Environmental Impact Monitoring of Polychlorinated Biphenyls Around the Sunken, Decommissioned Naval Vessel, the *'Saskatchewan'*

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Abstract

This study details the results of a preliminary monitoring survey conducted in the vicinity of one of five former Canadian naval vessels sunk off the coast of British Columbia under the authority of Part 7, Division 3 of the *Canadian Environmental Protection Act* (CEPA). Sediment and tissue samples were collected at the sinking site of the former *HMCS Saskatchewan* (‘*Saskatchewan*’) near Nanaimo, BC and analysed for priority contaminants including polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), trace metals and toxicity. This study was conducted to determine whether environmental impacts were occurring from the disposal of this vessel; and to determine the adequacy of vessel clean-up standard and procedures implemented for the protection of the marine environment, specifically with respect to PCBs. The results of this preliminary monitoring survey indicate PCBs are detectable at the site; however there does not appear to be any apparent risk to human health and minimal risk to the environment from the disposal of this vessel.

Résumé

Conformément à la section 3 de la partie 7 de la *Loi canadienne sur la protection de l'environnement* (LCPE), la présente étude donne les résultats détaillés d'une enquête préliminaire dans le cadre d'activités de surveillance au voisinage de l'un de cinq anciens navires canadiens, immergés au large de la Colombie-Britannique. Des échantillons de sédiments et de tissus ont été prélevés sur le site d'immersion de l'ancien *NCSM Saskatchewan* (« *Saskatchewan* ») près de Nanaimo (C.-B.) et analysés pour les contaminants d'intérêt prioritaire, y compris les polychlorobiphényles (PCB), les hydrocarbures aromatiques polycycliques (HAP), les métaux traces et la toxicité. Cette étude a été effectuée pour déterminer si l'immersion du navire exerce des effets sur l'environnement, et si les normes et méthodes de nettoyage du navire, mises en œuvre pour la protection du milieu marin, sont suffisantes, particulièrement pour les PCB. Les résultats de l'étude préliminaire montrent que des PCB ont été décelés à ce site; cependant, suite à l'immersion du navire, il ne semble pas y avoir de risque apparent pour la santé humaine, et le risque pour l'environnement apparaît comme minime.

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1.0 Introduction

Since 1992, five former Canadian naval ships have been sunk off the coast of British Columbia by the Artificial Reef Society of BC (ARSBC) under various permits administered by Environment Canada's Disposal at Sea program. The permits were issued following extensive clean-up requirements directed and certified by Environment Canada. In 2000, concerns over the adequacy of clean-up procedures for polychlorinated biphenyls on vessels being scuttled for use as artificial reefs were raised in the United States. This prompted Environment Canada to conduct a preliminary survey of British Columbia vessel sinking sites to determine if clean-up procedures implemented for priority contaminants, particularly polychlorinated biphenyls (PCBs), were sufficiently protective of the marine environment.

Over the last few years, there has been a growing interest in the use of vessels as artificial reefs. While Environment Canada does not advocate or oppose the use of vessels as artificial reefs in Canada, the disposal of vessels, aircraft or platforms falls under Environment Canada's jurisdiction and as such is regulated by Environment Canada under the *Canadian Environmental Protection Act* (CEPA). Environment Canada's primary concerns with respect to vessel disposal is that there be no adverse effects on the marine environment, resources and human health from the disposal of vessels in Canadian marine waters.

1.1 Background

Polychlorinated biphenyls (PCBs) are chemical formulations that were manufactured for use in electrical cable and insulation material due to their dielectric properties and insulation capabilities. They are found in a variety of materials, ranging from electrical cable to felt materials, sealant adhesives and paint. PCBs were manufactured in North America under the trade name Aroclor. In other parts of the world, PCBs were manufactured under different trade names and formulations by different manufacturers. Although manufacturing of PCBs ceased during the late 1970s, PCBs were widely used until the mid 1980s. Impacts related to PCB exposure to human health and the environment resulted in the ban of PCB production and distribution in both Canada and the United States. Yet, despite the cessation of PCB production in the 1970's, PCBs still persist in the environment due to their insolubility, resistance to degradation and their high bioaccumulation potential. In Canada, current regulatory clean-up standards for total PCB levels are set at 50 ppm (CEPA, 1999). Guidelines and criteria for PCBs in various media (water, sediment and tissue) have also been set by provincial and federal agencies to protect human health and the environment (CCME, 1999; updated 2001; Nagpal *et al.,* 1998).

Prior to its sale to the ARSBC, the decommissioned Canadian naval vessel, the former *HMCS Saskatchewan* (*'Saskatchewan'*) was certified PCB free by the Department of National Defense. The ARSBC also conducted additional clean-up of the vessel following the current Environment Canada vessel clean-up standard and guidelines at the time (Environment Canada 1998a, 1998b).

To date, five former Canadian naval vessels have been sunk off the coast of British Columbia under Environment Canada ocean disposal permits. Due, in part to concerns raised in the United States, Environment Canada undertook a preliminary environmental monitoring study to identify and address issues surrounding PCB presence in the marine environment; and the potential human health and ecological risks associated with vessel disposals.

Environment Canada's monitoring efforts have focused around the sinking site of one of the four former Canadian naval vessels, the *'Saskatchewan'*. The findings of this preliminary study will help assess the risks to human health and the environment and help determine what risk management approaches may be taken, if required, to ensure the protection of the marine environment. The monitoring results from the '*Saskatchewan*' are presented in this report.

1.2 Study Objectives

There are two main objectives of the monitoring study conducted around the sinking site of the '*Saskatchewan'.*

The primary objectives of this study are:

- to determine PCB levels in the vicinity of the sinking site and PCB levels in organisms found residing on and in the vessel; and
- if PCBs are detected, whether the PCB levels found are significant enough to cause environmental impacts, based on guideline levels set for the protection of human health and the environment.

From an ecological perspective, marine organisms which are using the vessel as a form of refuge or habitat substrate are the organisms most likely to be affected by any PCB contaminants potentially originating from the vessel. Target receptors from various trophic levels are suggested for use to determine whether ecosystem functioning is being impaired at different ecosystem levels. In order to determine whether PCB contaminants are present in various media (i.e. water, sediment and tissue), sediments and biota in the vicinity of the *'Saskatchewan'* were analysed. Marine pelagic, benthic and epibenthic organisms were chosen as target species to be used in this study to determine whether there was a potential for bioaccumulation of PCBs. Pelagic organisms would be exposed to water-borne contaminants which could potentially be passed further up the food chain. Benthic organisms would be directly exposed to particulate associated contaminants deposited directly in the sediments while epibenthic organisms would be exposed to both sediment associated contaminants and water-borne contaminants. The potential risk to marine mammals would be determined by calculating potential PCB exposure through the consumption of prey items and in a more complete study, the measurement of PCB tissue concentration levels in marine pelagic organisms found at the site.

Based on the field observations of divers and the availability of organisms found to colonize the *'Saskatchewan'*, swimming scallops and green sea urchins were chosen as potential receptors to represent prey items of marine mammals so the potential for bioaccumulation of PCBs in higher trophic levels could be determined.

1.3 Study Area

To date, monitoring has predominantly focused around the sinking site of the '*Saskatchewan'* and only this site will be discussed in this report. Future monitoring around vessel sinking sites can, however be expanded to include the other four former Canadian vessels sunk off the coast of British Columbia under Environment Canada permits.

The '*Saskatchewan'* was sunk on 14 June 1997 in approximately 27 m of water, off the leeward side of Snake Island, northeast of Nanaimo, BC at approximately 49°12.98 N and 123°53.15 W in the Strait of Georgia (Figure 1). The site for the '*Saskatchewan'* was selected based on the oceanographic properties of this site, in addition to considerations for marine navigational safety. The site was approved by Environment Canada, only after it was ensured that there would be no adverse impacts on existing aquatic resources or fish habitat. Consultations with the Regional Ocean Disposal Advisory Committee (RODAC), the Navigable Waters Protection Agency and the regional offices of Fisheries and Oceans Canada (DFO) and the BC Ministry of Environment, Lands and Parks (BC MELP) were conducted prior to the final approval of this sited.

The location of the ship is marked on the Canadian Hydrographic Service Chart 3458 (Figure 1). The ship is positioned with the bow oriented to the south. Three yellow and white cautionary buoys are located at the site, in addition to five mooring buoys. Tidal currents in the general area of Snake Island are detailed in the *Current Atlas - Juan de Fuca Strait to Strait of Georgia (1983).* Maximum flood and ebb tides move in a northwesterly/southeasterly direction in this area of the Strait of Georgia and the maximum tidal currents achieve speeds of 0.25 to 0.5 knots. Tides in the Nanaimo area are recorded in a range of 3.0 metres above chart datum. The area is affected by strong winds (predominantly NW) throughout the year and by significant local marine traffic, particularly large ferry vessels which travel a route between Nanaimo and the lower mainland of British Columbia.

Environment Canada's Disposal at Sea program has collected monitoring data from the surrounding area at the Five Finger Island Ocean Disposal site and reference site (Figure 1). The Five Finger Island reference site is located approximately 2.1 nautical miles north of the *'Saskatchewan'*. The most recent monitoring at Five Finger Island disposal and reference sites was conducted in September 1999. While data collected from the Five Finger Island reference site is typically used to determine whether impacts are occurring at the Five Finger Island Ocean Disposal site, data collected from the Five Finger Island reference site is included in this study for comparative purposes.

2.0 Methods

2.1 Sample Collection

Samples were collected from the *'Saskatchewan'* and the surrounding area on two separate occasions. Diver collected biota and sediments were collected on 15 April 2000. Sampling locations for the biota (1 through 10 excluding 4) and sediments (A through H) for this sampling event are shown on Figure 2.

Resident marine organisms on the '*Saskatchewan*' were predominantly pink scallops and spiny scallops (*Chlamys* spp.), in addition to a few green sea urchins (*Strongylocentrotus droebachiensis*). Scallops and green sea urchins were collected directly off of the *'Saskatchewan'* from various decks and locations in and on the vessel. The samples were kept cool (4°C) and the scallops were shucked under aseptic conditions using hexane rinsed scalpels prior to submission to the laboratory. Sea urchins were submitted whole for analyses. A total of thirteen biota samples were collected from nine sampling locations. Sea urchins and scallop tissue collected from the same site were kept separate and submitted for analysis. Since the '*Saskatchewan'* was sunk less than three years ago, the sample size of some of the biological samples collected for this study is limited since the reef community at this site is less than three years old. Eight surface sediment samples at a maximum distance of 5 m from the hull were also collected by divers. The sediments were collected underwater by divers using pre-labelled, pre-cleaned, heat treated amber jars and kept cool (4°C) until analyses. Both tissue and sediment samples were submitted for PCB analyses.

Five sediment reference stations off of Snake Island, in the vicinity of the *'Saskatchewan'*, ranging in depth from 39 m to 100 m (Figure 1; Stations 1-5) were also established in May 2000. Sediment samples from these sites were collected by Environment Canada's Pacific and Yukon Region Disposal at Sea program staff on 17 May 2000 using a modified Smith-McIntyre grab sampler. Three surface grabs were taken at each station and composited. Approximately 4-L of sediment from each station was collected for toxicity testing and placed in 4-L polystyrene pails with tight fitted lids. Sediments were placed in 50 mL polystyrene centrifuge tubes and kept in the dark at 4° C until porewater extraction and testing. Porewater was extracted from sediment by centrifugation at 4000 rpm for 30 minutes at 4°C in the laboratory. Sediments collected for metals, particle size and total organic carbon (TOC) analyses were placed in brown kraft paper bags, double bagged in whirl-pack™ bags and frozen. Sediments collected for polycyclic aromatic hydrocarbon (PAH) analyses were placed in pre-cleaned 125 mL heat treated glass jars and frozen. Sediments collected for PCB analyses were placed in pre-cleaned, heat treated amber glass jars with teflon lined lids while sediments collected for acid volatile sulphides (AVS), simultaneously extracted metals (SEM), sediment ammonia, sulphides and oxidation-reduction potential analyses were placed in pre-cleaned glass jars. Sediment samples collected for PCBs, ammonia, sulphides and oxidation-reduction potential were kept in the dark at 4°C until analysed.

2.2 Chemical Analyses

Sediments and tissue samples from the *'Saskatchewan'* were collected on 15 April 2000 by divers and analyzed for PCBs. TOC analysis was also performed on these sediment samples.

Sediments collected from the Snake Island reference sites by Environment Canada on 17 May 2000 around the *'Saskatchewan'* were analysed for PCBs, TOC, total metals, PAHs, particle size, sediment ammonia, sediment sulphide concentrations and oxidation-reduction potential.

Laboratory analyses for PCBs in sediments and tissue, TOC, AVS and SEM in sediments and total metals in sediment porewater were performed by ASL Analytical Services Laboratories Ltd., Vancouver B.C. Analyses for PAHs were performed by AXYS Analytical Services, Sidney, B.C. Total metals in sediments were performed in-house by Environment Canada, Pacific Environmental Science Centre, North Vancouver, B.C. and particle size analyses was performed by Soilcon Laboratories, Richmond B.C. Oxidation-reduction potential, sediment ammonia and sediment sulphide concentration measurements were performed by the Environment Canada Atlantic Region Environmental Quality Laboratory in Moncton, N.B. All laboratories are

Canadian Association of Environmental Analytical Laboratories (CAEAL) accredited laboratories.

2.2.1 Polychlorinated biphenyls

The methodology used to analyze PCBs in sediments was adapted from “Test Methods for Evaluating Solid Waste” SW 846, Methods 3540, 3620, 3640, 3630, 3665 and 8280 published by the US EPA. The procedure involves a dichloromethane soxhlet extraction of a subsample of the sediment dried with anhydrous sodium sulphate. The extract is then solvent exchanged to hexane and if required, followed by either florisil, silica gel and/or sulphuric acid clean-up. The final extract is then analysed by capillary column gas chromatography with electron capture detection (GC/ECD).

The analyses for PCBs in tissue were carried out using procedures adapted from “Test Methods for Evaluating Solid Waste” SW 846, Methods 3540, 3620, 3640, 3665, 8082 and 8270 published by the US EPA. The procedure involves a dichloromethane soxhlet extraction of a subsample of the tissue dried with anhydrous sodium sulphate. The resulting extract is then solvent exchanged to hexane and followed with florisil, sulphuric acid and/or gel permeation clean up. The final extract is then analyzed by GC/ECD and mass spectrometry (GC/MS).

Individual congeners degrade in the environment at different rates due to chemical weathering processes. The abiotic weathering of PCBs in the environment can cause the alteration of PCB characterization and PCB bioavailability in the environment. Alterations in PCBs in the environment also can result in PCB profiles different from the profiles of the original commercial Aroclor formulations from which they were derived (Roe *et al.,* 2000). Consequently, PCB concentrations in this study were quantified based on congeners and homologues in addition to Aroclors.

PCB analyses were conducted on sediments and tissue for 26 individual congeners, 10 homologues and selected Aroclors (Table 1). The 26 congeners analysed in this study were chosen based on their environmental relevance. PCB congeners are identified by the International Union of Pure and Applied Chemistry (IUPAC) numbering system (Table 1). Total PCBs are calculated based on all of the known 209 PCB congeners and 10 homologues. PCB congeners found to be below the detection limit were not used to calculate total PCB concentrations, although the method detection limit was used as the maximum PCB concentration in calculating Toxic Equivalency Factors (TEFs) and Toxic Equivalency Units (TEQs). TEFs and TEQs were calculated following Van den Berg *et al.* (1998). Selected Aroclor concentrations were also analysed so that PCB concentrations in sediments and tissues could also be compared to relevant PCB criteria and standards based on Aroclor concentrations.

2.2.2 Polycyclic Aromatic Hydrocarbons

Analyses for PAHs in sediments were conducted by spiking all samples with an aliquot of a surrogate standard solution containing perdeuterated analogues of acenaphthene, chrysene, naphthalene, perylene, phenanthrene, pyrene, dibenz*(a,h)*anthracene, benzo*(g,h,I)*perylene and benzo*(a)*pyrene prior to analyses. The samples were then ground with anahydrous sodium sulphate and eluted through a chromatographic extraction column. The extract was cleaned up on silica gel and analyzed by high resolution gas chromatography with low resolution (quadrupole) mass spectrometric detection (HRGC/MS). Analyte concentrations were calculated using the isotope dilution method of quantification. PAHs were quantified by comparing the area of the quantification ion to that of the corresponding deuterated surrogate standard and correcting for response factors. Response factors were determined daily using authentic PAHs. The concentrations of the analytes were determined based on the percent recovery of surrogate standards and are reported on a dry weight basis (AXYS Analytical Services, 1997).

2.2.3 Oxidation-Reduction Potential, Sediment Ammonia and Sediment Sulphides

Oxidation-reduction potential, sediment ammonia and sediment sulphide concentration measurements were performed using an ion-selective probe based standard operating procedure (Environment Canada, 1995b).

2.2.4 Total Organic Carbon

TOC was analyzed in accordance with US EPA Method 9060A. Total carbon is determined by high temperature oxidation of carbon to carbon dioxide. Inorganic carbon is determined by the reaction with phosphoric acid in which all carbonates are converted to carbon dioxide. Both these parameters are measured using a non-dispersive infrared analyzer. Total organic carbon is then calculated from the difference between total and inorganic carbons.

2.2.5 Total Metals in Sediments

Total metals in sediments were analysed by inductively coupled plasma atomic emission (ICP) analysis. Cadmium and lead concentrations were measured by graphite furnace atomic absorption (GFAA). Mercury in sediments were measured by cold vapour atomic fluorescence (CVAF). These analyses were conducted in accordance with Environment Canada (1999).

2.2.6 Acid Volatile Sulphides and Simultaneously Extracted Metals

AVS was analysed in accordance with US EPA (1991). Hydrochloric acid is added to the sediment sample. The hydrogen sulphide produced is then carried into sodium hydroxide sulphide traps by purified nitrogen gas. AVS is determined colourmetrically by measuring the AVS absorbed in the sodium hydroxide.

SEM was analysed in accordance with US EPA (1991). Hydrochloric acid is added to an aliquot of the sediment sample. An extract from the addition of the acid to the sediment is then analysed for simultaneously extracted metals using atomic absorption spectrophotometry and/or inductively coupled plasma-optical emission spectrophotometry.

2.3 Biological Testing

Sediments collected from five Snake Island reference sediments were subjected to biological testing consisting of a 10-day acute lethality test using three species of marine amphipods (*Eohaustorius estuarius, E. washingtonianus* and *Rhepoxynius abronius*) and a sub-acute bacterial bioluminescent test using *Vibrio fischeri* (Microtox® solid-phase metabolic inhibition test). An echinoid fertilization test using the gametes of the eccentric sand dollar, *Dendraster excentricus* and the Microtox® basic test were also performed on porewater extracted from the test sediments. Acute toxicity testing with marine amphipods and sublethal testing using *Vibrio fischeri* were conducted following Environment Canada approved methods (Environment Canada, 1992a; 1992b, and 1998c). The echinoid fertilization test was performed based on Environment Canada (1992c) and BC MELP (1994).

Toxicity testing of the sediment samples was performed in-house by Environment Canada's Environmental Toxicology Laboratory with the assistance of the regional Ocean Disposal Control program staff. Amphipod collections were undertaken by Biologica Environmental Services of Victoria, BC, Environmental Resolution Services of Vancouver, BC, Seacology Ltd. of North Vancouver, BC. and regional Disposal at Sea program staff.

2.4 Quality Assurance/Quality Control

2.4.1 Chemical Analyses

Quality Assurance/Quality Control (QA/QC) steps taken included submission of one blind duplicate sample for all analyses requested from samples taken off of the '*Saskatchewan'*. In addition, the analytical laboratory performed a laboratory duplicate and included a method (procedural) blank and matrix spike on for both sediment and tissue. A National Research Council (NRC) certified reference standard (MESS 2) was also run with the TOC analysis.

For the second set of sediment samples collected from the Snake Island reference sites, NRC certified metals reference standards MESS-2 and PACS-1 were run five times for every ten samples analyzed for metals. For the PCB analyses, the QA/QC procedures listed above were performed as listed above with the exception that a blind duplicate sample was not submitted for analyses.

2.4.2 Biological Testing

Both negative controls and positive controls are run routinely in conjunction with toxicity testing. Amphipod survival in control sediment must be 90% or greater with the amphipod, *Rhepoxynius abronius* and *Eohaustorius estuarius* and 85% or greater with *E. washingtonianus* to be considered valid. For the echinoid fertilization test to be considered valid, an average fertilization success rate of $\geq$ 50% and $\leq$ 100% must be achieved. For each of the biological tests conducted, a positive reference toxicant test was also conducted to measure species sensitivity. A 96-hour reference toxicant test was conducted using cadmium chloride to measure species sensitivity of the three amphipod species used. A copper sulphate reference toxicant test was run concurrently with the echinoid fertilization test. For the Microtox® tests, a phenol reference toxicant test was performed in addition to testing conducted with HS-6, a NRC PAH reference material.

3.0 Results

The results of all the analyses conducted in this study are listed in Tables 2 through 9. Quality assurance/quality control (QA/QC) data is listed with the test results. All QA/QC results are within acceptable ranges.

3.1 Sediment Chemistry

3.1.1 Polychlorinated biphenyls

The results of the sediment and tissue analyses and associated quality assurance data are presented in Tables 2 through 4b. Congeners which co-elute with those listed in Table 1 are listed together and reported as a single value since they could not be separated out by the analysis.

Of the 8 sediment samples collected around the *'Saskatchewan'* (Figure 2), total PCBs based on congeners and homologues ranged from less than the method detection limit (<0.01 μg/g) in 7 of the sediment samples to 0.06 μg/g in one of the sediment samples collected (Figure 2; Tables 2a and 2b). Under the *Canadian Environmental Protection Act* (CEPA, 1999), the current regulated level for total PCBs in sediments is 0.1μg/g. PCB levels measured in the sediments collected at this site are all below the CEPA regulated level. Measured PCB concentrations in sediments at this site were all found to be below the federal probable effects level (PEL) of 0.189 μg/g for total PCBs (CCME, 2001) and 0.709 μg/g based on Aroclor 1254 (CCME, 2001). Sediment PCB levels (Table 2a) were found to be below the interim sediment quality guideline (ISQG) of 0.0125 μg/g for total PCBs (CCME, 2001) and 0.0633 μg/g for Aroclor 1254 (CCME, 2001). The measured sediment PCB levels in sediments collected within 5 m of the *'Saskatchewan'* are within the ISQG for total PCBs.

PCB levels measured at the five Snake Island sediment reference sites (Figure 1; Table 3) were all found to be below the level of detection for all congeners, homologues and Aroclors analysed and consequently below all federal and provincial sediment criteria and standards for the protection of the marine environment.

Background levels of total PCBs in sediments were measured as Aroclors in 1995 and 1996 at the Five Finger Island sediment reference station (Figure 1), approximately 2.1 nautical miles north of Snake Island and the vessel. Total PCBs at the Five Finger reference station were found to be 0.002 μg/g in 1995 and 0.009 μg/g in 1996. Total PCBs in sediments from the sinking site of the *'Saskatchewan'* measured in this study are all below the method detection limit of 0.01 μg/g dry weight (Table 3) but the method detection limits used in the present study were not adequate to determine whether the total PCB levels measured at the sinking site were within background PCB levels measured at the Five Finger Island reference station in 1995 and 1996. However, the PCB sediment levels measured in the vicinity of the *'Saskatchewan'* do not appear to pose any environmental risks.

3.1.2 Polycyclic Aromatic Hydrocarbons

Total PAH concentrations in sediments collected from the Snake Island reference stations (Table 8a) were all found to be below the 2.5 mg/kg Ocean Disposal interim contaminant testing guideline for total PAHs. For the low molecular weight and high molecular weight PAHs for which ISQGs and PELs have been developed, the measured concentrations of PAHs in these sediments were, for the most part, above the ISQGs but all were below PELs. Organic content is factored into the provincial sediment PAH and PCB guidelines and criteria. When compared against the provincial standards, only naphthalene was found to exceed the BC approved and working guidelines for PAHs at all five stations; however, the PAH levels measured at these stations were all below the BC criteria of 3.7 μg/g for low molecular weight PAHs and 9.6 μg/g for high molecular weight PAHs for adverse effects on biota (Nagpal *et al*., 1998).

3.1.3 Oxidation-Reduction Potential, Sediment Ammonia and Sediment Sulphides

REDOX potential, corrected to the normal hydrogen electrode (Eh) measured from sediments from the five Snake Island reference stations indicated sediments collected from these stations were predominantly anaerobic, with sedimjents from Stations 3 and 5 being highly anaerobic (Table 5).

The sediment ammonia values in sediments collected from Stations 2 and 5 were slightly elevated. Sediment sulphide concentrations measured from sediments collected from all stations were relatively low (Table 5).

3.1.4 Total Organic Carbon in Sediments

TOC from sediments collected from the five Snake Island reference stations ranged from 1.86 to 4.54%. Organic carbon content is an important factor which can affect the bioavailability of PCBs, PAHs and some metals. Some criteria, such as the provincial guidelines and standards factor in organic carbon content when applying the standards set for various parameters such as PCBs and PAHs.

3.1.5 Total Metals in Sediments

Total metals concentrations were measured in samples collected from the Snake Island reference stations and are listed in Table 9. Cadmium and mercury levels in these sediments were all below the CEPA regulated limits of 0.6 μg/g and 0.75 μg/g respectively. Cadmium and mercury levels were also below ISQGs. All sediment metals levels were below PELs.

3.1.6 Acid Volatile Sulphides and Simultaneously Extracted Metals

AVS and SEM were also measured in the Snake Island sediments to determine the potential bioavailability of trace metals in sediments. AVS can be a key factor influencing the bioavailability of metals in sediments (Ankley *et al.,* 1994). SEM results are based on the total concentration of simultaneously extracted cadmium, copper, lead, mercury, nickel and zinc. The AVS/SEM ratio has been used to predict the potential for metal toxicity (Di Toro *et al.,* 1990; 1992). Metal toxicity is predicted if the AVS/SEM ratio is less than one. The AVS/SEM ratios for the Snake Island sites ranged from <0.25 to 1.40; however, the metals levels at all of these sites were all below PELs.

3.2 Tissue Analyses

Due to the limited time reef organisms had to colonize the site, organisms collected from the *'Saskatchewan'* were all fairly young and small in size, at the time the site was sampled. On average, green sea urchins collected from the vessel were sexually immature and weighed approximately 3 grams, with the maximum test diameter of approximately 25 mm. Green sea urchins in Alaska spawn at test diameters of 45 to 50 mm and the commercial harvesting of green urchins in BC is restricted to green urchins with a minimum test diameter of 55 mm due to market preferences for larger organisms; this also allows the urchins to spawn at least once (DFO, 2001). Shell diameter of scallops collected ranged from 18 to 50 mm. Scallops reach full growth at 85 mm in 4 to 5 years and sexual maturity at two to three years. Based on the scallop size of those collected at this site, the scallops collected off of the *'Saskatchewan'* are at a maximum, most likely only 2 years old.

3.2.1 Polychlorinated biphenyls

The total PCB concentrations in biota collected from the *'Saskatchewan'* (Figure 2) were found to range from the method detection limit (<0.01μg/g) to 0.23 μg/g wet weight (Tables 4a and 4b). For this study, the 1998 toxic equivalency factors developed by the World Health Organization (WHO) were used (Van den Berg *et al.,* 1998).

Mammalian TEFs and TEQs were calculated based on Aroclor 1242, 1248, 1254 and 1260 and listed in Table 4c but the method detection limits from these analyses were not sufficiently low enough to warrant comparisons of the calculated TEQs with the mammalian and avian reference concentration TEQs and tissue residue guidelines (TRGs) since the TEQs calculated from the tissue concentrations became a function of the detection limits.

For congeners for which TEFs have been developed (Environment Canada, 1998d), the measured concentrations of congeners analysed in biota were all below the method detection limit. Unfortunately, not all the congeners used in the TEF and TEQ calculations were quantified. For the missing congeners (81, 114, 157, 167 and 187), the total homologue concentrations were used to estimate the maximum concentration of these congeners. The TEF and TEQ estimates calculated are therefore maximum TEFs and TEQs and may over-estimate the true TEQ concentration; however, the TEQ calculated would err on the side of caution and the calculation of the TEQ using maximum concentrations of the missing congeners would therefore be more protective than performing the TEF and TEQ calculations without the estimated concentrations of the missing congeners. TEF and TEQ estimates calculated using the congener concentrations are listed in Tables 4d and 4e.

The TRG for PCBs is defined as the maximum concentration of PCBs in tissue of aquatic biota (prey items) that can be ingested by predators but is still considered protective of predators (CCME, 2001). Reference concentrations are the TRGs which can be safely ingested by mammals that consume aquatic biota. The reference concentration derived for mink (0.79 ng/kg/diet wet weight) is the most stringent reference concentration developed for mammals and has been chosen as the PCB TRG by the CCME (2001). The most relevant marine mammal for this site for which reference concentrations have been developed thus far is the harbour seal. The reference concentration for harbour seals is 1.12 ng/kg/diet wet weight. When compared to the mammalian reference concentration for harbour seals, the TEQs calculated from the PCB concentrations found in the scallops and sea urchins at this site are within levels deemed protective of marine mammals but the TEQ calculated from the sea urchins (0.87 ng/kg/diet wet weight) is above the 0.79 ng/kg/diet TRG, derived from mink data.

The risk of adverse effects from PCBs via dietary uptake is less for avian predators than mammalian predators. Avian predators are more tolerant of PCBs and therefore have higher TEQ values. The avian reference concentration from white leghorn chicken studies (CCME 2001) is 2.4 ng TEQ/kg/diet wet weight. Based on the avian TEQ calculation from the measured PCB congener concentrations, TEQ calculated from the scallop data (0.739 ng/kg/diet wet weight) is well below the avian TRG (2.4 ng/kg/diet wet weight) but the avian TEQ calculated from the sea urchin data (3.5 ng/kg/diet wet weight) is above the avian TRG.

All biota samples taken from the vessel and analysed were found to contain PCB levels below the current BC provincial criterion of 2.0 μg/g wet weight edible tissue for human consumption (Nagpal *et al.,* 1998). Of the thirteen biota samples submitted, eleven of the samples were found to be below the BC provincial criterion of 0.1 μg/g wet weight (whole fish) (Nagpal *et al.,* 1998), one was found to slightly above the criterion (0.12 μg/g) and one sample, consisting of one green urchin was found to exceed the BC provincial criterion (0.23 μg/g) for the protection of wildlife.

3.3 Biological Testing

The results of the toxicity tests were interpreted and assessed based on interpretative guidance as described in Lee *et al.*(1995) and Environment Canada (1998c). In summary, amphipod survival in test sediments found to be statistically significantly different and showing more than a 30% decrease from the control survival is considered a toxic response. A Microtox® response of less than 0.1% is considered a toxic response. Echinoid fertilization in sediment porewater found to be statistically significantly different and showing greater than 25% decrease in fertilization success in comparison to that in natural sea water (control) is considered a toxic response.

Based on the results of the biological testing, amphipod response to sediments from Station 1 would have been considered a toxic response to one of the three amphipod species used, (*E. washingtonianus*). However, this amphipod species has been shown to be sensitive to particle size effects (Lee, 1994 unpublished data; Lee *et al.,* 1995) and sediments collected from this site were found to contain over 20% clay. Environment Canada (1998c) has applied a test application limit for this amphipod species to sediments containing less than 80% fines and less than 20% clay, and as such the results of this toxicity test using this species would not be considered valid due to this amphipod species inability to survive in fine-grained sediments.

Control survival of *E. estuarius* was 89%, just below the 90% survival rate which is used to determine whether the test results are valid. Despite this, the survival rate of *E. estuarius* was relatively high, ranging from 64% to 87%. If the interpretative guidelines were applied to these results, *E. estuarius* would not have been considered to have elicited a toxic response to the sediments. Survival of *E. washingtonianus* ranged from 65% to 92%. *E. washingtonianus* response to sediments collected from Station 1 would have been considered as a toxic response but the survival results from this sediment would not be considered valid. *E. washingtonianus* would not have been considered to have elicited a toxic response to sediments collected from Stations 2 to 5. *R. abronius* survival in test sediments from Snake Island were relatively high, ranging from 73% to 91%. Based on Environment Canada's interpretive guidance, *R. abronius* survival observed in the test sediments are not considered toxic responses.

The results of the Microtox® tests performed did not show any toxic response to the sediments, according to the interpretative guidance used here. All Microtox® results from the test sediments were above the 0.1% criterion.

The fertilization success rate of gametes exposed to sediments tested from Stations 3 and 5 in the echinoid fertilization assay showed a greater than 25% decrease in fertilization success in comparison to the control fertilization rate. These would be considered toxic responses to the test sediments. The Eh values from these sediments (Table 7) indicate anaerobic conditions. Sediments containing more than 2 to 3% TOC can become anoxic and may produce high concentrations of hydrogen sulphide. Hydrogen sulphide directly inhibits mitochondrial cytochrome oxidase (Thompson *et al*., 1991), causing toxicity to many marine organisms. Thompson *et al* (1991) found that sulphide concentrations of 0.63 μmol/L (21 mg/L) caused mortalities in white sea urchins, *Lytechinus pictus* but no mortalities were observed at concentrations of 0.31 μmol/L (10.6 mg/L). Sediment hydrogen sulphide levels in sediments collected from the Snake Island reference sites were below the levels cited by Thompson *et al*. (1991). The highly negative Eh reading of the sediment, indicating anaerobic conditions, in conjunction with the elevated sulphide and elevated ammonia levels may have contributed to the low fertilization success exhibited by *D. excentricus* gametes exposed to porewater from Station 5 (Table 6). The low fertilization success in porewater collected from Station 3 sediments is a bit more problematic to explain since sediment quality measurements and contaminant concentrations with the exception of the high Eh reading obtained from this site were within the range as those measured from sediments which did not elicit a toxic response from *D. excentricus*.

4.0 Conclusions and Recommendations

Based on federal and provincial guidelines and criteria used in Canada and British Columbia, the data collected at this site indicates that PCB exposure from the decommissioned vessel poses no risk to human health and minimal risk to the marine environment. The range of PCBs found in biological samples taken in this study are within the range reported by Bell *et al.* (1997) in their study of artificial reefs constructed with ex-US naval vessels off the South Carolina coast on the east coast of the United States. Bell *et al.*(1997) also concluded that the PCB levels found in organisms residing on these artificial reefs were not posing any risk to human health and were within background PCB levels found in the environment at natural reef sites.

Analyses of the sediments collected from the Snake Island stations were all found to have PCB levels below the detection limit (<0.002 μg/g).

While all regulated contaminant concentrations were found to be below Environment Canada Ocean Disposal guidelines, depressed survival was observed in one of the three amphipod species exposed to sediments collected from one of the reference stations near Snake Island (Station 1); however, based on the particle size of the sediments collected there and the application limits set by Environment Canada for this amphipod species, it does not appear that the depressed survival of amphipods exposed to sediments collected from this station is due to contaminant effects but rather to the amphipods inability to survive in fine grained sediments. The results of the sub-lethal tests indicate no toxicity based on Microtox® results, however, a toxic response was elicited in the echinoid fertilization assay from sediment porewater from two of the sediments from Snake Island (Station 3 and Station 5). However, the observed toxicity at these stations may be caused by anaerobic conditions found in these sediments rather than from exposure to priority contaminants.

This preliminary study indicates that at present, there is no risk to human health or the environment from the presence of the *'Saskatchewan'* at the Snake Island site. However, further monitoring at vessel sinking sites would be useful in determining colonization of these vessels and the potential for contaminant uptake and bioaccumulation by higher trophic levels of marine organisms utilizing these sites as habitat. When released in the aquatic environment, the majority of PCBs released are ultimately incorporated into bedded sediments (Roe *et al.,* 2000). The fate and persistence of sediment associated PCBs are influenced by a number of processes, of which adsorption is the dominant process controlling distribution of PCBs in sediments. Aquatic organisms tend to bioaccumulate PCBs through a variety of exposure routes and PCBs readily partition into the lipid fraction of aquatic biota. Direct uptake of PCBs from water by aquatic organisms likely dominates in early life stages and those occupying lower trophic levels. The most important exposure route for many species, especially higher trophic level organisms is by direct ingestion of particulate associated PCBs or consumption of contaminated food. PCBs containing between five and seven chlorine atoms tend to be bioaccumulated to a greater extent than those with fewer chlorine atoms while PCBs with eight or more chlorine atoms do not bioaccumulate to the same extent since their size limits transportation across biological membranes (Coulston and Kolbye, 1994).

The results of this monitoring survey indicates that where PCBs are detected in biota, the PCBs detected are primarily the hexachlorobiphenyls through the octachlorobiphenyls. PCB concentrations found in the biota were all found to be below the provincial criterion for human consumption and all but one sample was found to contain concentrations deemed protective of wildlife. Human consumption of green sea urchins is limited to roe; however, there were limited numbers of sea urchins found on the site and all urchins collected were sexually immature at the time of collection. At the present time, the risk to human health is minimal since urchins collected from this site are sexually immature and would therefore not be used for human consumption, eliminating the human health pathway. Furthermore, the number of sea urchins at the site is, at present, limited. Organisms taken for consumption from this site would have to be harvested by divers, due to the depth of the site. In addition, organisms found on British Columbia recreational dive sites are not typically harvested for consumption.

The mammalian and avian TEQ calculated from the PCB tissue concentrations in scallops indicate no risk to marine mammals or birds but there may be some risk to marine birds ingesting sea urchins from this site, although the risk may be minimal due to the depth of the site, the small sample size used to calculate TEFs and the TEQs, and the conservative approach taken in calculating these values.

While the organisms found at this site did not appear to be impacted by PCBs originating from the vessel, it could not be determined whether PCBs could potentially be transferred further up the food web since there were no pelagic species found residing at the site. As such, pelagic species are not considered to be at risk from the presence of PCBs originating from the vessel at this time; however, at such time that pelagic communities establish at the site, further studies should be undertaken to determine potential risk to those resident species.

This study was conducted at only one site, however the results of the study indicate that there is no apparent risk to the environment due to PCB contamination from the presence of scuttled vessels. It would be worthwhile to expand the study to the other four sites where vessels have been sunk and compare PCB uptake in resident marine organisms in more established marine communities and different oceanographic conditions.

The establishment of a reference site at a natural reef within the vessel disposal site but outside of the area of influence around the vessel would be beneficial in determining the natural background concentration of PCBs and other priority contaminants in reef organisms in the local vicinity. The continued use of Aroclor and congener analyses of PCBs for tissue and sediments will allow comparison of PCB levels against various guidelines and criteria and PCB levels reported in other studies. Mammalian and avian TEFs and TEQs should be calculated from PCB concentrations derived from the analyses of congeners instead of Aroclors due to the high detection limits obtained from the Aroclor analyses.

It is also recommended that analyses for lipid content of tissues be added to any future monitoring studies since lipid content can affect the toxicity of PCBs. If the tissue lipid concentrations are known, PCB concentrations in tissues can be normalized, allowing comparison of PCB tissue levels from other studies. Human health risks due to consumption of marine organisms from the site should also be determined from the edible tissue contaminant concentrations, if the organisms are present, at sufficient numbers and size. As the site is colonized by fish, mixed function oxidase (MFO) induction should also be conducted since MFO in fish is a major response site to PCB exposure (Rice and O'Keefe, 1995)

Monitoring should be continued at this site and the site of the *'Cape Breton'* which was sunk in October 2001, south of the *'Saskatchewan'* (Figure 1). Since the *'Saskatchewan'* was sunk in 1997, Environment Canada's Clean-up guideline for vessels and Clean-up standard for vessels (Environment Canada, 2001a, b) were revised with stricter requirements being imposed in the current clean-up standard. Monitoring at both sites should be conducted in the future to determine the risk of trophic transfer of PCBs as more stable marine communities become established at these sites and whether the more stringent clean-up standard which was imposed on the '*Cape Breton´* will result in greater environmental benefits.

5.0 Acknowledgements

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Figures

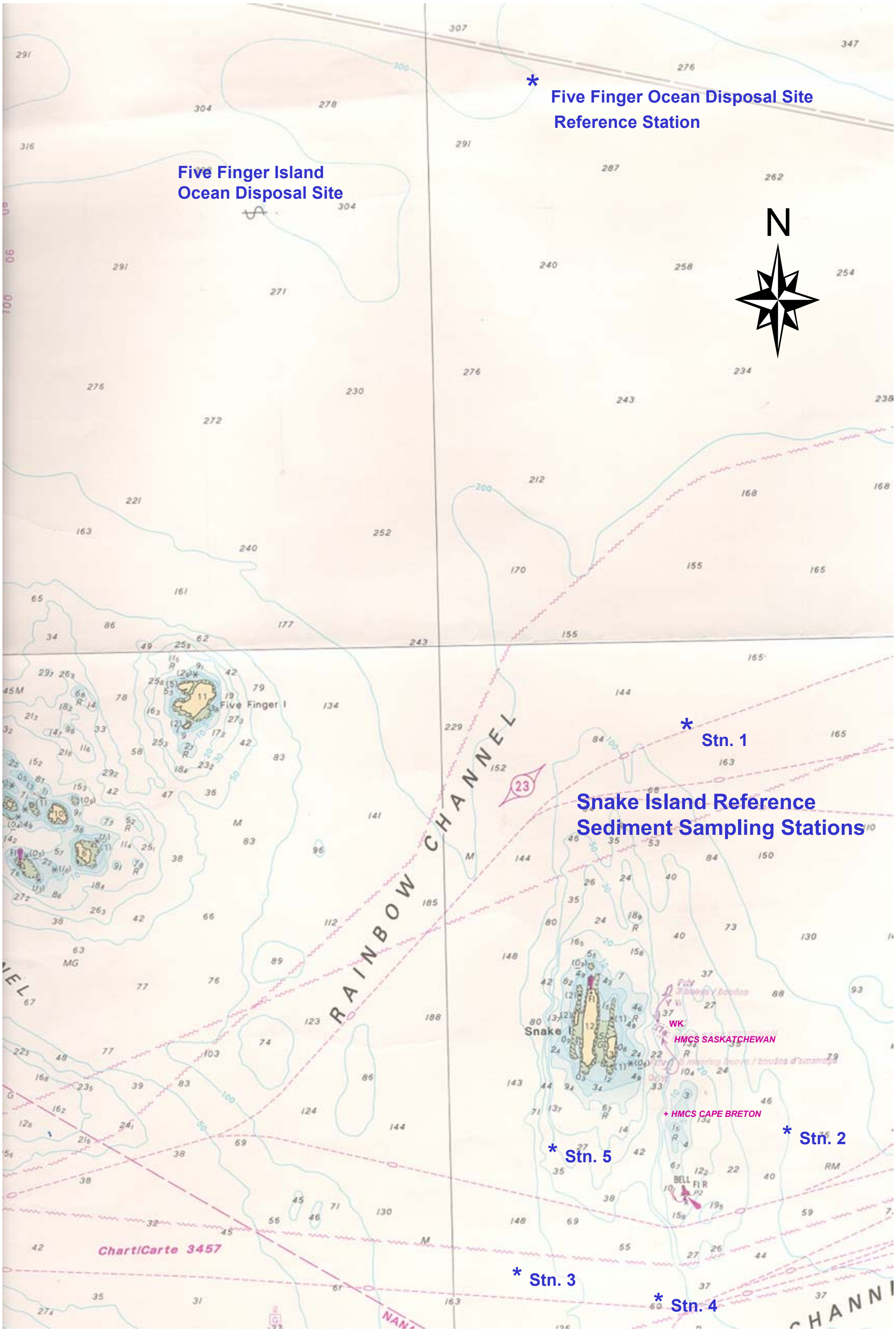

Figure 1: Location Map

0 500 1000 m c.a.

from CHS Chart 3458

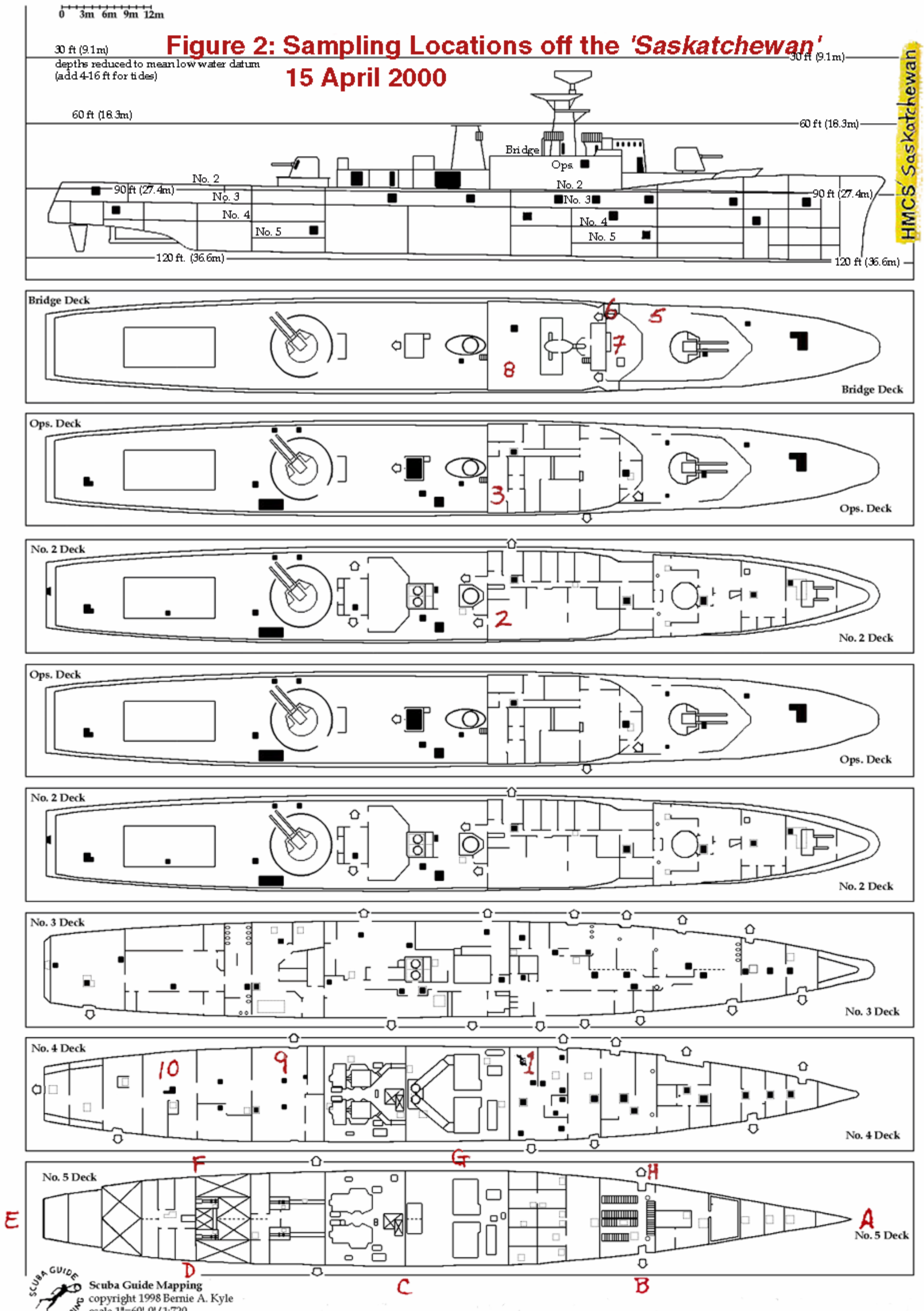

Figure 2: Sampling Locations off the *'Saskatchewan'*
15 April 2000

Tables

Table 1: Selected Polychlorinated biphenyl congeners, homologues and Aroclors analysed

IUPAC #	Congener	CAS Registry No.
	Dichlorobiphenyls	
BZ#8	2,4'-Dichlorobiphenyl	34883437
	Trichlorobiphenyls	
BZ#18	2,2',5-Trichlorobiphenyl	37680652
BZ#28	2,4,4'-Trichlorobiphenyl	7012375
	Tetrachlorobiphenyls	
BZ#44	2,2',3,5-Tetrachlorobiphenyl	41464395
BZ#49	2,2',4,5-Tetrachlorobiphenyl	41464408
BZ#52	2,2',5,5'-Tetrachlorobiphenyl	35693993
BZ#66	2,3',4,4'-Tetrachlorobiphenyl	32598100
BZ#77	3,3',4,4'-Tetrachlorobiphenyl	32598133
	Pentachlorobiphenyls	
BZ#87	2,2',3,4,5'-Pentachlorobiphenyl	38380028
BZ#101	2,2',4,5,5'-Pentachlorobiphenyl	37680732
BZ#105	2,3,3'4,4'-Pentachlorobiphenyl	32598144
BZ#118	2,3',4,4',5-Pentachlorobiphenyl	31508006
BZ#126	3,3',4,4',5-Pentachlorobiphenyl	57465288
	Hexachlorobiphenyls	
BZ#128	2,2',3,3',4,4'-Hexachlorobiphenyl	38380073
BZ#138	2,2',3,4,4',5-Hexachlorobiphenyl	35065282
BZ#153	2,2',4,4',5,5'-Hexachlorobiphenyl	35065271
BZ#156	2,3,3',4,4',5-Hexachlorobiphenyl	38380084
BZ#169	3,3',4,4',5,5'-Hexachlorobiphenyl	32774166
	Heptachlorobiphenyls	
BZ#170	2,2,'3,3',4,4',5-Heptachlorobiphenyl	35065306
BZ#180	2,2',3,4,4',5,5'-Heptachlorobiphenyl	36065293
BZ#183	2,2',3,4,4',5',6-Heptachlorobiphenyl	52663691
BZ#184	2,2',3,4,4',6,6'-Heptachlorobiphenyl	74472483
BZ#187	2,2',3,4',5,5',6-Heptachlorobiphenyl	52663680
	Octachlorobiphenyls	
BZ#195	2,2'3,3',4,4',5,6-Octachlorobiphenyl	52663782
	Nonachlorobiphenyls	
BZ#206	2,2',3,3'4,4',5,5',6-Nonochlorobiphenyl	40186729
	Decachlorobiphenyl	
BZ#209	Decachlorobiphenyl	2051243

Homologues	**Aroclors**
Total Monochlorobiphenyls	1221
Total Dichlorobiphenyls	1232
Total Trichlorobiphenyls	1242
Total Tetrachlorobiphenyls	1254
Total Pentachlorobiphenyls	1260
Total Hexachlorbiphenyls	1262
Total Heptachlrobiphenyls	1268
Total Octachlorobiphenyls	
Total Nonachlorobiphenyls	
Total Decachlorobiphenyls	

Table 2a: Polychlorinated biphenyls[1] (μg/g) in Sediments Collected in the Vicinity of the '*Saskatchewan*'

Sampling Location[2]	Bow	Starboard;	Starboard;	Starboard;	Stern	Port;	Port;	Port;
Sampling Date: 15 April 2000		Forward	Aft of Stack	Mortar Bay		Fwd, Mortar Bay	Stack	Bridge
Sample Id.	A	B	C	D	E	F	G	H
Physical Tests								
Moisture (%)	31.9	28.6	22.1	24.3	28.6	26.1	22.0	23.4
Polychlorinated Biphenyls[3]								
BZ#18	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#44	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#49	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#66	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#101,113	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#105	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#118	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#123	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#126	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#128,162	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#132,153,168	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.002	<0.002
BZ#134	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#138,160,163,164	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#156	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#169	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#170,190	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002
BZ#180	<0.002	<0.002	<0.002	<0.002	0.002	0.008	<0.002	<0.002
BZ#182,187	<0.002	<0.002	<0.002	<0.002	<0.002	0.005	<0.002	<0.002
BZ#183	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002
BZ#184	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#28,31	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#39	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#43,52	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#5,8	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#77	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#87,111,115	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

Table 2a (cont'd.): Polychlorinated biphenyls[1] (μg/g) in sediments collected off the '*Saskatchewan*'

Sampling Location[2]	Bow	Starboard;	Starboard;	Starboard;	Stern	Port;	Port;	Port;
Sampling Date: 15 April 2000		Forward	Aft of Stack	Mortar Bay		Fwd. Mortar Bay	Stack	Bridge
Sample Id	A	B	C	D	E	F	G	H
Aroclors								
PCB 1221	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCB 1232	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCB 1242	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01
PCB 1254	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCB 1260	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01
PCB 1262	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCB 1268	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Polychlorinated Biphenyls[3]	<0.01	<0.01	<0.01	<0.01	0.01	0.06	<0.01	<0.01
Total Monochlorobiphenyls (Cl_1)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Dichlorobiphenyls (Cl_2)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Trichlorobiphenyls (Cl_3)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Tetrachlorobiphenyls (Cl_4)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Pentachlorobiphenyls(Cl_5)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Hexachlorobiphenyls (Cl_6)	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Total Heptachlorobiphenyls (Cl_7)	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01
Total Octachlorobiphenyls (Cl_8)	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Total Nonachlorobiphenyls (Cl_9)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Decachlorobiphenyls (Cl_{10})	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Organic Parameters								
Total Organic Carbon (%)	0.57	0.8	0.52	0.45	0.48	0.51	0.42	0.32

[1] PCB concentrations in μg/g dry weight

Table 2b: Polychlorinated biphenyls[1] (μg/g) in Sediments Collected in the Vicinity of the *'Saskatchewan'* QA/QC Data

Sampling Location[2]	Port; Stack	Port; Stack (Field Duplicate)	Starboard; Mortar Bay	Starboard Mortar Bay lab duplicate	Method Blank Sed/Soil	Matrix Spike Found	Matrix Spike Targets	MESS-2 Found	MESS-2 Target
Sample Id	G	H	D	D					
Physical Tests									
Moisture %	22	21	24.3	18.8	-	-	-	-	-
Polychlorinated Biphenyls									
BZ#18	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	-	-
BZ#44	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	-	-
BZ#49	<0.002	<0.002	<0.002	<0.002	<0.002	0.013	0.014	-	-
BZ#66	<0.002	<0.002	<0.002	<0.002	<0.002	0.013	0.014	-	-
BZ#101,113	<0.002	<0.002	<0.002	<0.002	<0.002	0.013	0.014	-	-
BZ#105	<0.002	<0.002	<0.002	<0.002	<0.002	0.014	0.014	-	-
BZ#118	<0.002	<0.002	<0.002	<0.002	<0.002	0.014	0.014	-	-
BZ#123	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	-	-
BZ#126	<0.002	<0.002	<0.002	<0.002	<0.002	0.014	0.014	-	-
BZ#128,162	<0.002	<0.002	<0.002	<0.002	<0.002	0.014	0.014	-	-
BZ#132,153,168	<0.002	<0.002	<0.002	<0.002	<0.002	0.014	0.014	-	-
BZ#134	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	-	-
BZ#138,160,163,164	<0.002	<0.002	<0.002	<0.002	<0.002	0.016	0.014	-	-
BZ#156	<0.002	<0.002	<0.002	<0.002	<0.002	0.014	0.014	-	-
BZ#169	<0.002	<0.002	<0.002	<0.002	<0.002	0.015	0.014	-	-
BZ#170,190	<0.002	<0.002	<0.002	<0.002	<0.002	0.014	0.014	-	-
BZ#180	<0.002	<0.002	<0.002	<0.002	<0.002	0.015	0.014	-	-
BZ#182,187	<0.002	<0.002	<0.002	<0.002	<0.002	0.013	0.014	-	-
BZ#183	<0.002	<0.002	<0.002	<0.002	<0.002	0.014	0.014	-	-
BZ#184	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	-	-
BZ#28,31	<0.002	<0.002	<0.002	<0.002	<0.002	0.013	0.014	-	-
BZ#39	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	-	-
BZ#43,52	<0.002	<0.002	<0.002	<0.002	<0.002	0.014	0.014	-	-
BZ#5,8	<0.002	<0.002	<0.002	<0.002	<0.002	0.012	0.014	-	-
BZ#77	<0.002	<0.002	<0.002	<0.002	<0.002	0.014	0.014	-	-
BZ#87,111,115	<0.002	<0.002	<0.002	<0.002	<0.002	0.013	0.014	-	-

Table 2b (cont'd): Polychlorinated biphenyls[1] (μg/g) in Sediments Collected in the Vicinity of the *'Saskatchewan'* QA/QC Data

Sampling Location[2] Sample Id	Port Stack G	Port Stack (Field duplicate) H	Starboard Mortar Bay D	Starboard Mortar Bay lab duplicate D	Method Blank Sed/Soil	Matrix Spike Found	Matrix Spike Targets	MESS-2 Found	MESS-2 Target
Aroclors									
PCB 1221	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
PCB 1232	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
PCB 1242	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
PCB 1254	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
PCB 1260	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
PCB 1262	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
PCB 1268	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Total	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Polychlorinated Biphenyls[3]									
Total Monochlorobiphenyls (Cl_1)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Total Dichlorobiphenyls (Cl_2)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Total Trichlorobiphenyls (Cl_3)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Total Tetrachlorobiphenyls (Cl_4)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Total Pentachlorobiphenyls(Cl_5)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Total Hexachlorobiphenyls (Cl_6)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Total Heptachlorobiphenyls (Cl_7)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Total Octachlorobiphenyls (Cl_8)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Total Nonachlorobiphenyls (Cl_9)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Total Decachlorobiphenyls (Cl_{10})	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Organic Parameters									
Total Organic Carbon (%)	0.42	0.38	-	-	<0.05	-	-	2.24	2.14

[1] PCB concentrations in μg/g dry weight

[2] Sampling sites located 5 m from the hull of the vessel.

[3] Total PCB concentrations (μg/g dry weight) calculated based on the 209 known PCB congeners. Concentrations of congeners below the method detection limit are not included in the calculation for total PCBs.

Table 3: Polychlorinated biphenyl (μg/g dry weight) in Snake Island Reference Sediments

Sampling Location	Station 1	Station 2	Station 3	Station 4	Station 5	Station 2 Lab Duplicate	Method Blank	Reference Material Found	Reference Method Target	Method Spike Recovery
Physical Tests										
Moisture %	63.6	67.3	60.7	41.4	66.1	67.3	-	-	-	-
Polychlorinated Biphenyls										
BZ#18	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	108
BZ#44	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	4.05	4.20	110
BZ#49	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	97
BZ#66	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	100
BZ#101,113	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	107
BZ#105	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	106
BZ#118	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	102
BZ#123	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	122
BZ#126	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	100
BZ#128,162	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	96
BZ#132,153,168	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	107
BZ#134	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	108
BZ#138,160,163,164	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	102
BZ#156	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	108
BZ#169	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	106
BZ#170,190	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	108
BZ#180	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	100
BZ#182,187	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	105
BZ#183	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	100
BZ#184	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	110
BZ#195	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	98
BZ#206	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	96
BZ#209	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	102
BZ#26	-	-	-	-	-	-	-	0.900	1.07	-
BZ#28,31	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	7.62	9.07	110
BZ#39	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	118
BZ#43,52	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	105
BZ#5,8	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	50
BZ#77	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	112
BZ#87,111,115	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	86

Table 3 (cont'd.): Polychlorinated biphenyls (μg/g dry weight) in Snake Island Reference Sediments

Sampling Location	Station 1	Station 2	Station 3	Station 4	Station 5	Station 2 Lab Duplicate	Method Blank	Reference Material Found	Reference Material Target	Method Spike Recovery
Aroclors										
PCB 1221	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
PCB 1232	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
PCB 1242	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
PCB 1248	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
PCB 1254	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
PCB 1260	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
PCB 1262	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
PCB 1268	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Polychlorinated Biphenyls[1]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Monochlorobiphenyls (Cl1)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Dichlorobiphenyls (Cl2)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Trichlorobiphenyls (Cl3)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Tetrachlorobiphenyls (Cl4)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Pentachlorobiphenyls(Cl5)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Hexachlorobiphenyls (Cl6)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Heptachlorobiphenyls (Cl7)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Octachlorobiphenyls (Cl8)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Nonachlorobiphenyls (Cl9)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Decachlorobiphenyls (Cl10)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Organic Parameters (%)										
Total Organic Carbon C (%)	3.79	3.54	2.78	1.86	4.54	3.54	<0.05	1.98	2.14	-

[1] Total PCB concentrations calculated based on the 209 known PCB congeners. Concentrations of congeners below the method detection limit are not included in the calculation for total PCBs.

Table 4a: Polychlorinated biphenyls (µg/g) in Biota Collected off of the '*Saskatchewan*'

Sampling Location	Port side; switchboard		Starboard side; amidships ward room		Starboard side; Captain's day room		Port side; fwd of bridge	Port side Operations room	Amidships Operations room	Outside; Amidships top Cptn's Qtrs	#8 Mess Amidships; aft of gunnar room	#11 Mess Amidships
Sample Id	1	1B	2	2B	3	3B	5	6	7	8	9	10
Organism	scallops	urchin	scallop	urchin	scallop	urchin	urchin	scallop	scallop	urchin	scallop	scallop
Sample size	10	1	5	1	5	1	4	9	6	4	16	13
Polychlorinated Biphenyls												
BZ#18	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#44	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#49	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#66	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#101,113	<0.002	0.003	<0.002	<0.004	0.002	0.003	0.003	0.002	0.002	<0.002	0.002	<0.002
BZ#105	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#118	<0.002	<0.002	<0.002	<0.004	0.002	0.002	0.005	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#123	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#126	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#128,162	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#132,153,168	0.005	0.02	<0.002	0.005	0.007	0.006	0.014	0.006	0.009	0.003	0.008	0.005
BZ#134	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#138,160,163,164	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	0.003	<0.002	0.002	<0.002	0.002	<0.002
BZ#156	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#169	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#170,190	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#180	0.004	0.039	<0.002	0.005	0.004	0.005	0.015	0.006	0.01	0.003	0.008	0.004
BZ#182,187	0.004	0.032	<0.002	0.007	0.004	0.006	0.017	0.004	0.008	0.006	0.008	0.004
BZ#183	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	0.003	<0.002
BZ#195	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#206	<0.002	0.004	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#209	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#28,31	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#39	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#43,52	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#5,8	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#77	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
BZ#87,111,115	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

Table 4a (cont'd): Polychlorinated biphenyls (μg/g) in Biota Collected off of the *'Saskatchewan'*

Sampling Location	Port side; switchboard		Starboard side; amidships ward room		Starboard side; Captain's day room		Port side; fwd of bridge	Port side Operations room	Amidships Operations room	Outside; Amidships top; Captain's Quarters	#8 Mess Amidships aft of gunnar room	#11 Mess
Sample Id	1	1B	2	2B	3	3B	5	6	7	8	9	10
Organism	scallops	urchin	scallop	urchin	scallop	urchin	urchin	scallop	scallop	urchin	scallop	scallop
Sample size	10	1	5	1	5	1	4	9	6	4	16	13
Aroclor												
PCB 1221	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCB 1232	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCB 1242	0.02	<0.01	<0.01	<0.02	0.01	0.01	0.02	0.01	<0.01	0.01	0.01	<0.01
PCB 1248	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCB 1254	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCB 1260	0.02	0.23	<0.01	0.05	0.03	0.01	0.1	0.01	0.07	0.03	0.06	0.03
PCB 1262	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCB 1268	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Polychlorinated Biphenyls[1]	0.04	0.23	<0.01	0.05	0.04	0.05	0.12	0.05	0.07	0.04	0.07	0.04
Total Monochlorobiphenyls (Cl1)	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Dichlorobiphenyls (Cl2)	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Trichlorobiphenyls (Cl3)	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Tetrachlorobiphenyls (C14)	0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Pentachlorobiphenyls (Cl5)	<0.01	<0.01	<0.01	<0.02	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Hexachlorobiphenyls (Cl6)	0.01	0.05	<0.01	<0.02	0.02	0.01	0.04	0.02	0.03	0.01	0.03	0.02
Total Heptachlorobiphenyls (Cl7)	0.01	0.1	<0.01	0.02	0.01	0.02	0.05	0.02	0.03	0.01	0.03	0.01
Total Octachlorobiphenyls (Cl8)	<0.01	0.05	<0.01	0.02	<0.01	0.01	0.02	<0.01	<0.01	0.01	<0.01	<0.01
Total Nonachlorobiphenyls (Cl9)	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Decachlorobiphenyls (Cl10)	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

[1] Total PCB concentrations calculated based on the 209 known PCB congeners. Concentrations of congeners below the method detection limit are not included in the calculation for total PCBs

Table 4b: Polychlorinated biphenyls (μg/g) in Biota Collected off of the *'Saskatchewan'* - QA/QC Data

Sampling Location	#8 Mess Amidships aft of Gunnar room	Field duplicate	Starboard side; Captain's day room	lab duplicate	Matrix Blank Tissue	Matrix Spike Found	Matrix Spike Target
Organism	scallop	scallop	scallop	scallop			
Polychlorinated Biphenyls							
BZ#18	<0.002	<0.002	<0.002	<0.002	<0.002	-	-
BZ#44	<0.002	<0.002	<0.002	<0.002	<0.002	-	-
BZ#49	<0.002	<0.002	<0.002	<0.002	<0.002	0.028	0.031
BZ#66	<0.002	<0.002	<0.002	<0.002	<0.002	0.029	0.031
BZ#101,113	0.002	<0.002	0.002	0.003	<0.002	0.031	0.031
BZ#105	<0.002	<0.002	<0.002	<0.002	<0.002	0.03	0.031
BZ#118	<0.002	<0.002	0.002	0.002	<0.002	0.031	0.031
BZ#123	<0.002	<0.002	<0.002	<0.002	<0.002	-	-
BZ#126	<0.002	<0.002	<0.002	<0.002	<0.002	0.031	0.031
BZ#128,162	<0.002	<0.002	<0.002	<0.002	<0.002	0.031	0.031
BZ#132,153,168	0.008	0.007	0.007	0.009	<0.002	0.037	0.031
BZ#134	<0.002	<0.002	<0.002	<0.002	<0.002	-	-
BZ#138,160,163,164	0.002	<0.002	<0.002	<0.002	<0.002	0.038	0.031
BZ#156	<0.002	0.002	<0.002	<0.002	<0.002	0.032	0.031
BZ#169	<0.002	<0.002	<0.002	<0.002	<0.002	0.032	0.031
BZ#170,190	<0.002	<0.002	<0.002	<0.002	<0.002	0.033	0.031
BZ#180	0.008	0.007	0.004	0.005	<0.002	0.037	0.031
BZ#182,187	0.008	0.007	0.004	0.005	<0.002	0.034	0.031
BZ#183	0.003	0.003	<0.002	<0.002	<0.002	0.032	0.031
BZ#195	<0.002	<0.002	<0.002	<0.002	<0.002	-	-
BZ#206	<0.002	<0.002	<0.002	<0.002	<0.002	-	-
BZ#209	<0.002	<0.002	<0.002	<0.002	<0.002	-	-
BZ#28,31	<0.002	<0.002	<0.002	<0.002	<0.002	0.029	0.031
BZ#39	<0.002	<0.002	<0.002	<0.002	<0.002	-	-
BZ#43,52	<0.002	<0.002	<0.002	<0.002	<0.002	0.03	0.031
BZ#5,8	<0.002	<0.002	<0.002	<0.002	<0.002	0.026	0.031
BZ#77	<0.002	<0.002	<0.002	<0.002	<0.002	0.031	0.031
BZ#87,111,115	<0.002	<0.002	<0.002	<0.002	<0.002	0.03	0.031

Table 4b (cont'd): Polychlorinated biphenyls (μg/g) in Biota Collected off of the *'Saskatchewan'* - QA/QC Data

Sampling Location	#8 Mess Amidships aft of gunnar room	Field duplicate	Starboard Side; Captain's day room	lab duplicate	Matrix Blank Tissue	Matrix Spike Found	Matrix Spike Target
PCB 1221	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
PCB 1232	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
PCB 1242	0.01	0.01	0.01	0.01	<0.01	-	-
PCB 1248	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
PCB 1254	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
PCB 1260	0.06	0.05	0.03	0.04	<0.01	-	-
PCB 1262	<0.01	<0.01	<0.01	<0.01	-	-	-
PCB 1268	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Polychlorinated Biphenyls[1]	0.07	0.06	0.04	0.05	<0.01	-	-
Total Monochlorobiphenyls (Cl1)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Total Dichlorobiphenyls (Cl2)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Total Trichlorobiphenyls (Cl3)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Total Tetrachlorobiphenyls (C14)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Total Pentachlorobiphenyls (Cl5)	<0.01	<0.01	0.01	0.01	<0.01	-	-
Total Hexachlorobiphenyls (Cl6)	0.03	0.02	0.02	0.02	<0.01	-	-
Total Heptachlorobiphenyls (Cl7)	0.03	0.02	0.01	0.02	<0.01	-	-
Total Octachlorobiphenyls (Cl8)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Total Nonachlorobiphenyls (Cl9)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Total Decachlorobiphenyls (Cl10)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-

[1] Total PCB concentrations calculated based on the 209 known PCB congeners.
Concentrations of congeners below the method detection limit are not included in the calculation for total PCBs.

Table 4c: Mammalian and Avian PCB TEQ Estimates from Aroclor Concentrations

PCB concentrations (μg/g) wet weight[1]

SCALLOPS			Sample ID								
	Conversion Factor		1	2	3	6	7	9	10		
Aroclor	TEF $_m$[2]	TEF$_a$[2]	n=10	n=5	n=5	n=9	n=6	n=16	n=13	**TEF$_m$[4]**	**TEF$_a$[5]**
1242	5.1	234.6	0.02	<0.01	0.01	0.01	<0.01	0.01	<0.01	0.057544	2.386353
1248	12.8	251.3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.131624	2.304926
1254	30.1	44.5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.309522	0.408154
1260	11.3	25.5	0.02	<0.01	0.03	0.01	0.07	0.06	0.03	0.338396	0.735304
										TEQ$_m$[3]	**TEQ$_a$[3]**
										0.84	**5.83**

URCHINS			Sample ID						
	Conversion Factor		1	2	3	5	8		
Aroclor	TEF $_m$[2]	TEF$_a$[2]	n=1	n=1	n=1	n=4	n=4	**TEF$_m$[4]**	**TEF$_a$[5]**
1242	5.1	234.6	<0.01	0.02	0.01	0.02	0.01	0.24225	11.1435
1248	12.8	251.3	<0.01	<0.02	<0.01	<0.01	<0.01	0.576	11.3085
1254	30.1	44.5	<0.01	<0.02	<0.01	<0.01	<0.01	1.3545	2.0025
1260	11.3	25.5	0.23	0.05	0.01	0.1	0.03	3.64425	8.22375
								TEQ$_m$[3]	**TEQ$_a$[3]**
								5.82	**32.68**

1 Where concentrations were found to be below the analytical detection limit, the detection limit was used in the calculation to determine TEQs.
2 TEF$_m$= Mammalian Toxic Equivalency Factor
3 TEF$_a$ = Avian Toxic Equivalency Factor
4 TEQ$_m$= Mammalian Toxicity Units
5 TEQ$_a$= Avian Toxicity Units

Table 4d: Mammalian and Avian PCB TEQ Estimates from Congener Concentrations in Scallop Tissue

PCB concentrations (μg/g) wet weight[1]											
SCALLOPS											
			Sample ID								
	Conversion Factor		1	2	3	6	7	9	10		
Congener	TEF_m[2]	TEF_a[2]	n=10	n=5	n=5	n=9	n=6	n=16	n=13	**TEF_m[2]**	**TEF_a[2]**
105	0.0001	0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.000000183	0.000000183
118	0.0001	0.00001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.000000183	0.000000183
123	0.0001	0.00001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.000000183	0.000000018
126	0.1	0.1	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.000183	0.000183
156	0.0005	0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.000000917	0.000000183
169	0.01	0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.0000183	0.00000183
77	0.0001	0.05	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.000000183	0.0000917
81	0.0001	0.05	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.000000917	0.000459
114	0.0005	0.0001	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.00000459	0.000000917
157	0.0005	0.0001	0.01	<0.01	0.02	0.02	0.03	0.03	0.02	0.00000882	0.00000176
167	0.00001	0.00001	0.01	<0.01	0.02	0.02	0.03	0.03	0.02	0.000000176	0.000000176
189	0.0001	0.00001	0.01	<0.01	0.01	0.02	0.03	0.03	0.01	0.00000149	0.000000149
										TEQ_m[3]	**TEQ_a[3]**
										0.000219	**0.000739**

1 Where concentrations were found to be below the analytical detection limit, the detection limit was used in the calculation to determine TEFs and TEQs.
For specific congeners (81, 114, 157, 167 and 189) not individually quantified, the total homologue concentration was used to estimate congener concentrations to calculate the TEFs and TEQs

2 TEF_m= Mammalian Toxic Equivalency Factor

3 TEF_a = Avian Toxic Equivalency Factor

4 TEQ_m= Mammalian Toxicity Units

5 TEQ_a= Avian Toxicity Units

Table 4e: Mammalian and Avian PCB TEQ Estimates from Congener Concentrations in Sea Urchins

PCB concentrations (μg/g) wet weight[1]										
URCHINS										
			Sample ID							
	Conversion Factor		1	2	3	5	8			
Congener	TEF $_m$[2]	TEF$_a$[2]	n=1	n=1	n=1	n=4	n=4	**TEF $_m$[2]**	**TEF$_a$[2]**	
105	0.0001	0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	0.0000007	0.0000007	
118	0.0001	0.00001	<0.002	<0.002	0.002	0.005	<0.002	0.000000775	0.0000000731	
123	0.0001	0.00001	<0.002	<0.002	<0.002	<0.002	<0.002	0.0000007	0.00000007	
126	0.1	0.1	<0.002	<0.002	<0.002	<0.002	<0.002	0.0007	0.00085	
156	0.0005	0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	0.0000035	0.0000007	
169	0.01	0.001	<0.002	<0.002	<0.002	<0.002	<0.002	0.00007	0.000007	
77	0.0001	0.05	<0.002	<0.002	<0.002	<0.002	<0.002	0.0000007	0.00035	
81	0.0001	0.05	<0.01	<0.02	<0.01	<0.01	<0.01	0.0000045	0.00225	
114	0.0005	0.0001	<0.01	<0.02	0.01	0.01	<0.01	0.0000225	0.0000045	
157	0.0005	0.0001	0.05	<0.02	0.01	0.04	0.01	0.0000463	0.00000925	
167	0.00001	0.00001	0.05	<0.02	0.01	0.04	0.01	0.000000925	0.000000925	
189	0.0001	0.00001	0.1	0.02	0.02	0.05	0.01	0.0000155	0.00000155	
								TEQ$_m$[4]	**TEQ$_a$[5]**	
								0.000866	**0.003475**	

[1] Where concentrations were found to be below the analytical detection limit, the detection limit was used in the calculation to determine TEFs and TEQs.
For specific congeners (81, 114, 157, 167 and 189) not individually quantified, the total homologue concentration was used to estimate congener concentrations to calculate the TEFs and TEQs

[2] TEF$_m$= Mammalian Toxic Equivalency Factor

[3] TEF$_a$ = Avian Toxic Equivalency Factor

[4] TEQ$_m$= Mammalian Toxicity Units

[5] TEQ$_a$= Avian Toxicity Units

Table 5: Snake Island Sediment Quality Measurements

Station	Particle Size (%) Gravel >2.00 mm	Sand 2.00-0.063mm	Clay 0.063-0.004mm	Silt <0.004mm	TOC (%)	Sulphide (mg S/g)	Ammonia (mg NH3-N/g)	Eh (mV)	AVS/SEM
1	0.67	29.54	23.86	45.93	3.79	1.6 ± 0.3	7.3 ± 0.2	-43 ± 1	<0.25
2	11.64	33.21	21.04	34.11	3.54	5.3 ± 0.4	48.9 ± 0.8	-20 ± 2	0.17
3	10.63	38.76	20.31	30.3	2.78	2.1 ± 0.2	12.6 ± 0.3	-101 ± 1	0.17
4	17.18	56.62	12.61	27.53	1.86	4.5 ± 0.7	7.7 ± 0.4	7 ± 1	1.03
5	2.84	32.36	13.59	37.27	4.54	10.8 ± 1.0	38.2 ± 0.4	-157 ± 1	1.4

Table 6: Snake Island Sediment Toxicity Test Results

Station	Acute Lethality			Sublethal Tests		
	E. washingtonianus	*E. estuarius*	*Rhepoxynius abronius*	Microtox Solid Phase		*Dendraster excentricus*
	% Survival ± S.D.	% Survival ± S.D.	% Survival ± S.D.	%	(95% C.I.)	% Fertilization ± S.D.
Control	97 ± 6.7	89 ± 8.5	95 ± 5.0			89 ± 1.5
1	65 ± 7.9	64 ± 6.5	73 ± 7.6	0.49	(0.43 - 0.57)	82 ± 3.1
2	81 ± 2.2	71 ± 12.9	91 ± 4.2	0.91	(0.68 - 1.21)	72 ± 5.3
3	75 ± 13.2	76 ± 11.4	83 ± 8.4	0.38	(0.34 - 0.43)	63 ± 3.1
4	78 ± 14.4	86 ± 9.6	83 ± 13.5	0.53	(0.44 - 0.64)	64 ± 5.5
5	92 ± 9.1	87 ± 9.1	85 ± 10.0	0.39	(0.37 - 0.42)	55 ± 6.2
Reference Toxicant Test	96-h LC50(95%CI) (mg Cd^{++}/L) 1.2 (1.0 - 1.8)	96-h LC50 (95%CI) (mg Cd^{++}/L) 1.7 (1.0 - 2.3)	96-h LC50 (95%CI) (mg Cd^{++}/L) 0.34 (0.27 - 0.42)	15 min liquid phase (95% CI) IC50 (mg/L phenol) 17.3 (15.6 - 19.1) 5 min solid phase IC50 (HS-6) (%) 0.0309 (0.0301 - 0.0318)		20 min IC50 (95%CI) µg Cu^{++}/L 39.4 (36.2 - 42.5)

Table 7: Snake Island Total Metals (µg/g) in Sediments

	Station 1	Station 2	Station 3	Station 4	Station 5	Mess-2 Rep 1	Mess-2 Rep 2	Mess-2 Rep 3	PACS-1 Rep 1	PACS-1 Rep 2	PACS-1 Rep 3
Total metals (µg/g)											
Aluminum	32800	30100	30200	26500	24800	66200	53500	57200	28100	24200	28600
Antimony	<8	<8	<8	<8	<8	<8	<8	<8	157	148	158
Arsenic	8	14	8	<8	<8	24	22	23	201	200	202
Barium	153	147	142	123	110	746	631	660	425	385	425
Berylium	0.3	0.3	0.2	<0.2	<0.2	3	2.7	2.8	0.3	0.3	0.4
Boron	118	132	119	104	105	216	199	209	155	144	148
Cadmium	0.39	0.33	0.31	0.31	0.27	0.18	0.23	0.16	2.18	2.14	2.04
Calcium	10100	10600	10500	11000	14500	14400	14300	14500	11600	10500	11500
Chromium	45.8	46.1	47.2	42.8	38.3	86	75	79.1	67.5	62.8	65.5
Cobalt	13.1	12.2	8.5	8.5	7.8	10	11.1	12.2	14	14.5	13.7
Copper	51.3	63.7	51.4	44.7	50.7	36.5	37.3	38.8	442	440	429
Iron	32500	33200	31100	27000	25900	42700	41300	42700	45800	43700	44700
Lead	23	45	28	24	34	37	32	36	409	400	408
Magnesium	11700	11300	10500	9060	9460	16300	15400	16100	10900	10500	10700
Manganese	453	1480	744.9	343	377	307	302	314	327	303	322
Molybdenum	<2	<2	<2	<2	<2	<2	<2	<2	8	8	9
Nickel	46	57	45	32	35	50	48	55	44	43	42
Phosphorus	926	1520	1080	880	1030	1140	1120	1130	1040	1020	993
Potassium	6890	5990	5910	4620	4480	20200	16100	17200	5540	4560	5770
Selenium	10	15	13	10	<8	25	10	13	13	9	14
Silicon	1160	1440	1600	1060	1590	1400	1560	1570	1560	1250	1260
Silver	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Sodium	8930	10500	8142	7030	8770	10900	10700	10900	17600	17100	17100
Strontium	76.2	91.8	80.5	77.5	102	103	92.9	96.2	98.8	88	97.7
Sulphur	2770	2790	2290	2790	2540	1870	1860	1900	13300	13100	12500
Tin	<8	<8	<8	<8	<8	<8	<8	<8	40	36	38
Titanium	2120	1950	2080	2180	1900	446	305	345	2080	1780	2060
Vanadium	113	116	115	104	95	222	196	206	116	105	115
Zinc	95.8	131	110	80.7	93.1	159	157	160	853	834	859
Mercury	0.078	0.115	0.102	0.118	0.127	0.084	0.084	0.086	4.52	4.48	4.64

Table 8a: Snake Island Polycyclic Aromatic Hydrocarbons (ng/g) in Sediments

Polynuclear Aromatic Hydrocarbons (ng/g)	Station 1	Station 2	Station 3	Station 4	Station 5
Naphthalene	330	250	240	190	380
Acenaphthylene	25	17	13	8.7	13
Acenaphthene	19	30	19	26	43
Fluorene	27	30	26	25	47
Phenanthrene	250	250	220	160	290
Anthracene	54	57	51	45	78
Sum of LMW PAHs	710	630	570	450	850
Fluoranthene	71	290	190	160	270
Pyrene	81	220	170	130	220
Benz(a)anthracene	46	85 (NDR)	69 (NDR)	55 (NDR)	92
Chrysene	56	150	99	71	130
Benzofluoranthenes	78	210	160	94	180
Benzo(e)pyrene	32	79	58	37	81
Benzo(a)pyrene	35	79	62	44	82
Perylene	77	92	88	51	110
Dibenz(a,h)anthracene	5.8	15	12	7.8	14
Indeno(1,2,3-cd)pyrene	37	85	73	34	74
Benzo(g,h,I)perylene	49	100	92	45	97
Sum of HMW PAHs	570	1300	1000	670	1400
Total PAH	1300	1900	1600	1100	2200

Table 8b: Snake Island Polycyclic Aromatic Hydrocarbons[1] (ng/g) in Sediments - QA/QC Data

	Station 4	Station 4 Duplicate	Spiked Matrix Determined	Spiked Matrix Expected	% Recovery	Lab Blank	Spike Matrix Determined	Spike Matrix Expected	% Recovery	Lab Blank
Polynuclear Aromatic Hydrocarbons										
Naphthalene	190	200	205	200	103	1.4	211	200	106	1.3
Acenaphthylene	8.7	8.6	212	196	108	ND	185	196	95	0.21(NDR)
Acenaphthene	26	27	217	197	110	ND	216	197	110	ND
Fluorene	25	26	169	196	86	ND	188	196	96	ND
Phenanthrene	160	170	213	196	108	0.33 (NDR)	204	196	104	0.25
Anthracene	45	42	183	197	93	ND	182	198	92	ND
Sum of LMW PAHs	450	470				1.4				1.6
Fluoranthene	160	150	218	203	107	0.19 (NDR)	218	203	107	0.082
Pyrene	130	120	223	202	111	0.15 (NDR)	218	202	108	ND
Benz(a)anthracene	55 (NDR)	50 (NDR)	206	194	106	ND	207	194	107	0.22 (NDR)
Chrysene	71	65	216	200	108	0.095 (NDR)	219	200	110	0.17
Benzofluoranthenes	94	86	425	401	106	ND	443	401	111	0.44 (NDR)
Benzo(e)pyrene	37	33	215	194	111	ND	208	194	107	0.21 (NDR)
Benzo(a)pyrene	44	40	204	195	105	ND	193	195	99	ND
Perylene	51	54	202	197	103	ND	181	198	91	ND
Dibenz(a,h)anthracene	7.8	6.8	212	195	108	ND	221	195	113	ND
Indeno(1,2,3-cd)pyrene	34	32	209	192	109	ND	222	192	116	0.24 (NDR)
Benzo(g,h,I)perylene	45	45	204	191	107	ND	216	191	113	ND
Sum of HMW PAHs	670	630				0				0.25
Total PAH	1100	1100				1.4				1.8

[1] PAH concentrations in ng/g dry weight

- NDR - Peak detected but did not meet quantification criteria
- ND - Not detected