
Vndovi-R2	2.20	54.40	30.00	13.30	51.1	0.97	0.81
RPD	149	12	11	32	6	8	22

PCBs (EPA method 8082, ug/kg, dw)

Station	PCB 1016	PCB 1221	PCB 1232	PCB 1242	PCB 1248	PCB 1254	PCB 1260
ComBay	4.5 u	4.5 u	4.5 u	4.5 u	4.5 u	**6.6**	**4.3** j
ComBay-R1	4.5 u	4.5 u	4.5 u	4.5 u	4.5 u	**7.2**	**4** j
RPD						9	7
Vndovi	4.4 u	4.4 u	4.4 u	4.4 u	4.4 u	4.4 u	4.4 u
Vndovi-R2	4.9 u	4.9 u	4.9 u	4.9 u	4.9 u	4.9 u	4.9 u
RPD							

j= Analyte was positively identified. Associated numerical value is an estimate.
u= Analyte was not detected at or above the reported value.
Bold= Analyte was positively identified or detected.

Conventionals

Table 3 shows results for grain size, percent solids, and total organic carbon (TOC) for each sample. Thirteen of the 17 samples were composed primarily of coarse sediments (sand plus gravel fraction greater than or equal to 56.6%). Four samples were composed primarily of fine-grained sediments (silt plus clay fraction greater than or equal to 74%); these samples were collected from Outer Commencement Bay, Possession Point, and Hood Canal South. TOC values ranged from 0.14-2.45%, while the values of eight samples were quite low (< 0.5%). The highest TOC values were found at the four stations with the highest percent fines. Two of these stations had detectable levels of PCBs: Outer Commencement Bay and Possession Point.

Table 3: Results of Conventionals Analyses of Sediments from Selected Sites in Puget Sound.

Station ID	Sample No.	% Gravel (>2mm)	% Sand (2mm-62.5um)	% Silt (62.5-4um)	% Clay (<4um)	% Solids	% TOC @70°C	% TOC @104°C
ComBay	218155	0.03	16.8	63.1	20.0	50.6	1.45	1.47
ComBay-R1	218170	0.5	22.8	58.9	17.8	54.6	1.42	1.42
DashPt	218156	0.3	69.7	15.8	14.2	54.9	0.99	1.00
Carr	218157	0.3	85.2	9.5	5.0	66.2	0.38	0.38
PntRbt	228158	0.0	96.2	2.9	0.9	74.0	0.15	0.14
StrGrg	228159	0.3	60.2	30.2	9.3	57.4	0.8	0.8
Vndovi	228160	15.1	48.4	26.9	9.6	54.5	1.05	1.01
Vndovi-R	228171	2.2	54.4	30.0	13.3	51.1	0.97	0.81
JuanFc	228161	12.8	82.9	3.3	1.0	85.5	0.23	0.23
PrtTwn	228162	0.0	81.1	14.1	4.9	66.3	0.42	0.42
AplCve	228163	0.1	88.2	8.5	3.2	66.8	0.36	0.36
PosPnt	228164	0.3	25.7	49.3	24.7	37.3	1.81	1.83
Shilsh	228165	0.4	96.5	1.2	1.9	75.1	0.14	0.14
PicPsg	238166	4.3	89.9	3.4	2.4	76.8	0.25	0.25
HodCnS	238167	0.2	19.9	52.1	27.8	37.2	2.45	2.48
HodCnM	238168	8.3	77.7	10.2	3.8	62.3	1.00	1.00
Blake	238169	1.0	91.5	4.4	3.0	74.8	0.28	0.28

PCBs

Concentrations of PCBs in sediment samples from the 15 sites were low as determined by the two analytical methods.

EPA Method 8082

Using method 8082, only three sites had detectable levels of PCBs: Outer Commencement Bay, Port Townsend, and Possession Point. Aroclors 1254 and 1260 were the only PCBs detected. Total PCB levels on a dry weight basis ranged from 3.5-11.2 ug/kg. The highest total PCB levels were measured in Outer Commencement Bay (11.2 ug/kg, dw).

Table 4 shows that PCBs were mostly below the PQL of method 8082 which ranged from 2.7-6.7 ug/kg, dw. Values with a "j" qualifier are estimates because concentrations were below the PQL. Table 4 values for total PCBs are also reported as normalized to organic carbon.

Table 4: Results of PCB Analyses Using Method 8082 (ug/kg, dw).

Station ID	PCBs							Total PCBs (ug/kg, dw)	Total PCBs (ug/kg, OC)
	1016	1221	1232	1242	1248	1254	1260		
ComBay	4.5 u	4.5 u	4.5 u	4.5 u	4.5 u	**6.6**	**4.3 j**	**10.9 j**	**746**
ComBayR1	4.5 u	4.5 u	4.5 u	4.5 u	4.5 u	**7.2**	**4.0 j**	**11.2 j**	**789**
DashPt	4.5 u	4.5 u	4.5 u	4.5 u	4.5 u	4.5 u	4.5 u	4.5u	u
Carr	3.8 u	3.8 u	3.8 u	3.8 u	3.8 u	3.8 u	3.8 u	3.8u	u
PntRbt	3.4 u	3.4 u	3.4 u	3.4 u	3.4 u	3.4 u	3.4 u	3.4u	u
StrGrg	4.3 u	4.3 u	4.3 u	4.3 u	4.3 u	4.3 u	4.3 u	4.3u	u
Vndovi	4.4 u	4.4 u	4.4 u	4.4 u	4.4 u	4.4 u	4.4 u	4.4u	u
VndoviR2	4.9 u	4.9 u	4.9 u	4.9 u	4.9 u	4.9 u	4.9 u	4.9u	u
JuanFc	2.7 u	2.7 u	2.7 u	2.7 u	2.7 u	2.7 u	2.7 u	2.7u	u
PrtTwn	3.7 u	3.7 u	3.7 u	3.7 u	3.7 u	3.7 u	**3.5 j**	**3.5 j**	**833**
AplCve	3.7 u	3.7 u	3.7 u	3.7 u	3.7 u	3.7 u	3.7 u	3.7u	u
PosPnt	6.7 u	6.7 u	6.7 u	6.7 u	6.7 u	**5.7 j**	**4.3 j**	**10 j**	**546**
Shilsh	3.1 u	3.1 u	3.1 u	3.1 u	3.1 u	3.1 u	3.1 u	3.1u	u
PicPsg	3.2 u	3.2 u	3.2 u	3.2 u	3.2 u	3.2 u	3.2 u	3.2u	u
HodCnS	6.5 u	6.5 u	6.5 u	6.5 u	6.5 u	6.5 u	6.5 u	6.5u	u
HodCnM	4.0 u	4.0 u	4.0 u	4.0 u	4.0 u	4.0 u	4.0 u	4.0u	u
Blake	3.3 u	3.3 u	3.3 u	3.3 u	3.3 u	3.3 u	3.3 u	3.3u	u

j= Analyte was positively identified. Associated numerical value is an estimate.
u= Analyte was not detected at or above the reported value.
Bold= Analyte was positively identified or detected.

Sediment PCB results are frequently normalized to organic carbon (OC) for comparison to other sample results and to various criteria. Since PCBs are highly lipophilic, the TOC content of the sediment is a major factor in controlling the bioavailability of PCBs. Sediments with lower TOC generally result in a higher proportion of their PCBs partitioning into porewater and being absorbed by benthic organisms (Rand, 1995). Washington's Sediment Management Standards (Chapter 173-204 WAC) define a sediment quality standard (SQS) for total PCBs (dry weight) of 12,000 ug/kg, OC. All 15 sites were at least an order of magnitude lower than this SQS. The Port Townsend site had the highest concentration of total PCBs (833 ug/kg, OC).

Normalization of sediment PCB results to OC may not be appropriate for comparison to all criteria. Michelsen (1988) suggests that where samples are low in TOC (< 0.1-0.2%), sediment data for non-ionic organic chemicals be reported on a dry weight basis when comparing to criteria for effects on biota. Low TOC values used in normalizing to OC can artificially inflate chemical concentration values. The highest total PCB value in this study, reported on a dry weight basis, was 11.2 ug/kg, dw. This is an order of magnitude below the lowest apparent effects threshold of 130 ug/kg, dw for total PCBs (PSEP, 1988).

At the three sites where PCBs were detected with method 8082, PCB levels exceeded the Human Health Cleanup Screening Level (HHCSL) of 260 ug/kg, OC. These proposed criteria were developed in Ecology's *Preliminary Implementation Strategy for Human Health Sediment Criteria*. The Strategy is the result of efforts to develop risk-based, human health sediment quality criteria for cleanup sites; the current sediment standards rules address environmental risk only (Weiss, 1997).

For sites where PCBs were not detected with method 8082, the reported detection limit value could be used for comparing to the HHCSL criteria. When these detection limit values are normalized to OC, values range from 262 ug/kg OC to 2429 ug/kg OC. This approach shows that all sites but one would exceed the HHCSL of 260 ug/kg, OC. The exception is the Hood Canal South site with a value of 262 ug/kg OC, which essentially meets the HHCSL. The low TOC content of sediments in many of these samples contributed to these sites exceeding the HHCSL

As described above, "background" levels in relatively clean areas in Puget Sound could exceed the human health-based criteria of 260 ug/kg, OC, particularly where TOC values are low. The *Preliminary Implementation Strategy* recognizes this and allows for some cleanup decisions to be based on a total PCB value of 1200 ug/kg, OC. This value was determined to be the Puget Sound-wide background level of total PCBs. Weiss (1997) describes the derivation and use of background concentrations for the purpose of setting cleanup levels for contaminated sediment sites.

EPA Method 1668a

Using method 1668a, all three samples from the Vendovi Island and Outer Commencement Bay sites showed detectable levels of PCBs. Each sample was analyzed for all 209 congeners, with 150 being separately quantified and the remainder quantified as groups of congeners. The much lower PQLs of method 1668a (0.00003-0.004 ug/kg, dw) resulted in the detection of PCBs, where method 8082 showed no detectable PCBs. At the Vendovi Island site, method 8082

showed no apparent detection of PCBs, while method 1668a showed 0.636 ug/kg, dw of total PCBs. Appendix C contains the results from method 1668a.

The results of estimated Aroclor values from method 1668a are shown in Table 5. These values were estimated from the presence and ratios of specific congeners in the sample. The estimation of Aroclors from individual congeners is an emerging science, and results should be considered estimates only (Magoon, 2001).

Table 5: Aroclor Values as Estimated from Individual Congener Results Using Method 1668a (ug/kg, dw).

Station ID	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
ComBay	1.12	0.0047	3.22	2.35
ComBayR1	1.23	0.0036	4.32	2.80
Vndovi	0.23	0.0012	0.30	0.16

Comparing Results of Methods 8082 and 1668a

Table 6 compares the total PCB value obtained from the results of methods 8082 and 1668a. Results from method 8082 were higher than those from method 1668a.

Table 6: Comparison of Total PCB Values from Methods 8082 and 1668a (ug/kg, dw).

Station	Method 8082 Total PCBs (sum of Aroclors)	Method 1668a Total PCBs (sum of Aroclors)	Method 1668a Total PCBs (sum of congeners)
ComBay	10.9	6.70	7.26
ComBayR1	11.2	8.35	9.32
Vendovi	4.4u	0.69	0.64

u= Analyte was not detected at or above the reported value

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Conclusions

Sediments from 15 sites in Puget Sound were collected in May 2001 and analyzed for PCBs as Aroclors; a subset of these was analyzed for individual PCB congeners. This study was conducted to support efforts by Ecology and WDFW to relate PCB concentrations in sediments to concentrations in muscle tissue of English sole *(Plueronectes vetulus)*, to help develop sediment tissue bioaccumulation factors, and to evaluate background conditions in Puget Sound.

Concentrations of PCBs in sediment samples from all 15 sites were generally low, and results were compared to various sediment criteria.

Using method 8082, only three sites had detectable levels of PCBs: Outer Commencement Bay, Port Townsend, and Possession Point. The concentrations of PCBs at these three sites exceeded the proposed Human Health Cleanup Screening Level of 260 ug/kg, OC. It was not possible to determine whether PCB concentrations at the remaining sites were lower than this screening level. All 15 sites were at least an order of magnitude lower than the Washington State sediment quality standard of 12,000 ug TPCB/kg, OC. The highest total PCB value in this study, reported on a dry weight basis, was 11.2 ug/kg, dw, an order of magnitude below the lowest apparent effects threshold of 130 ug/kg, dw

Three samples from the Vendovi Island and Outer Commencement Bay sites were analyzed by method 1668a, and all showed detectable levels of PCBs. Practical quantitation limits for method 1668a ranged from 0.00003 to 0.004 ug/kg, dw. Method 8082, with practical quantitation limits ranging from 2.7 to 6.3 ug/kg, dw, did not detect PCBs at the Vendovi Island site, while method 1668a showed 0.636 ug/kg, dw of total PCBs at the site.

While method 1668a has the ability to detect PCBs at lower levels than method 8082, the price difference is considerable: $1,100/sample (1668a) vs. $130/sample (8082). Due to this expense, few samples were analyzed with method 1668a. In addition, improvement of correlations between sediment and English sole PCB concentrations will be minimal due to the majority of non-detected values from method 8082.

This study documents that method 8082 detection limits are too high to characterize background PCB levels in Puget Sound reference areas or to determine compliance with Ecology's proposed Human Health Cleanup Screening Level of 260 ug/kg, OC. To meet these needs, future studies must use methods that attain low quantitation limits for sediment PCBs.

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Appendices

Appendix A

Sampling Site Information

Figure A1: Maps of Sampling Locations

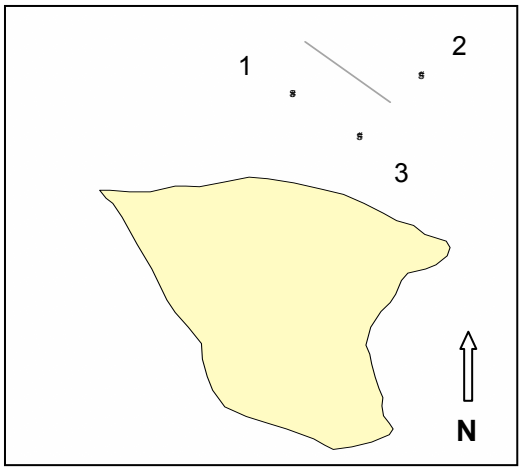

Fig.1 Blake Island (Blake)

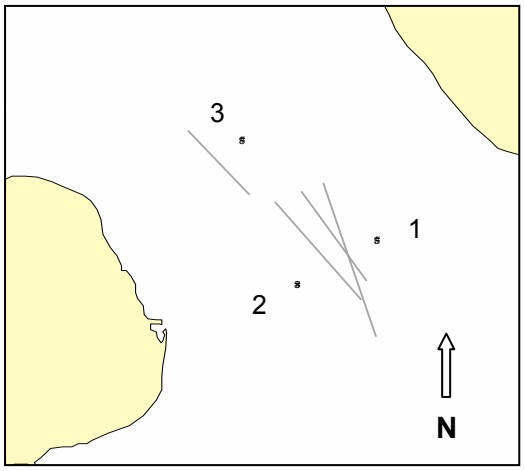

Fig. 2 Carr Inlet (Carr)

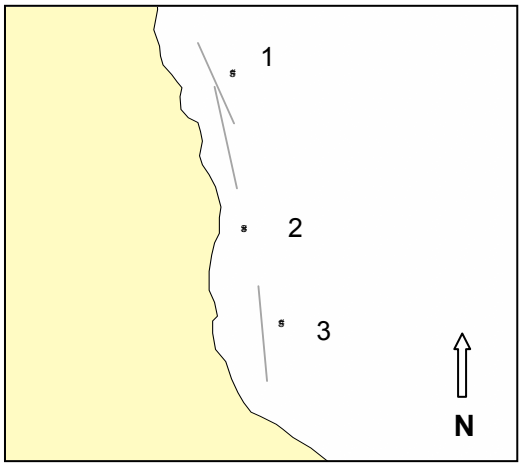

Fig. 3 Apple Cove Point (AplCve)

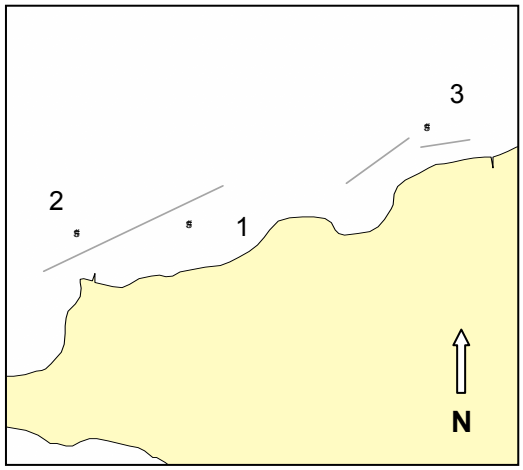

Fig. 4 Dash Point (DashPt)

LEGEND

Historic Fish Trawl Track Lines

Grab Locations

Replicate Sample Sites

Historic Puget Sound Ambient Monitoring Program Sites (PSAMP)

Figure A1: Maps of Sampling Locations

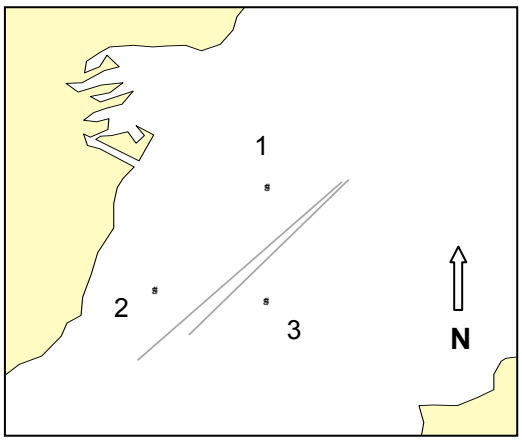

Fig. 5 Hood Canal-Middle (HodCnm)

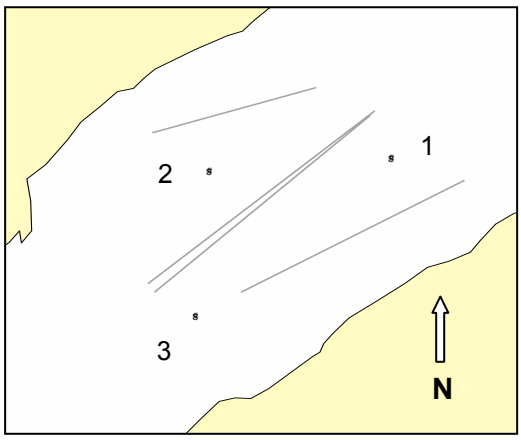

Fig. 6 Hood Canal-South (HodCns)

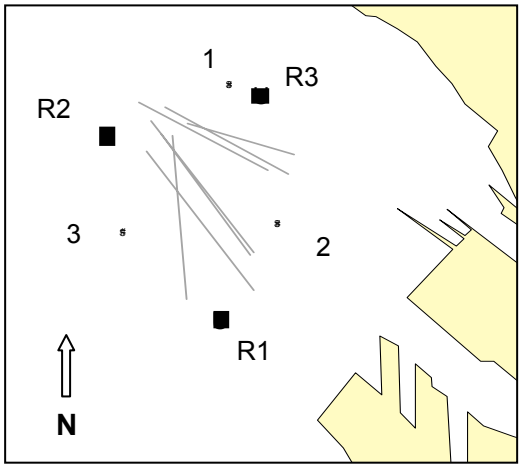

Fig. 7 Outer Commencement Bay (Combay)

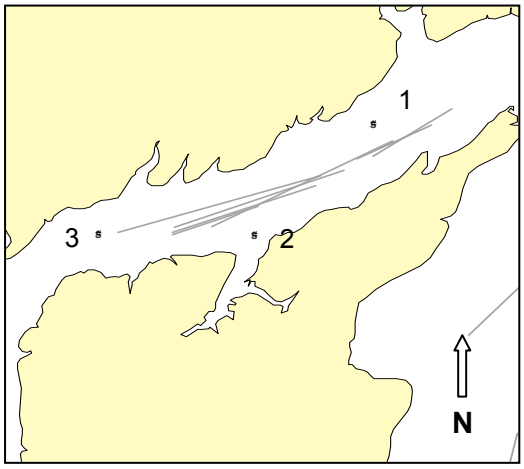

Fig. 8 Pickering Passage (PicPsg)

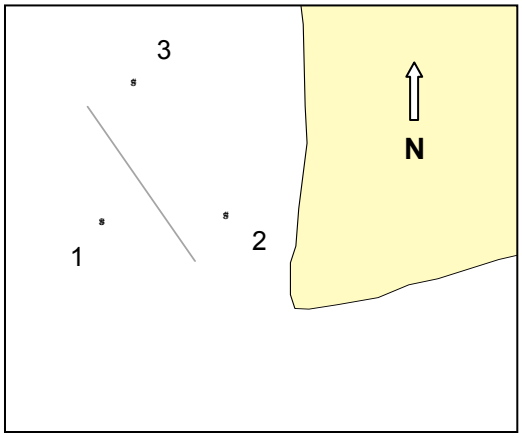

Fig. 9 Point Roberts (PntRbt)

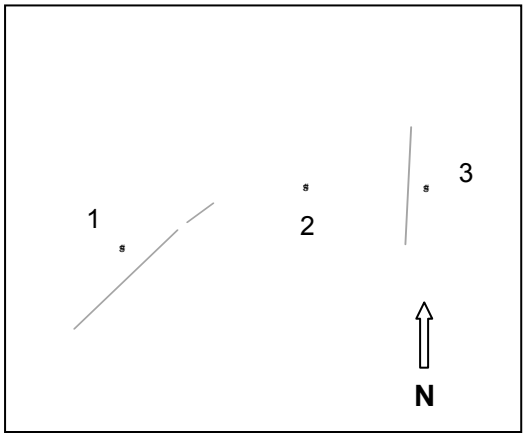

Fig. 10 Possession Point (PosPnt)

Figure A1: Maps of Sampling Locations

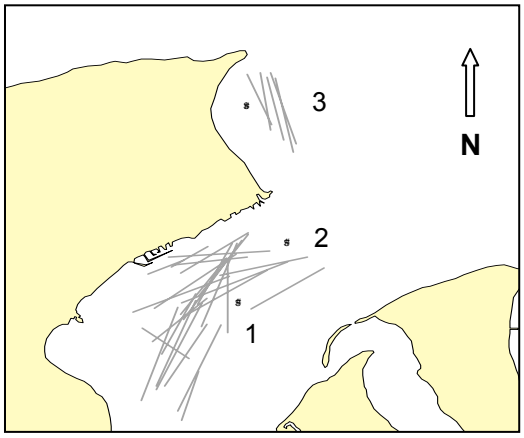

Fig. 11 Port Townsend (PrtTwn)

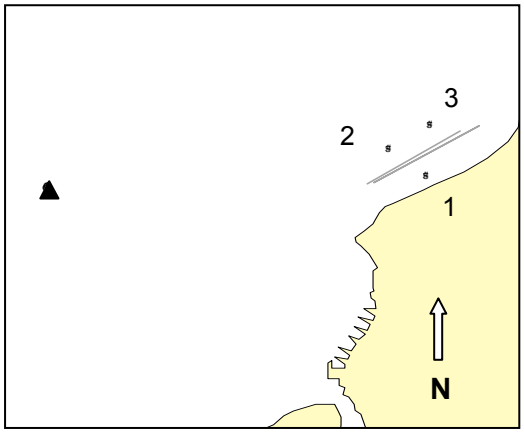

Fig. 12 Shilshole (Shilsh)

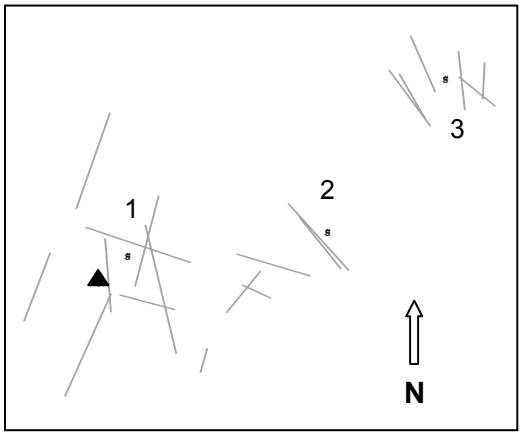

Fig. 13 Straits of Georgia (StrGrg)

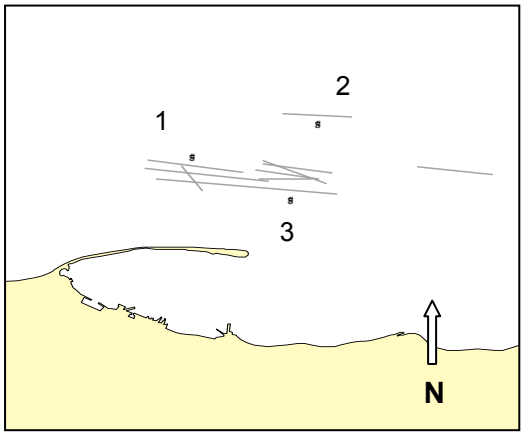

Fig. 14 Straits of Juan de Fuca (JuanFc)

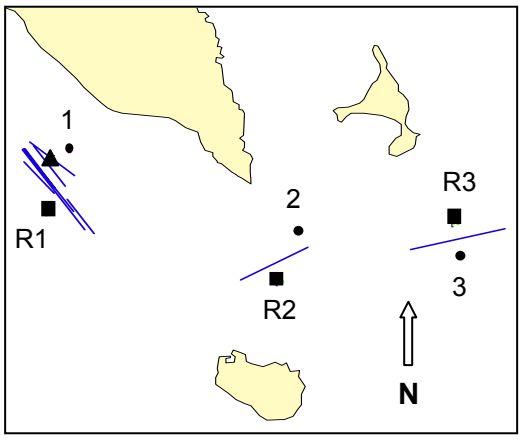

Fig. 15 Vendovi Island (Vndovi)

Table A1: Sampling Station Log - pg 1

			Sample Location Trimble NT300D (2-m. accuracy) NAD 1983, Decimal Minutes				Predicted Tide (m.)	Predicted Mudline	GPS Status
Site Name	Site Code	Date	Latitude	Longitude	Time	Depth (m)	Nearest Station	Depth (m) (MLLW)	PDOP/HDOP
Outer Commencement Bay	ComBayR1	25-May-01	47 16.8092	122 25.5520	1010	76	1.1	-74	2.4/1.3
	ComBayR2		47 17.4153	122 26.0230	1027	62	0.8	-61	2.3/1.2
	ComBayR3		47 17.5436	122 25.3784	1042	21	0.6	-20	2.2/1.2
Outer Commencement Bay	ComBay-1	25-May-01	47 17.5774	122 25.5162	1108	49	0.2	-49	2.8/1.5
	ComBay-2		47 17.1254	122 25.3128	1124	61	0.0	-61	2.1/1.3
	ComBay-3		47 17.0984	122 25.9643	1141	106	0.2	-106	1.9/1.1
Dash Point	DashPt-1	25-May-01	47 19.6944	122 24.5507	1308	61	-0.8	-62	2.4/1.2
	DashPt-2		47 19.6186	122 25.7249	1325	138	-0.9	-1	1.8/1.1
	DashPt-3		47 20.4766	122 22.0668	1236	57	-0.7	-58	1.8/0.9
Carr Inlet #1	Carr-1	25-May-01	47 12.7956	122 37.2446	1529	162	-0.4	-162	2.4/1.2
	Carr-2		47 12.5987	122 37.7033	1554	165	0.1	-165	2.8/1.1
	Carr-3		47 13.2441	122 38.0196	1613	141	0.4	-141	2.6/1.1
Point Roberts	PntRbt-1	30-May-01	48 58.5252	123 05.6188	0913	53	1.6	-51	1.9/1.1
	PntRbt-2		48 58.5435	123 05.2122	0924	11	1.6	-9	2.0/1.1
	PntRbt-3		48 58.8943	123 05.5159	0932	10	1.6	-8	2.2/1.2
Strait of Georgia	StrGrg-1	30-May-01	48 52.5108	122 58.2561	1150	222	1.8	-220	1.8/0.9
	StrGrg-2		48 52.8208	122 55.1139	1125	91	1.8	-89	1.7/0.9
	StrGrg-3		48 54.7742	122 53.2624	1058	50	1.9	-48	2.1/1.3

Table A1: Sampling Station Log - pg 2

			Sample Location Trimble NT300D (2-m. accuracy) NAD 1983, Decimal Minutes				Predicted Tide (m.)	Predicted Mudline	GPS Status
Site Name	Site Code	Date	Latitude	Longitude	Time	Depth (m)	Nearest Station	Depth (m) (MLLW)	PDOP/HDOP
Vendovi Island	Vndovi-1	30-May-01	48 38.7198	122 38.2881	1428	54	1.1	-53	3.5/2.2
	Vndovi-2		48 38.0040	122 35.8065	1548	104	0.7	-103	2.8/1.1
	Vndovi-3		48 37.7962	122 34.0638	1605	42	0.6	-41	2.6/1.1
Vendovi Island	VndoviR1	30-May-01	48 38.2016	122 38.5215	1441	64	1.1	-63	3.3/2.1
	VndoviR2		48 37.5814	122 36.0259	1530	116	0.8	-115	2.7/1.1
	VndoviR3		48 38.0971	122 34.1174	1614	73	0.5	-73	2.4/1.1
Strait of Juan de Fuca	JuanFc-1	31-May-01	48 10.0395	123 25.0668	0750	94	1.0	-93	2.4/1.3
	JuanFc-2		48 10.5779	123 22.5561	0839	102	1.1	-101	2.0/1.2
	JuanFc-3		48 09.3216	123 23.1028	0730	75	1.0	-74	2.8/1.3
Port Townsend	PrtTwn-1	31-May-01	48 05.8285	122 45.2577	1312	19	1.7	-17	1.8/1.1
	PrtTwn-2		48 06.5177	122 44.5770	1300	18	1.7	-16	1.8/1.1
	PrtTwn-3		48 08.0893	122 45.1393	1209	25	1.7	-23	1.8/0.9
Apple Cove Pt.	AplCve-1	31-May-01	47 51.7262	122 30.1724	1550	45	1.7	-43	2.6/1.1
	AplCve-2		47 50.7458	122 30.0753	1604	21	1.6	-19	2.5/1.1
	AplCve-3		47 50.1485	122 29.7736	1616	72	1.5	-71	2.3/1.2
Possession Pt.	PosPnt-1	31-May-01	47 51.8636	122 24.0153	1701	153	1.2	-152	1.5/1.0
	PosPnt-2		47 52.2541	122 22.6043	1723	176	1.1	-175	1.5/1.0
	PosPnt-3		47 52.2497	122 21.6729	1740	189	1.0	-188	3.6/2.0

Table A1: Sampling Station Log - pg 3

			Sample Location Trimble NT300D (2-m. accuracy) NAD 1983, Decimal Minutes				Predicted Tide (m.)	Predicted Mudline	GPS Status
Site Name	Site Code	Date	Latitude	Longitude	Time	Depth (m)	Nearest Station	Depth (m) (MLLW)	PDOP/HDOP
Shilshole	Shilsh-1	31-May-01	47 42.1744	122 23.6659	1943	5.4	0.9	-4.5	2.5/1.6
	Shilsh-2		47 42.3812	122 24.0251	1936	44	0.8	-43	2.6/1.7
	Shilsh-3		47 42.5730	122 23.6270	1927	73	0.8	-72	2.7/1.7
Hood Canal-South	HodCnS-1	07-Jun-01	47 22.621	122 59.612	1249	113			
	HodCnS-2		47 22.580	123 00.284	1315	102			
	HodCnS-3		47 22.134	123 00.335	1442	125			
Hood Canal-Middle	HodCnM-1	07-Jun-01	47 32.542	123 01.694	1005	42			
	HodCnM-2		47 32.153	123 02.202	1100	103			
	HodCnM-3		47 32.111	123 01.696	1120	204			
Pickering Passage	PicPsg-1	08-Jun-01	47 18.040	122 52.045	1150	98			
	PicPsg-2		47 17.317	122 53.041	1125	64			
	PicPsg-3		47 17.320	122 54.339	1220	78			
Blake Island	Blake-1	08-Jun-01	47 33.022	122 29.383	1630	64			
	Blake-2		47 33.086	122 28.803	1737	162			
	Blake-3		47 32.874	122 29.081	1700	51			

Table A2: Sediment Log - pg 1

Station	Grab. No.	Depth (m)	Date	Time	Penetration (cm)	Sample Description
COMBAY-R1	1	76	5/25/01	1010	17	Light Brown, sandy-silt, dark grey below 2cm. Some shell, no odor, no oil.
COMBAY-R2	1	62	5/25/01	1027	15	Light Brown, sandy-silt, dark grey below 2cm. Tube worms present. No odor, no oil.
COMBAY-R3	1	21	5/25/01	1042	14	Light Brown, silty-sand. Some tube worms, wood in jaws, small gravel @depth.
COMBAY-1	1	49	5/25/01	1108	17	Light brown silty-sand, dark gray mud below 1/2 cm, some shell and snails.
COMBAY-2	1	61	5/25/01	1124	17	Light brown silty-sand, dark gray mud below 5 cm, some shell, no odor.
COMBAY-3	1	106	5/25/01	1141	17	Light brown silty-sand, dark gray below 5 cm. No shell, no odor.
DASHPT-1	1	61	5/25/01	1310	7	Gray sand, shell, tube worms.
DASHPT-2	1	138	5/25/01	1325	15	Gray silty sand, tube worms, some shells, no odor.
DASHPT-3	1	57	5/25/01	1235	10	Gray sand, with some silt, tube worms.
CARR-1	1	162	5/25/01	1530	10	Gray brown sand, some silt, small crabs, algae holdfast, clam, tubeworms, no odor.
CARR-2	1	165	5/25/01	1600	14	Brown sandy silt, many tube worms, seawhip (aerobic sed.)
CARR-3	1	141	5/25/01	1615	17	Gray brown sandy-silt, no odor , few shell, some tube worms.
PNTRBT-1	1	53	5/30/01	913	10	Gray-green silty sand, some shell, small pebbles, some seaweed, no odor or oil.
PNTRBT-2	1	11	5/30/01	924	8	Gray silty sand, one big shell, some small shell, algae on sand.
PNTRBT-3	1	10	5/30/01	932	12	Gray silty sand, some shell, some tube casing.
STRGRG-1	1	222	5/30/01	1150	9	Gray/black large grain sand, silty after 5cm. Tube worms, large shell fragments.
STRGRG-2	1	91	5/30/01	1125	12	Gray Silty mud, tube worms, large shell shragments, polychaetes, no smell, or oil.
STRGRG-3	1	50	5/30/01	1058	16	Gray-brown silty mud, some shell, tube worms, no smell or oil.

Table A2: Sediment Log - pg 2

Station	Grab. No.	Depth (m)	Date	Time	Penetration (cm)	Sample Description
VNDOVI-1	1	54	5/30/01	1428	11	Black sand on dark fine silt. Shells w/barnacles, and tubeworms present.
VNDOVI-2	1	104	5/30/01	1548	10	Thin layer of silt on sandy pebbly substrate. Lots of shells and small rocks. Black silt 5cm down.
VNDOVI-3	1	42	5/30/01	1605	17	Brown silt w/black silt 2cm down, a few polychaetes, no odor or oil.
VNDOVI -R1	1	64	5/30/01	1441	16	Brown algae and black sand on muddy silt, lots of shell and pebbles in grab.
VNDOVI -R2	1	116	5/30/01	1530	7	Gray silty-sand. Tube worms, lots of shell fragment and seaweed.
VNDOVI -R3	1	73	5/30/01	1614	17	Brown gray silt. Tubeworms, some shell.
JUANFC-1	1	94	5/31/01	750	11	Gray, medium grain sand w/ small pebbles, shell fragments and small tubeworms, no odor or oil.
JUANFC-2	1	102	5/31/01	839	8	Gray silty sand, some small pebbles, lots of sea life. Sea whip, hermit brabs, snails, tube worms, and a thin algae layer.
JUANFC-3	1	75	5/31/01	730	7	Fine gray black sand some sand fleas, no odor or oil.
PRTTWN-1	1	19	5/31/01	1312	16	Gray brown, sandy silt, tubeworms. Darker gray below 5cm.
PRTTWN-2	1	18	5/31/01	1300	10	Gray brown, sandy silt, razor clam shells, seaweed, tube worms.
PRTTWN-3	1	25	5/31/01	1209	9	Gray silty sand, seaweed, some shell, algae growth and tube worms.
APLCVE-1	1	45	5/31/01	1550	12	Gray-green silty sand, no odor or oil. Tube worms.
APLCVE-2	1	21	5/31/01	1604	10	Gray-green silty sand. Tube worms, small bivalves, no odor or oil.
APLCVE-3	1	72	5/31/01	1616	17	Gray sandy silt. Tubeworms. No odor.
POSPNT-1	1	153	5/31/01	1701	17	Dark brown silt. Heavier and black under 5cm. Large polychaetes, sea urchin, trevarius, strange odor, no oil.
POSPNT-2	1	176	5/31/01	1723	17	Heavy dark mud. Consistent throughout, no oil, no odor, no sea life.

Table A2: Sediment Log - pg 3

Station	Grab. No.	Depth (m)	Date	Time	Penetration (cm)	Sample Description
POSPNT-3	1	189	5/31/01	1740	17	Heavy black mud. Many traverias in sample. Nothing else.
SHILSH-1	1	5.4	5/31/01	1943	10	Gray sand. Small bivalves, no odor, tube worms.
SHILSH-2	1	44	5/31/01	1936	10	Gray brown silty sand, some shell and tube worms.
SHILSH-3	1	73	5/31/01	1927	8	Gray brown silty sand. Some polychaetes and tube worms.
HODCNM-1	1	42	6/7/01	1005	10	Mostly sand with some fines, small organic debris, hermit crabs, sand fleas and small clams
HODCNM-2	1	103	6/7/01	1100	15	Fine sediment just on the course side of mud. Fairly consistent in texture.
HODCNM-3	1	204	6/7/01	1120	15	Sandy with lots of gravel (gravel removed from sample)
HODCNS-1	1	113	6/7/01	1249	17	Brown mud, consistent in texture
HODCNS-2	1	102	6/7/01	1315	17	Brown mud, consistent in texture
HODCNS-3	1	125	6/7/01	1442	17	Brown mud, consistent in texture
PICPSG-1	1	98	6/8/01	1150	10	Grey-greenish brown sandy with silt. About 10 tube worms.
PICPSG-2	1	64	6/8/01	1125	9	Grey brown silty sand, with some shell fragments. 10-15 tube worms.
PICPSG-3	1	78	6/8/01	1220	7	Sandy, pebbles and gravel, grey green brownish.
BLAKE-1	1	64	6/8/01	1630	7	Sandy olive brown color, 24 tube worms.
BLAKE-2	1	51	6/8/01	1737	6	Sandy-olive brown color, 6 tube worms
BLAKE-3	1	162	6/8/01	1700	9	Silty sand- olive brown color, higher density of worms.

Recorder: Dale Norton, Morgan Roose, Brandee Era, Keith Seiders, Randy Coots and Dave Serdar.

Appendix B

Case Narratives

Manchester Environmental Laboratory
7411 Beach Drive East, Port Orchard Washington 98366

CASE NARRATIVE

June 29, 2001

Subject:	Puget Sound Sediment PCBs
Samples:	01218155 – 01218157, 01218170, 01228158 – 01228165, 01228171, 01238166 - 01238169
Case No.	1548-01
Officer:	Keith Seiders
By:	Myrna Mandjikov

PCB Aroclor and % Solid Analysis of Puget Sound Sediments

SUMMARY

Aroclor results reported below the practical quantitation limit (PQL) are qualified as estimates, "J".

The data is useable as qualified.

METHODS

The sediment samples were extracted with acetone using the Soxhlet extraction procedure. Each extract was eluted through a Florisil® column with 6% v/v preserved diethyl ether/hexane.

The extracts were solvent exchanged to iso-octane and treated with elemental mercury to remove sulfur and then treated with concentrated sulfuric acid. Several extracts required four mercury treatments to remove excess sulfur. The extracts were then analyzed by GC-ECD.

These methods are modifications of EPA SW- 846 methods 3540, 3550, 3620, 3665, and 8082.

BLANKS

No target analytes were detected in the blanks.

SURROGATES

All samples and blanks were spiked with decachlorobiphenyl (DCB) prior to extraction. All recoveries are within the acceptable range of 50 % - 150 %.

DUPLICATES

Sample 01228171 was prepared in duplicate for both the PCB analysis and the % solids analysis. The relative percent difference (RPD) between the % solids found is 3%. There are no PCB Aroclors detected in either the sample or the duplicate. Therefore, the RPD is not calculated for the Aroclor results.

SPIKED AND DUPLICATE SPIKED SAMPLE

Samples 01228160 and 01228165 were prepared in triplicate. Two replicates of each were spiked at the project officer's request with Aroclors 1016 and 1260. All Aroclors were recovered within 50 % - 150% of spiked concentration. The following are the percent recoveries and relative percent difference (RPD) between the recoveries

Sample	**Aroclor**	**LMX1**	**LMX2**	**RPD**
01228160	Aroclor 1016	98 %	98 %	1 %
	Aroclor 1260	75 %	73 %	3 %
01228165	Aroclor 1016	101 %	64 %	45 %
	Aroclor 1260	83 %	55 %	40 %

01228165 LMX2 "bumped" on the steam bath during concentration. The estimated loss of the extract is 20% which is apparent in the result for the spike recoveries and RPD. Results are not qualified on the basis of this anomaly.

LABORATORY CONTROL SAMPLES

Environmental Resource Associates' "PCBs in Soil" was used for the preparation of the laboratory control samples for this analysis. The recoveries of the Laboratory Control Samples (LCS) are 83 % and 88 % of the certified value. These recoveries are consistent with recoveries from previous PCB analysis. We are currently evaluating this control sample.

The certified value provided by the vendor is 12.6 mg/Kg with acceptance recovery limits of 31 % to 129% recovery.

HOLDING TIMES

The sample was extracted and analyzed within the recommended holding times.

DATA QUALIFIERS

Code	Definition
E	Reported result is an estimate because it exceeds the calibration.
J	The analyte was positively identified. The associated numerical result is an estimate.
N	There is evidence the analyte is present in this sample.
NJ	There is evidence that the analyte is present. The associated numerical result is an estimate.
NAF	Not analyzed for.
NC	Not calculated.
REJ	The data are unusable for all purposes.
U	The analyte was not detected at or above the reported result.
UJ	The analyte was not detected at or above the reported estimated result.
Bold Type	The analyte was present in the sample. Used as a visual aid to locate detected compounds on the report sheet.

Manchester Environmental Laboratory
7411 Beach Drive East, Port Orchard Washington 98366

August 17, 2001

TO: Keith Seiders

FROM: Kamilee Ginder, Chemist

SUBJECT: **General Chemistry Quality Assurance Memo for Puget Sound Sediment PCBs**

SUMMARY

The data generated by the analysis of these samples can be used without qualification. All analyses requested were evaluated by established regulatory quality assurance guidelines.

SAMPLE INFORMATION

Samples for Puget Sound Sediment PCBs project were received by Manchester Environmental Laboratory on 05/29/01, 06/01/01 and 06/11/01 in good condition. Samples were stored frozen until 08/01/01 when they were transferred to a 4^{o}C refrigerator to thaw for analysis.

HOLDING TIMES

All analyses were performed within established EPA holding times.

ANALYSIS PERFORMANCE

Instrument Calibration

Instrument calibration was checked by initial calibration verification standards and blanks. All initial and continuing calibration verification standards were within control limits. A correlation coefficient of 0.995 or greater was met. Balances are professionally calibrated yearly and calibrated in-house daily. Oven temperature is recorded before and after each analysis batch.

Procedural Blanks

The procedural blanks associated with these samples showed no significant analytical levels of analytes.

Spiked Sample Analysis

Spiked sample analyses were performed where applicable with all spike recoveries within acceptance limits of ± 25%. Spiked sample analysis is performed at a frequency of at least 5%.

Precision Data

Spiked sample results and duplicate sample results were used to evaluate precision on this sample set. Relative Percent Differences (RPD) for general chemistry parameters were within acceptance limits of ± 20% for duplicate analysis. Laboratory duplication is performed at a frequency of at least 10%. Precision and accuracy specifications are based on sample concentrations greater than four times the reporting limit. For results near the reporting limit, the criteria are not guaranteed to be better than +/- the method detection limit.

Laboratory Control Sample (LCS) Analyses

LCS analyses were within the windows established for each parameter.

Other Quality Assurance Measures and Issues

The "U" qualification indicates that the analyte was not detected at or above the reporting limit.

Please call Jim Ross at (360) 871-8808 or Kamilee Ginder at (360) 871-8826 to further discuss this project.

cc: Project File

Manchester Environmental Laboratory
7411 Beach Drive East, Port Orchard Washington 98366

October 26, 2001

Subject:	**Puget Sound Sediment PCB**
Samples:	Manchester: 01218155, 01218170, 01228160
	Axys: L3607-1 through L3607-3
Project ID:	Manchester: 1548-01, Axys: 4078
Laboratory:	Axys Analytical Services Ltd
Project Officer:	Keith Seiders
By:	Karin Feddersen

Data Review for PCB Congener and PCB Equivalent Analysis

Summary

Data from these analyses were reviewed for qualitative and quantitative accuracy following the method 1668A.

Samples were prepared and analyzed according to EPA method 1668A. Dilutions were performed for several congeners. Axys has used the qualifier "X" for these results on the original report. The dilution results are reported separately on the hard copies.
Results have been reported in nanograms per kilogram (ng/Kg), dry weight.

Axys estimated the concentration of Aroclors 1242, 1248, 1254, 1260 from various congeners. Axys did not identify Aroclor 1248 in the samples. However, upon review of the data, there does appear to be evidence that 1248 is present.

I used the research paper "Complete PCB Congener Distributions for 17 Aroclor Mixtures Determined by 3 HRGC Systems Optimized for Comprehensive, Quantitative, Congener-Specific Analysis" by Frame, Cochran and Bøwadt as a reference for percentages of congeners in each Aroclor. See the Excel spreadsheet "pcb congener_Aroclor equivalents Puget Sound.xls".

Axys uses congeners 44, 49 and 66 to estimate presence and concentration of Aroclor 1248. According to the research paper above, the distribution of congener 44 in Aroclor 1248 is approximately 6%; congener 49 is approximately 4%; congener 66: 6½ %. (See the table below.) Therefore if Aroclor 1248 is present in the sample, 44 and 66 would

each be expected to be present at approximately the same level, and at 1½ times the level of 49.

Looking at the samples, the concentration of congener 44 is 1½ times congener 49, while congener 66 is approximately twice as high as 49.

To account for this apparent anomaly, referring again to the research paper tables, one finds congener 66 distribution in Aroclor 1254 to be between 1 and 3½ %. Since Aroclor 1254 has been identified in the samples, it seems possible that the higher amount of congener 66 is contribution for Aroclor 1254.

Since it is possible that Aroclor 1248 is present, the estimated values for the tentatively identified Aroclor 1248 in each sample have been reported with the qualifier "NJ".

All results may be used as qualified.

% PCB congener distributions in Aroclors*

Aroclor Congener	**1242**	**1248**	**1254**
8	~ 7 %	~ ½ %	**
18	~ 8½ %	~ 3½ %	**
28	~ 7 %	~ 4½ %	**
31	~ 7 %	~ 5 %	**
44	~ 3½ %	~ 5½ %	**
49	~ 2½ %	~ 4 %	**
66	~ 3½ %	~ 6½ %	1 - 3.6%
87	**	~ 1 %	~ 3½ %
99	**	~ 1½ %	~ 3½ %

*Average values from different manufacturers. Adapted from Complete PCB Congener Distributions for 17 Aroclor Mixtures Determined by 3 HRGC Systems Optimized for Comprehensive, Quantitative, Congener-Specific Analysis by Frame, Cochran and Bøwadt, table 4A.

**Less than 1%

Holding Times

EPA method 1668A allows storage of samples for one year from the date of collection. Extraction and analysis took place within this time frame.

Blanks

Low levels of certain target compounds were detected in the laboratory blanks. These congeners were also detected in the samples. If the concentration of a congener in a sample was less than five times that of the method blank, a "U" or "UJ" qualifier was added to the result. In cases where the sample concentration for a congener was greater than five times that of the blank, the blank result is considered insignificant relative to the

native concentration detected in the sample. No qualification is warranted in these situations.

Calibration

The calibration standards were within 20% relative standard deviations (RSD) for all target analytes and 30% for all the labeled reference compounds (Internal Standards).

All calibration verification standard recoveries were within QC limits of 70% to 130% for target analytes and 50% to 150% for the labeled reference compounds.

All the ion abundance ratios and relative retention times were within QC criteria.

Internal Standard Recoveries

Internal standard recoveries for these samples were all within the method specified QC limits of 25% to 150%.

Ion abundance ratios

Each congener reported as detected met the isotopic abundance ratio and retention time criteria for positive identification with several exceptions, which have been qualified "NJ".

On-going Precision and Recovery (OPR)

Target analyte recoveries were within quality control limits. Labeled compound recoveries were within quality control limits.

Data Qualifier Codes

U	-	The analyte was not detected at or above the reported value.
J	-	The analyte was positively identified. The associated numerical value is an estimate.
UJ	-	The analyte was not detected at or above the reported estimated result.
NJ	-	There is evidence that the analyte is present. The associated numerical result is an estimate.

Manchester Environmental Laboratory
7411 Beach Drive East, Port Orchard Washington 98366

June 29, 2001

Project: Puget Sound Sediments

Samples: 21-8155-57, 21-8170, 22-8158-65, 22-8171, 23-8166-69

Laboratory: Rosa Environmental

By: Pam Covey

Case Summary

These samples required seventeen (17) Grain Size analyses on sediment samples using Puget Sound Estuary Protocol (PSEP) method for gravel, sand, silt and clay fractions only. One sample was analyzed in triplicate. The samples were received at the Manchester Environmental Laboratory and transported to the contract lab on June 13, 2001 for Grain Size analyses.

The analyses were reviewed for qualitative and quantitative accuracy, validity and usefulness. The results are acceptable for use as reported.

If you have any questions, please call me at (360) 871-8827.

Appendix C

Congener Analysis Results

Appendix C1. Congener Results from Analysis with EPA Method 1668a (ng/Kg, dw) - pg 1

PCB Congener	CAS Number	Site ComBay		Site ComBay Rep		Site Vendovi		Lab Blank		Matrix Spike Recovery (%)	RPD of ComBay & ComBay Rep (%)
CL1-PCB-1	2051-60-7	6.17		8.00		1.93	J	0.170	J	96	-13%
CL1-PCB-2	2051-61-8	2.57		2.92		1.68	J	0.0897	U		-6%
CL1-PCB-3	2051-62-9	5.27		6.94		1.46	J	0.155	NJ	95	-14%
CL2-PCB-4	13029-08-8	8.15		9.31		2.69		0.393	U	95	-7%
CL2-PCB-5	16605-91-7	0.439	UJ	0.582	UJ	0.086	UJ	0.309	U		
CL2-PCB-6	25569-80-6	5.79		6.46		1.61	J	0.291	U		-5%
CL2-PCB-7	33284-50-3	1.58	J	2.06		0.379	UJ	0.287	U		-13%
CL2-PCB-8	34883-43-7	31.3		37.5		9.81		0.319	NJ		-9%
CL2-PCB-9	34883-39-1	1.48	J	1.71	J	0.367	UJ	0.288	U		-7%
CL2-PCB-10	33146-45-1	0.415	UJ	0.57	UJ	0.137	UJ	0.293	U		
CL2-PCB-11	2050-67-1	14.7		11.4		13.2		0.393	NJ		13%
CL2-PCB-12/13		4.99		4.88		1.57	J	0.307	U		1%
CL2-PCB-14	34883-41-5	0.147	U	0.223	UJ	0.128	UJ	0.301	U		
CL2-PCB-15	2050-68-2	34.2		35.5		10.4		0.367	U	90	-2%
CL3-PCB-16	38444-78-9	17.4		21.4		3.89		0.145	U		-10%
CL3-PCB-17	37680-66-3	23.1		27.0		4.51		0.161	NJ		-8%
CL3-PCB-18/30		38.7		46.5		8.07		0.273	NJ		-9%
CL3-PCB-19	38444-73-4	3.89		5.38		0.789	J	0.113	U	95	-16%
CL3-PCB-20/28		129		140		25.6		0.306	J		-4%
CL3-PCB-21/33		45.9		48.9		9.38		0.176	J		-3%
CL3-PCB-22	38444-85-8	33.9		36.5		6.82		0.1250	NJ		-4%
CL3-PCB-23	55720-44-0	0.089	UJ	0.114	UJ	0.0466	U	0.0916	U		
CL3-PCB-24	55702-45-9	0.619	J	0.787	J	0.136	UJ	0.0850	U		-12%
CL3-PCB-25	55712-37-3	8.71		8.95		1.68	J	0.0820	U		-1%
CL3-PCB-26/29		16.7		17.4		3.10	J	0.0924	U		-2%
CL3-PCB-27	38444-76-7	3.99		5.00		0.758	J	0.0830	U		-11%
CL3-PCB-31	16606-02-3	95.9		99.1		17.4		0.274	J		-2%
CL3-PCB-32	38444-77-8	18		21.7		2.87		0.0883	U		-9%
CL3-PCB-34	37680-68-5	0.503	J	0.527	J	0.089	UJ	0.0951	U		-2%
CL3-PCB-35	37680-69-6	2.82		2.89		0.793	J	0.0929	U		-1%
CL3-PCB-36	38444-87-0	0.612	J	0.489	NJ	0.460	J	0.0865	U		11%
CL3-PCB-37	38444-90-5	42.1		44.6		8.30		0.107	U	91	-3%
CL3-PCB-38	53555-66-1	0.093	UJ	0.167	UJ	0.0560	UJ	0.0929	U		
CL3-PCB-39	38444-88-1	0.706	J	0.74	J	0.164	UJ	0.0880	U		-2%
CL4-PCB-40/41/71		61.9		77.2		8.91		0.0911	U		-11%
CL4-PCB-42	36559-22-5	33.3		41.3		4.52		0.0985	U		-11%
CL4-PCB-43	70362-46-8	3.9		4.73		0.593	J	0.110	U		-10%
CL4-PCB-44/47/65		117		143		15.5		0.223	NJ		-10%
CL4-PCB-45/51		15		21		2.08	J	0.0986	U		-17%
CL4-PCB-46	41464-47-5	5.23		7.27		0.761	J	0.115	U		-16%
CL4-PCB-48	70362-47-9	19.4		23.0		2.98		0.0910	U		-8%
CL4-PCB-49/69	41464-40-8	83.2		98.4		10.3		0.1020	NJ		-8%
CL4-PCB-50/53	62796-65-0	12.4		17.1		1.76	J	0.0974	U		-16%
CL4-PCB-52	35693-99-3	146		176		17.4		0.211	J		-9%
CL4-PCB-54	15968-05-5	0.205	UJ	0.258	UJ	0.0600	UJ	0.0720	U	94	
CL4-PCB-55	74338-24-2	4.31		4.86		0.619	J	0.0461	U		-6%
CL4-PCB-56	41464-43-1	69.1		75.7		10.3		0.0458	U		-5%
CL4-PCB-57	70424-67-8	0.648	U	0.676	J	0.162	U	0.0422	U		
CL4-PCB-58	41464-49-7	0.665	U	0.609	J	0.167	U	0.0432	U		
CL4-PCB-59/62/75		11		14		1.49	J	0.0684	U		-12%
CL4-PCB-60	33025-41-1	37.1		42.4		6.47		0.0449	U		-7%
CL4-PCB-61/70/74/76		279		302		39.0		0.1200	NJ		-4%
CL4-PCB-63	74472-34-7	5.98		6.45		0.868	J	0.0444	U		-4%
CL4-PCB-64	52663-58-8	52		62.4		6.87		0.0672	U		-9%
CL4-PCB-66	32598-10-0	168		186		24.5		0.0910	NJ		-5%
CL4-PCB-67	73575-53-8	4.16		4.78		0.662	J	0.0374	U		-7%
CL4-PCB-68	73575-52-7	0.98	J	0.975	NJ	0.152	U	0.0394	U		0%
CL4-PCB-72	41464-42-0	1.74	J	1.70	J	0.160	U	0.0414	U		1%
CL4-PCB-73	74338-23-1	0.0490	U	0.0384	U	0.0276	U	0.0697	U		
CL4-PCB-77	32598-13-3	19.3		21.2		3.16		0.0495	U	91	-5%
CL4-PCB-78	70362-49-1	0.696	U	0.538	U	0.174	U	0.0453	U		
CL4-PCB-79	41464-48-6	3.31		3.65	NJ	0.367	J	0.0395	U		-5%
CL4-PCB-80	33284-52-5	0.656	U	0.508	U	0.165	U	0.0427	U		
CL4-PCB-81	70362-50-4	0.746	U	0.59	U	0.187	U	0.0492	U	93	

Appendix C1. Congener Results from Analysis with EPA Method 1668a (ng/Kg, dw) - pg 2

PCB Congener	CAS Number	Site ComBay		Site ComBay Rep		Site Vendovi		Lab Blank		Matrix Spike Recovery (%)	RPD of ComBay & ComBay Rep (%)
CL5-PCB-82	52663-62-4	28		38.7		2.73		0.127	U		-16%
CL5-PCB-83/99		157		206		15.1		0.114	U		-13%
CL5-PCB-84	52663-60-2	52		74.7		4.20		0.125	U		-18%
CL5-PCB-85/116/117		47		60.9		5.13	J	0.0922	U		-13%
CL5-PCB-86/87/97/108/119/125		166		226		14.3		0.0955	U		-15%
CL5-PCB-88/91		29.5		40.0		2.46	J	0.107	U		-15%
CL5-PCB-89	73575-57-2	2.34		3.25		0.257	UJ	0.117	U		-16%
CL5-PCB-90/101/113		245		344		21.3		0.195	NJ		-17%
CL5-PCB-92	52663-61-3	46.7		62.7		3.48		0.112	U		-15%
CL5-PCB-93/95/98/100/102		158		238		12.8		0.105	U		-20%
CL5-PCB-94	73575-55-0	0.998	J	1.23	J	0.127	U	0.114	U		-10%
CL5-PCB-96	73575-54-9	1.32	J	1.92	J	0.174	UJ	0.110	U		-19%
CL5-PCB-103	60145-21-3	2.1		3.31		0.121	UJ	0.0970	U		-22%
CL5-PCB-104	56558-16-8	0.0463	U	0.0626	U	0.0628	U	0.0926	U	96	
CL5-PCB-105	32598-14-4	119		142		12.3		0.0989	U	94	-9%
CL5-PCB-106	70424-69-0	1.26	U	1.36	U	0.132	U	0.0907	U		
CL5-PCB-107/124		9.33		10.7		0.854	J	0.0997	U		-7%
CL5-PCB-109	74472-35-8	22.5		25.0		2.17	J	0.0975	U		-5%
CL5-PCB-110/115		280		382		22.5		0.1320	J		-15%
CL5-PCB-111	39635-32-0	0.225	UJ	0.195	U	0.0921	U	0.0832	U		
CL5-PCB-112	74472-36-9	0.158	U	0.182	U	0.0859	U	0.0776	U		
CL5-PCB-114	74472-37-0	4.46		6.02		0.582	J	0.101	U	95	-15%
CL5-PCB-118	31508-00-6	275		328		25.1		0.1140	J	93	-9%
CL5-PCB-120	68194-12-7	1.18	J	1.37	J	0.135	UJ	0.0817	U		-7%
CL5-PCB-121	56558-18-0	0.162	U	0.187	U	0.0884	U	0.0799	U		
CL5-PCB-122	76842-07-4	2.84	NJ	4.00		0.401	UJ	0.111	U		-17%
CL5-PCB-123	65510-44-3	3.72		5.91		0.499	UJ	0.103	U	94	-23%
CL5-PCB-126	57465-28-8	1.65	J	1.72	J	0.171	UJ	0.111	U	94	-2%
CL5-PCB-127	39635-33-1	1.52	U	1.64	U	0.159	U	0.109	U		
CL6-PCB-128/166		66.7		74.6		4.76		0.0858	U		-6%
CL6-PCB-129/138/160/163		403		463		29.3		0.231	J		-7%
CL6-PCB-130	52663-66-8	25.2		25.9		1.71	J	0.106	U		-1%
CL6-PCB-131	61798-70-7	3.21	U	4.00	U	0.242	UJ	0.101	U		
CL6-PCB-132	38380-05-1	100		134		6.03		0.0990	U		-15%
CL6-PCB-133	35694-04-3	8.00		7.71		0.424	UJ	0.0960	U		2%
CL6-PCB-134/143		13.7		18.8		0.863	J	0.0953	U		-16%
CL6-PCB-135/151/154		102		149		6.76		0.0611	U		-19%
CL6-PCB-136	38411-22-2	29.7		47.1		2.01	J	0.0471	U		-23%
CL6-PCB-137	35694-06-5	16.9		17.6		1.02	J	0.0949	U		-2%
CL6-PCB-139/140		4.52		5.74		0.306	UJ	0.0857	U		-12%
CL6-PCB-141	52712-04-6	46.1		65.6		3.01		0.0939	U		-17%
CL6-PCB-142	41411-61-4	3.07	U	3.83	U	0.173	U	0.0965	U		
CL6-PCB-144	68194-14-9	12.6		18.9		0.849	NJ	0.0639	U		-20%
CL6-PCB-145	74472-40-5	0.1350	UJ	0.0788	U	0.0606	U	0.0478	U		
CL6-PCB-146	51908-16-8	70.1	D	88.4	D	4.96		0.0878	U		-12%
CL6-PCB-147/149		226		313		14.7		0.1420	NJ		-16%
CL6-PCB-148	74472-41-6	0.795	J	1.16	J	0.126	UJ	0.0638	U		-19%
CL6-PCB-150	68194-08-1	0.693	J	1.08	J	0.0581	U	0.0458	U		-22%
CL6-PCB-152	68194-09-2	0.296	J	0.363	J	0.0576	U	0.0455	U		-10%
CL6-PCB-153/168		327		406		24.2		0.185	NJ		-11%
CL6-PCB-155	33979-03-2	0.107	UJ	0.215	UJ	0.0493	U	0.0440	U	96	
CL6-PCB-156/157		40.9		52.1		2.91	J	0.0829	U	96	-12%
CL6-PCB-158	74472-42-7	34.3		42.6		2.18	J	0.0676	U		-11%
CL6-PCB-159	39635-35-3	2.38	U	3.28		0.211	UJ	0.0746	U		
CL6-PCB-161	74472-43-8	2.18	U	2.71	U	0.122	U	0.0684	U		
CL6-PCB-162	39635-34-2	2.33	U	2.90	U	0.234	UJ	0.0731	U		
CL6-PCB-164	74472-45-0	27.1		33.4		1.39	J	0.0712	U		-10%
CL6-PCB-165	74472-46-1	2.37	U	2.95	U	0.133	U	0.0744	U		
CL6-PCB-167	52663-72-6	13.9		18.1		1.10	J	0.0671	U	95	-13%
CL6-PCB-169	32774-16-6	2.44	U	3.03	U	0.134	U	0.0737	U	95	
CL7-PCB-170	35065-30-6	72.2		115		5.99		0.0874	U		-23%
CL7-PCB-171/173		26.6		37.1		2.12	J	0.0870	U		-16%
CL7-PCB-172	52663-74-8	12.9		22.5		1.07	J	0.0859	U		-27%

Appendix C1. Congener Results from Analysis with EPA Method 1668a (ng/Kg, dw) - pg 3

PCB Congener	CAS Number	Site ComBay		Site ComBay Rep		Site Vendovi		Lab Blank		Matrix Spike (%)	RPD of ComBay & ComBay Rep (%)
CL7-PCB-174	38411-25-5	99.2		154		5.47		0.0823	U		-22%
CL7-PCB-175	40186-70-7	6.14		6.51		0.35	UJ	0.0800	U		-3%
CL7-PCB-176	52663-65-7	11.4		16.5		0.76	J	0.0592	U		-18%
CL7-PCB-177	52663-70-4	56.5		82.1	D	4.89		0.0863	U		-18%
CL7-PCB-178	52663-67-9	44.7		59.6		1.80	J	0.0834	U		-14%
CL7-PCB-179	52663-64-6	40.3		57.2		2.42		0.0583	U		-17%
CL7-PCB-180/193		176		279		12.2		0.0950	NJ		-23%
CL7-PCB-181	74472-47-2	4.76		5.01		0.101	U	0.0802	U		-3%
CL7-PCB-182	60145-23-5	2.36		2.02	U	0.0973	U	0.0774	U		
CL7-PCB-183/185		83.4		2.03	U	4.64		0.0780	U		
CL7-PCB-184	74472-48-3	0.374	U	1.45	U	0.0700	U	0.0557	U		
CL7-PCB-186	74472-49-4	1.87	J	1.57	U	0.0758	U	0.0603	U		
CL7-PCB-187	52663-68-0	152		213		10.5		0.0880	NJ		-17%
CL7-PCB-188	74487-85-7	0.485	J	1.35	U	0.0646	U	0.0522	U	98	
CL7-PCB-189	39635-31-9	3.49	U	3.91		0.238	J	0.0467	U	92	
CL7-PCB-190	41411-64-7	14.4		21.8		1.26	J	0.0623	U		-20%
CL7-PCB-191	74472-50-7	1.79	J	3.89		0.228	UJ	0.0617	U		-37%
CL7-PCB-192	74472-51-8	0.434	U	1.69	U	0.0814	U	0.0647	U		
CL8-PCB-194	35694-08-7	91.6		140		3.56		0.0621	U		-21%
CL8-PCB-195	52663-78-2	18.3		25.0		1.29	J	0.0617	U		-15%
CL8-PCB-196	42740-50-1	36.2		54.7		1.96	J	0.0768	U		-20%
CL8-PCB-197/200		14.3	D	20.9	D	0.829	NJ	0.0561	U		-19%
CL8-PCB-198/199		168		265		6.23		0.0776	U		-22%
CL8-PCB-201	40186-71-8	10.8		17.5		0.768	J	0.0580	U		-24%
CL8-PCB-202	2136-99-4	31.9		50.5		1.67	J	0.0616	U	95	-23%
CL8-PCB-203	52663-76-0	54.4		80.1		3.49		0.0684	U		-19%
CL8-PCB-204	74472-52-9	0.874	NJ	1.43	J	0.0966	U	0.0580	U		-24%
CL8-PCB-205	74472-53-0	4.9		13.2		0.0788	U	0.0532	U	95	-46%
CL9-PCB-206	40186-72-9	347		601		5.73		0.0990	U	96	-27%
CL9-PCB-207	52663-79-3	10.5		18.8		1.12	J	0.0841	U		-28%
CL9-PCB-208	52663-77-1	80.3		143		2.09	J	0.0853	U	95	-28%
CL10-PCB-209	2051-24-3	695		818		3.55		0.0788	U	96	-8%

Estimated Aroclor Values	CAS Number	Site ComBay		Site ComBay Rep		Site Vendovi		Lab Blank		Matrix Spike (%)	
Aroclor 1242	53469-21-9	1120		1230		231		2.2	J		
Aroclor 1248	12672-29-6	4.69	U	3.63	U	1.17	U	0.615	U		
Aroclor 1254	11097-69-1	3220		4320		295		1.14	U		
Aroclor 1260	11096-82-5	2350		2800		162		0.621	U		

Internal Standard Recovery	CAS Number	Site ComBay (%)		Site ComBay Rep (%)		Site Vendovi (%)		Lab Blank (%)		Matrix Spike (%)	
13C12-CL1-PCB-1		36		41		33		35		23	
13C12-CL1-PCB-3		48		51		45		37		29	
13C12-CL2-PCB-4		47		51		44		39		30	
13C12-CL2-PCB-15		74		75		69		45		49	
13C12-CL3-PCB-19		58		59		55		42		38	
13C12-CL3-PCB-37		89		88		83		59		75	
13C12-CL4-PCB-54		66		68		62		48		49	
13C12-CL4-PCB-77		100		96		94		77		92	
13C12-CL4-PCB-81		98		95		91		72		91	
13C12-CL5-PCB-104		80		72		67		59		61	
13C12-CL5-PCB-105		108		95		91		84		92	
13C12-CL5-PCB-114		104		89		85		77		86	
13C12-CL5-PCB-118		102		89		86		78		87	
13C12-CL5-PCB-123		102		89		86		79		87	
13C12-CL5-PCB-126		110		100		92		89		93	
13C12-CL6-PCB-155		67		75		72		57		67	
13C12-CL6-PCB-156/157		86		93		87		81		92	
13C12-CL6-PCB-167		85		89		86		80		89	
13C12-CL6-PCB-169		84		93		88		83		91	

Appendix C1. Congener Results from Analysis with EPA Method 1668a (ng/Kg, dw) - pg 4

Internal Standard Recovery	CAS Number	Site ComBay (%)		Site ComBay Rep (%)		Site Vendovi (%)		Lab Blank (%)		Matrix Spike Recovery (%)	
13C12-CL7-PCB-170		95		93		91		87			
13C12-CL7-PCB-180		92		92		87		83			
13C12-CL7-PCB-188		74		69		68		62		68	
13C12-CL7-PCB-189		96		90		87		81		90	
13C12-CL8-PCB-202		76		71		73		69		74	
13C12-CL8-PCB-205		92		86		85		82		86	
13C12-CL9-PCB-206		92		92		82		84		82	
13C12-CL9-PCB-208		86		88		90		75		80	
13C12-CL10-PCB-209		80		78		77		80		77	
13C12-CL3-PCB-28		84		85		77		54		59	
13C12-CL5-PCB-111		101		93		88		76		81	
13C12-CL7-PCB-178		87		90		84		80		77	

U - Analyte was not detected at or above the reported value.
UJ - Analyte was not detected at or above the reported estimated result.
J - Analyte was positively identified. Associated numerical value is an estimate.
NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.