Artificial Reefing

# Ex-ORISKANY Artificial Reef Project

## Prospective Risk Assessment Model (PRAM) Version 1.4C

SPAWAR
Systems Center
San Diego

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FINAL REPORT

Program Executive Office Ships

# Ex-ORISKANY
# Artificial Reef Project

# Prospective Risk Assessment Model (PRAM) Version 1.4c

## FINAL REPORT

*Prepared for:*
*Program Executive Office Ships (PMS 333)*

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ATSDR | Agency for Toxic Substances and Disease Registry |
| BAF | biological accumulation factor |
| BCF | bioconcentration factor |
| CB | Chlorobiphenyl |
| CalTOX | California EPA Multimedia Total Exposure Model for Hazardous Waste Sites |
| CFR | Code of Federal Regulations |
| cm | Centimeters |
| CNO | Chief of Naval Operations |
| COC | constituent of concern |
| CTE | central tendency exposure |
| d | day |
| deca-CBs | PCB congeners with 10 of 10 possible chlorine substitutions |
| DO | dissolved oxygen |
| DOC | dissolved organic carbon |
| ECETOC | European Centre for Ecotoxicology and Toxicology of Chemicals |
| *f* | fugacity |
| FI | fraction of fish ingested |
| FWCC | Florida Fish and Wildlife Conservation Commission |
| FWR | Final Weight Report |
| g | gram |
| GUI | Graphical User Interface |
| hexa-CBs | PCB congeners with 6 of 10 possible chlorine substitutions |
| hr | hour |
| IR | ingestion rate |
| IRIS | Integrated Risk Information System |
| kg | kilogram |
| $K_{oc}$ | water to particulate organic carbon partitioning coefficient |
| $K_{doc}$ | water to dissolved organic carbon partitioning coefficient |
| $K_{ow}$ | octanol to water partitioning coefficient |
| L | Liters |
| LAARS | large area artificial reef site |
| LLNL | Lawrence Livermore National Laboratory |
| m | meter |
| MAMES | Mississippi-Alabama Marine Ecosystem Study |
| mg | milligram |

ACRONYMS AND ABBREVIATIONS (Continued)

| | |
|---|---|
| MMS | Minerals Management Service |
| mol | mole |
| mono-CBs | PCB congeners with 1 of 10 possible chlorine substitutions |
| NAVSEA | Naval Sea Systems Command |
| NDBC | National Data Buoy Center |
| NEHC | Navy Environmental Health Center |
| ng | nanogram |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| nona-CBs | PCB congeners with 9 of 10 possible chlorine substitutions |
| Pa | Pascals |
| PCB | Polychlorinated Biphenyl |
| PRAM | Prospective Risk Assessment Model |
| QSAR | Quantitative structure activity relationship |
| RAGS | Risk Assessment Guidance for Superfund |
| REEFEX | Reef Exercise (Sunken Vessels Used to Construct Artificial Reefs on the Continental Shelf of the US) |
| RfD | reference dose |
| RISC | Risk-Integrated Software for Clean-ups |
| RME | reasonable maximum exposure |
| s | seconds |
| SCEM | Site Conceptual Exposure Model |
| SF | slope factor |
| SHHRA | Supplemental Human Health Risk Assessment |
| SSC-SD | Space and Naval Warfare Systems Center (SPAWARSYSCEN) San Diego, an organization of the Space and Naval Warfare Systems Command (SPAWAR) |
| SPAWAR | Space and Naval Warfare |
| TDM | Time-dynamic model |
| TL | Trophic Level |
| TWG | Technical Working Group |
| UCD | University of California – Davis |
| UCL | Upper confidence limit |
| USEPA | U.S. Environmental Protection Agency |
| USGS | United States Geological Survey |

ACRONYMS AND ABBREVIATIONS (Continued)

| | |
|---|---|
| ZOI | Zone of Influence |

This document describes a predictive model, Prospective Risk Assessment Model (PRAM), initially developed under the technical direction of the Navy Environmental Health Center (NEHC), Portsmouth, Virginia and more recently under the technical direction of SPACE and NAVAL WARFARE SYSTEMS CENTER – San Diego (SSC-SD). Its application supports the environmental evaluation of a decommissioned Navy vessel (ex-ORISKANY) proposed for sinking and use as a potential artificial reef.

The purpose of PRAM is to predict concentrations of PCBs in abiotic media, predict concentrations of PCBs in tissue of marine organisms on or near the sunken ex-ORISKANY, and estimate human health risks for use in a human health risk assessment (Ex-Oriskany Artificial Reef Project Human Health Risk Assessment) and ecological risk assessment (Ex-Oriskany Artificial Reef Project Ecological Risk Assessment).

These predictions reflect the incremental exposure to PCBs associated with the presence of the sunken vessel after its colonization as an artificial reef under steady state assumptions. A companion model, the Time Dynamic Model (TDM), predicts the abiotic concentrations during the first two years after sinking, a period that we assume is non-steady state (NEHC/SSC-SD. 2005).

These incremental estimates of exposure associated with sinking the ex-ORISKANY do not include or estimate background[1] concentrations of PCBs in the local marine environment.

## 1.1 MODEL BACKGROUND AND DEVELOPMENT

The PRAM predictions apply to a proposed future environmental condition, the biological colonization of a sunken ship to form an artificial reef. Therefore, we characterized the risk assessments as prospective. An interagency Technical Working Group (TWG)[2] first entertained the concept of such a prospective risk assessment at a 1999 meeting. The concept was briefed to the Navy as:

[1] Background referring to the in-situ concentration of PCBs within the system prior to the deployment of a vessel for artificial reef building.

[2] The REEFEX interagency Technical Working Group (TWG) was comprised of U.S. Environmental Protection Agency (USEPA) representatives from the Office of Pollution Prevention and Toxics (USEPA OPPT), the Office of Water (USEPA OW), the state of Florida (Florida Fish and Wildlife Commission, Escambia County Marine Resources Division), Navy representatives, and contractors to the Navy.

> *"An assessment of risk that is based on known/estimated contaminant source values, modeled fate and transport values, and assumptions about exposure pathways and extent of exposure"* (A. Lunsford, NEHC – RDML L.C. Baucom Briefing, February 23, 2000).

*Steps in Model Development*

The history of PRAM development included:

2000

An initial demonstration program, with all of the relevant equations considered at that time, presented to the REEFEX TWG;

Late 2000 to 2001

NEHC reviewed the modeling algorithms and mathematical assumptions in PRAM;

2001

Formal sensitivity analysis on the list of variables within the PRAM;

Late 2001

Incorporation of draft leachate rates of PCB-containing bulk product materials developed by the SSC-SD Marine Environmental Support Office

Research Triangle Institute (RTI) provided review that resulted in, among other things, the incorporation of a compartment, interior to the sunken vessel, into which PCBs are initially released;

The Navy addressed comments from external reviewers (non-Navy TWG representatives);

2003

The Navy tested PRAM using data obtained from the ex-AGERHOLM (a Gearing class destroyer [DD-826], deployed in deep water off the coast of California); and published the results (Goodrich et al., 2003).

July 2004
The Navy provided PRAM (Version 1.3) to the USEPA[3] and State of Florida representatives for review in July 2004. The Navy incorporated experimentally derived leach rates for PCB homologs into PRAM and changed various parameters (e.g. vessel dimensions, PCB source material amounts, and water column height) to make the model specifically applicable to the proposed ex-ORISKANY[4] Memorial Reef.

This document addresses PRAM Version 1.4c. Subsection 1.3 describes the technical enhancements added to PRAM Version 1.3 to develop Version 1.4c.

## 1.2 GENERALIZED DESCRIPTION OF PRAM

This section provides a generalized description of PRAM. Sections 2, 3, and 4 of this document provide more scientific and detailed descriptions of the model's construct, algorithms, and assumptions.

### 1.2.1 Introduction

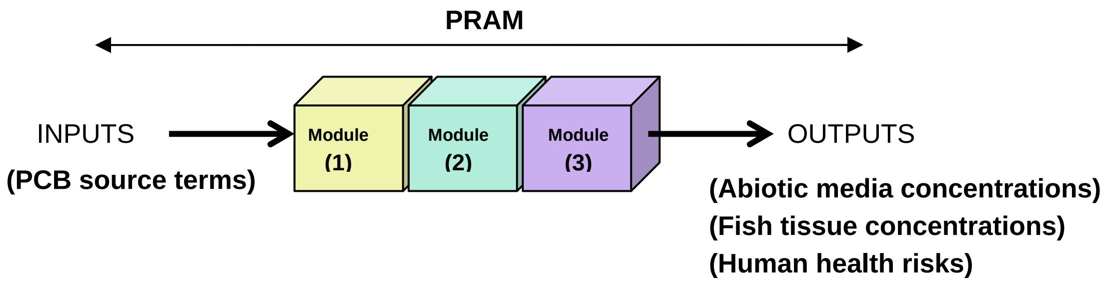
Within PRAM there are three modules (Figure 2): a multimedia, environmental chemical fate module, a biotic food web module, and a risk characterization module. These three modules are directly linked within PRAM, such that the model begins with a known quantity of a chemical, or known quantities of several chemicals (chemical source terms), simulates how these chemicals will be distributed within a marine environment, simulates how the chemicals will be taken up and bioaccumulated in living organisms, and finally, calculates the human health risks (carcinogenic risks and non-cancer hazards) that would be associated with consuming fish that have accumulated those chemicals. It also provides estimates of exposure point concentrations to assess impacts to survival, growth, and reproduction of representative receptors from pelagic, benthic, and reef communities associated with the artificial reef .

[3] The PRAM (Version 1.3) was provided to EPA Region 4, EPA Headquarters, EPA OPPT, and EPA National Exposure Research Laboratory (NERL) representatives for review.

[4] Ex-ORISKANY (CVA-34) is the last Essex class aircraft carrier that served the Navy fleet for more than 25 years, maintaining a powerful presence during the Korean War and the Vietnam conflict. The vessel was launched on October 13, 1945 and was commissioned on September 25, 1950. It was decommissioned in 1976.

### 1.2.2 Generalized Model Construct

The following illustration shows the general relationship among the three PRAM modules.




In the illustration:

- Inputs to the PRAM are the chemical source terms specific to a particular sunken vessel. For the ex-ORISKANY risk assessment, the primary chemical of concern is PCBs. The amount of each PCB homolog (mono- through deca-chlorobiphenyl) remaining in materials onboard the ex-ORISKANY when it is deployed as an artificial reef are the source terms (inputs) to PRAM for this assessment.

- Module 1 is the multimedia environmental chemical fate module. It incorporates the equations and physical parameters that govern the processes by which PCB homologs are released and dispersed in the marine environment surrounding the sunken vessel, and distributed into the various abiotic media (water, suspended solids, dissolved organic carbon, sediment, and air) within a defined volume around the sunken vessel.

- Module 2 is the PRAM biotic-food web module. It incorporates the equations and parameters that govern the processes by which the PCB homologs in the abiotic media accumulate through the food web and into the tissues of marine biota.

- Module 3 is the risk characterization model. It incorporates the equations and parameters for assessing human health risks from ingestion of PCB contaminated fish.

- Outputs of the PRAM are abiotic media concentrations from the multimedia environmental model of chemical fate; tissue concentrations from the biotic food web module; and cancer risk and non-cancer hazard estimates for adults and children that are associated with chronic ingestion of representative reef fish.

Section 2 of this document expands upon these descriptions.

### 1.2.3 Rationale for PRAM Development

The PRAM was developed in order to be able to assess the potential risks, to human health and the environment, that could be associated with leaving PCBs of greater than or equal to 50 ppm on decommissioned ships that will be deployed as artificial reefs.

### 1.2.4 Constructing the PRAM

A marine model must consider that there are few, if any, physical boundaries in an ocean environment (e.g., no nearby walls, stream banks, or other barriers). Fate and transport models must address physical processes such as ocean currents, tides, the large volume of water into which chemicals are released; chemical/physical properties such as the solubilities of different chemicals; diffusion limitations; and the capacities of the various media within the marine environment to adsorb or absorb the chemicals.

Eventually, the dissolved chemicals that have not been absorbed into the sediment or other media compartments will be distributed over such a large volume of water that the concentrations will become very low. Thus, for a marine chemical fate and transport model, one must define a relevant exposure zone around the point of release, within which marine organisms may be assumed to be exposed to higher-than-background levels of the chemical. This exposure zone is referred to as a Zone of Influence (ZOI) throughout this report.

*Multimedia Environmental Chemical Fate Module – A Fugacity Approach*
The PRAM multimedia environmental chemical fate module is a fugacity model (Mackay, 2001).

The fugacity model is a compartment model that has the advantage of allowing the user to select or specify the compartments and the reactions within them. Therefore, one is able to use the fugacity model to predict the partitioning of PCBs among abiotic media only, and then use this output (abiotic media concentrations) as input to a separate calculation in the biotic food web module. The underlying assumption in doing so is that the partitioning to biota or biological degradation will not substantially affect abiotic partitioning. This assumption likely increases the predicted concentrations in the abiotic media that are then input to the biotic food web module.

*Biotic Food Web Module*

While the biotic food web module is a de novo construction, it uses well known and accepted equations to estimate biological uptake and bioaccumulation in representative species at four trophic levels within each of three different communities associated with artificial reefs (pelagic community, reef-associated community, and benthic community).

This module required a great deal of information from the literature about:

- the energy budgets of representative marine fish species (i.e. respiration, growth and reproduction, excretion)
- the biological makeup (average adult body weight, fraction of lipid content, fraction of water content, average caloric intake, fraction of metabolizable energy relative to gross energy).
- their diets (e.g., fraction of suspended solids in diet, fraction of phytoplankton in diet, fraction of zooplankton in diet, fraction of sessile filter feeders, and fractions of infaunal and epifaunal benthos in diet, fractions of benthic foragers and reef/vessel foragers in diet).

In many cases, the values of specific parameters, such as diet fraction or respiration rates, were the result of a consensus among members of the TWG.

*Risk Characterization Module*

The equations used in the risk characterization module to estimate human health risk are from the U.S. EPA publication "Risk Assessment Guidance for Superfund" (RAGS, 1989).

Other U.S. EPA guidance documents such as the *Exposure Factors Handbook* (1997) provided input parameters such as the average and upper bound fish ingestion rates for the Gulf States.

### 1.2.5 PRAM Format and User Interface

PRAM was developed with Microsoft Excel™ software, and Visual Basic++™. All of the equations and input parameters used in the model are resident in an Excel database that is supported by a Graphical User Interface (GUI). The database and GUI are bundled in an electronic file, PRAM, Version 1.4c. Electronic copies of the model have been provided to personnel at the U.S. EPA, the State of Florida, and the U.S. Navy.

The GUI of PRAM provides users with many options. The opening screen allows the user to either:

- Run the program (using default values) to estimate PCB concentrations in abiotic and biotic media, and estimate human health risks; or
- View the individual modules that comprise the PRAM, and the various equations, parameters, and values that are used in each of the modules.

The user can change input parameter values such as lipid fraction of a representative organism or mass of PCB source material. Users can reset input parameters to the default values.

### 1.2.6 Empirical Data Used in PRAM

The PRAM relied on data from published scientific literature and three significant sources:

- The December 7, 2004 CACI report, "Final Report, Revision 4, Polychlorinated biphenyls (PCB) Source Term Estimates for ex-ORISKANY (CVA-34)"
- The October, 2004 SSC-SD report, "Draft Final Report: Investigation of Polychlorinated Biphenyl (PCB) Release-Rates from Selected Shipboard Solid Materials Under Laboratory-Simulated Shallow Ocean (Artificial Reef) Environments"
- The June, 2004 Escambia County, FL report, "Escambia County Fish Consumption Survey"

## 1.3 VERSIONS OF THE PRAM MODEL

This document presents the technical details of PRAM 1.4c.

Changes made from PRAM Version 1.3 (July 2004) to Version 1.3c (September 2004) included:

1. Incorporating a child receptor into the risk characterization module.
2. Updating default values, to reflect ex-ORISKANY-specific exposure scenario.
3. Fixing typographical errors in PRAM Version 1.3 modules for solving to non-risk PCB load onboard and risk estimates for range of PCB loads onboard.
4. Reprogramming PRAM to provide additional outputs from the model, including: bioaccumulation factors calculated for each trophic level for each homolog series; feeding rates calculated for each trophic level; and growth rates calculated for each trophic level.
5. Incorporating revised leachate rate data (from SSC-SD, 2004) into the model.
6. Adding a factor to account for metabolizable energy, versus gross energy, of dietary items.

Changes made from PRAM Version 1.3c (September 2004) to Version 1.4c (May 2005) included:

1. Revising fish respiration parameters to reflect marine species.
2. Incorporating gill efficiency correction for PCB uptake rates in fish.
3. Refining algorithms to achieve Level III fugacity, versus using a Level II fugacity approach.
4. Incorporating a pycnocline boundary condition that divides the external water column into two layers (i.e., into upper, epilimnion layer and lower, hypolimnion layer).
5. Revising the biotic-food web module for the lower epilimnion layer and designing a new biotic-food web module for the upper epilimnion layer (Appendix G), per diet-water exposure matrix table developed with TWG.

6. Constructing an interface or macro to receive TDM abiotic media concentration output to estimate biota concentrations in water column (Time Dynamic Model Documentation, January 2006).
7. Incorporating multiple zones of influence according to a negotiated agreement established in the TWG based on feeding behavior, range and habitat of relevant fish species of concern.
8. Modifying the GUI to provide default input values for parameters and to generate output from the model, based on the above structural modifications.
9. Conducting a preliminary quality assurance check, testing, and sensitivity analysis (Appendix K).

## 1.4 PURPOSE OF THE DOCUMENT

The purpose of this document is to provide background and technical information to USEPA, State of Florida, and external reviewers on PRAM Version 1.4c as revised from versions 1.3 and 1.3c in response to comments and resolution of issues by the TWG.

It provides PRAM version 1.4c objectives and background information, and details the scientific basis, model structure, assumptions, input parameters, output, findings of limited testing and sensitivity analysis, and uncertainties/limitations. PRAM Version 1.4c, in conjunction with the Time Dynamic Model (TDM) (NEHC/SSC-SD, 2006) supports both a Human Health Risk Assessment and an Ecologcial Risk Assessment

### 1.4.1 Model Objectives

PRAM Version 1.4c has two objectives:

- Predict human health risks from the fish ingestion pathway of anglers at or near the ex-ORISKANY artificial reef under steady-state (i.e., chronic-exposure) conditions.
- Estimate PCB concentrations in a variety of representative biological species that reside on or near the artificial reef during the first two years post sinking under an assumption of a changing leach rate.

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This section describes PRAM's modules and their governing equations, describes how the model algorithm works, and points out its strengths and limitations. Figure 3 presents the modules.

## 2.1 MODEL CONSTRUCT: BASIC CONCEPT

The PRAM is a compartmental model that spatially and biologically defines an environment into which PCBs are released. Compartmental models consist of interconnected compartments (Figure 4). The arrows represent the PCB exchanges, or fluxes, that occur between the compartments. The initial source of PCBs within the system is from the sunken ship compartment (Compartment 5).

The PRAM is an open system[5] model where some material will leave the modeled environment due to processes such as a current flowing through the water compartments, a current flowing through the air compartment, and possible sediment burial.

The model assumes that each of the compartments:

- is homogeneously mixed
- exchanges chemical substances and energy following thermodynamic processes that can be described mathematically
- has a defined geometry, volume, density, and mass.

PRAM contains 11 categories of abiotic environmental compartments outside the sunken vessel (air, aerosols in air, an upper water column and lower water column separated by a pycnocline, suspended solids in the upper and lower water columns, dissolved organic carbon in the upper and lower water columns, sediment on the ocean floor, sediment pore water, and dissolved organic carbon in pore water).

PRAM has five basic assumptions for the exposure modeling[6] (adapted from Trapp and Matthies 1996):

---

[5] Closed compartmental systems only interact with each other and are analogous to a closed bottle or jar containing a liquid and air space. PRAM is an open compartmental system where, for example, water flows into and out of the modeled environment and is analogous to water flowing through an open trough with its inlet and outlet.

[6] In the context here, exposure modeling refers to the estimation of PCB chemical concentrations in abiotic media to which biota (plants and animals) can be directly exposed.

1. The environmental compartments can be defined to represent phases or mixtures of phases in a thermodynamic sense (a phase is a physical stage of a chemical).
2. Rules and laws of chemical equilibrium and kinetics can be applied to describe PCB movement and/or fate.
3. Feedback of effects due to biota on PCB fate can be neglected.
4. Interactions among the various PCB homolog groups can be neglected, in the context of modeling PCB fate and transport.
5. Each PCB homolog series can be considered as a single phase in each compartment.

As Trapp and Matthies (1996) indicate, these assumptions are not trivial. For example, “sediment” is actually a mixture of minerals, organic components, water, and biota. The simplifying assumption of using a single compartment for sediment in the model represents a general level of resolution. A finer level of resolution could be achieved by adding more compartments within the sediment bed. However the development of PRAM followed the cautions of:

- Trapp and Matthies (1996) that “*The model should only include the considerably important processes. It should also require a minimum of data and be comparable with environmental results;*” and,
- Mackay et al. (1995) that “*To select the appropriate model complexity, it is important to remember not to make the model more complex than the data set available…. Models should not be too complex, because it is then hard to obtain the data needed for calibration and validation.*”

Thus, developing the PRAM required:

- an appropriate balance, or level of resolution, considering the complexity of the real-world environment it attempted to characterize;
- the level of resolution in data that was available and/or obtainable;
- the level of resolution needed in the PRAM outputs.

The goal was to provide decision makers with additional information about the potential exposure conditions and human health risks associated with leaving regulated PCBs on the ex-ORISKANY so they can determine whether the ex-ORISKANY artificial reef would present an unacceptable risk to human health or the environment.

To keep the model minimally complex and more likely to overestimate than underestimate risk, the PRAM was designed as a steady-state model. Steady-state in environmental modeling refers to the state where fluxes among compartments and across boundaries (i.e., between sources and sinks) are balanced, i.e., the concentrations of PCBs in various compartments remain the same as inflows to compartments balance outflows. The assumption of steady-state has a number of mathematical advantages in the context of risk assessments. These include, but are not limited to:

- Within the mathematical algorithms, under an assumption of thermodynamic steady-state, the time-dependent differential terms for the algorithms can be set to zero, resulting in computationally easy solutions.
- A thermodynamic steady-state allows for the incorporation of empiric methods/results to define the highly complex interactions that result in environmental partitioning among various phases within the environment (e.g., it allows the use of empirically-derived partitioning coefficients such as $K_{oc}$, $K_{doc}$, $K_{ow}$, etc.).
- A thermodynamic steady-state represents the long-term overall condition of the system. This condition fits well with evaluations of chronic exposure regimes for potential receptors of concern (e.g., humans and long-lived ecologically relevant predators).

## 2.2 PHYSICAL AND CHEMICAL PROCESSES OF PCBS

Modeling the fate and transport of PCBs requires an understanding of those processes that functionally control or determine fate and transport (Mackay et al. 1995). PRAM considers four physical processes/mechanisms: release, transport, partitioning, and transformation.

### 2.2.1 PCB Release from Shipboard Materials: Normalized Release Rates

This subsection describes the rationale for using a two-year constant release rate in PRAM.

Release in environmental modeling represents the input of PCBs into the environment from bulk product materials within the vessel that contain PCBs. PRAM handles PCB release with an empiric method[7] (Trapp and Matthies, 1996).

The Navy developed a release rate for each PCB homolog leaching from each shipboard PCB containing material by:

- Measuring release rate for various homologs from each material in a laboratory;
- Comparing the time scales of these experiments to human exposure durations;
- Demonstrating a statistical relationship between release rates and time;
- Normalizing the release rates to PCB mass in each shipboard material;
- Selecting a steady state constant rate based on the comparison between the two-year release and predicted release rates over 30 years.

*Laboratory Measurement of PCB Homolog Release Rates*

SSC-SD (2004) provides the results of a laboratory investigation of the release of PCBs from a variety of PCB-containing bulk product materials from decommissioned US Navy vessels. PRAM does not model the mechanisms that control PCB release from these shipboard materials because these processes are very complex. It uses the PCB releases rates for specific shipboard materials. A companion volume (SSC-SD, 2004) provides the PCB homolog release rates, with units of nanogram of PCB homolog per gram of PCB-containing material per day ($ng_{PCB}\cdot g_{material}^{-1}\cdot d^{-1}$).

The experiments used nine PCB-containing bulk product materials, seven of which were collected from ex-US Navy vessels: felt gaskets (2 types – inner and outer gasket material), rubber pipe hanger/liner material, bulkhead insulation, electrical cable, foam rubber material, aluminized paint, and standard samples of Aroclor© 1254, and Aroclor© 1268. Based on the leachate rate of PCBs from a known quantity of each material, the distribution of each homolog[8] series was determined and the release rates were adjusted to reflect release of the homolog series, as a total, on a per gram material per day basis (e.g., $ng_{PCB}\cdot g_{material}^{-1}\cdot d^{-1}$). Additionally, a subset of PCB congener masses per unit mass material per day was calculated (SSC-SD 2004). Initially PCB leached from the shipboard materials on the order of days,

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[7] The empiric method is generally applied for those systems and processes that are too complex or too little understood for a physicochemical mathematical description (modified definition from Trap and Matthies 1996, Mackay et al., 1995).

[8] As PCBs represent a mixture of 209 congeners that exhibit differences in environmental fate and effects, subsequent analysis utilized the grouping of the congeners by homolog series (the number of chlorines within the conger defines the homolog series or grouping, e.g., see Eisler and Belisle, 1996).

with an increase in rate followed by a decrease in rate over a longer period of time (Figure 5).

*Experimental Time Scales and Exposure Durations*

The leachate experiments show a decrease in release over the experimental period of approximately 18 months, which is about 5% of the 30-year chronic exposure period used in the human health risk assessment (NHEC (SHHRA), 2004).

*Demonstrate a Statistical Relationship Between Release Rate and Time*

Integration of the release rates over a 30-year period is not possible using the existing data. To further characterize these data, they were statistically evaluated for the potential development of a functional relationship between homolog-specific release rate and time using regression analysis (Appendix A). This analysis was for only those data that represent detections[9] and was based on the natural log transformed PCB release rate in nanograms of PCB (by homolog) per gram of total PCB (sum total of all homologs) within the material per day (Appendix A). The reported rates from SSC-SD (2004) within the PRAM were normalized, by material, to the observed concentration of PCBs within the material used in the experimentation, before the statistical analysis.

*PCB Normalized Release Rate*

The rationale for the adjustment of units is to account for the potential variation in PCB concentrations within materials collected from a ship being evaluated for disposal and those used in the laboratory measurements. This adjustment assumes that the relationship between release rate and PCB concentration is linear. For example, suppose that one vessel has 1,000 kilograms (kg) of an onboard material containing 100 milligrams (mg) of PCB per kg and the laboratory-observed release rate for this material is 1 nanogram (ng) PCB per gram (g) PCB per day. The total release (flux) from the material would be 100 ng PCB per day ([100 mg PCB/kg material * 1,000 kg material]/1,000 mg PCB/g PCB * 1 ng PCB/g PCB-day). Suppose another vessel, with the same 1,000 kg of onboard material contains a concentration of 50 mg PCB per kg. The total release or flux would be 50 ng PCB per day based on the 1 ng PCB per g PCB per day rate. Thus, by using the normalized release rates, variable material concentrations can be addressed.

The release rate regression format would be as follows, assuming exponential decay:

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9 As the objective of the statistical evaluation was to establish a functional relationship, it was believed appropriate to rely solely on detected and quantified values and not use surrogate values for non-detect samples that may skew or bias the statistical analysis.

(1) $$release\left[\frac{ngPCB}{gPCB}\right] = e^{a+b\cdot\ln(time)}$$

where:
release = PCB homolog series mass release per unit time
a = the intercept of the regression
b = the exponential slope of the regression
ln(time) = natural log of time

The decrease in release, based on those SSC-SD experimental data sets that could be regressed, is highly significant over a 30-year period. For example, the release rate of pentachlorobiphenyl from bulkhead insulation material peaks at 73 days after immersion into seawater. However, at 1 year the PCB release rate is predicted (based on the regression analysis) to be 37% of the peak rate; at 5 years to be 14% of the peak rate; and at 15 years and 30 years to be 7% and 4%, respectively, of the peak rate.

Not all of the leachate rate data sets (homolog series and material) revealed a statistically significant regression; some data sets contained only one or two detections for the homolog series while others contained only non-detects for the PCB homolog series.

*Selecting a Steady State Constant Release Rate*

Incorporating decay in the PCB release rate from the vessel is problematic because PRAM is designed as a steady-state model. Modification to a non-steady state scheme to account for these release patterns was also considered problematic because:

- The existing data are insufficient to establish decay curves for all of the homolog series within the various PCB-containing shipboard materials.
- The approach would complicate the model; that is, other empiric approaches, for example, partitioning of the released PCBs into sediment, would no longer be appropriate.
- The resultant exposure levels would need to be integrated over time to calculate a reasonable maximum exposure level for human health risk calculations.

Therefore, PRAM uses a constant release rate that probably overestimates release over a 30-year exposure period. The model assumes that the colonization of an artificial reef will take two years. Additionally, the maximum bioaccumulation of PCBs, via the food web, into top sports fish taken for human consumption from the reef can require as much or more than two years time for the heavier homolog groups. Therefore, PRAM uses a two-year release rate for modeling a steady-state condition. This rate is higher than the predicted release rate over the 30-year exposure period assumed for risk characterization. For example, the predicted two-year release rate for pentachlorobiphenyl from bulkhead insulation material is 5 times the predicted 30-year release rate. Therefore, the two-year release rate probably overestimates PCB release during a 30-year period.

When there were only one or two detections within the release rate data set (as obtained from SSC-SD 2004) or where the statistical analysis failed to produce a significant regression, the maximum reported rate was used in the PRAM. This approach decreases the probability of underestimating the exposure levels to humans and relevant ecological receptors of concern.

Table 1 shows the material-specific PCB homolog release rates incorporated into the PRAM.

### 2.2.2 Physical Transport Mechanisms

Diffusion, dispersion, and advection are the three physical forcing functions[10] within the PRAM. These three mechanisms drive the transport of PCBs within the modeled environment and are applied to the released PCBs within and outside the sunken vessel.

#### 2.2.2.1 Diffusion

The molecules of a solute are in a state of continuous motion due to their kinetic energy. This motion, also called the Brownian motion, moves mass from regions of higher concentration (more molecules) to regions of lower concentration (less molecules). This gradual mixing or transport that occurs even in the absence of the bulk movement (advection) of fluid is called molecular diffusion. PCB molecules will show a net flux from places of higher concentrations to lower concentrations via molecular diffusion (e.g., see Trapp and Matthies, 1996). In one direction, diffusional flux is dependant on the area the flux is occurring across, the thickness of the layer it is occurring across, and the

[10] Forcing functions are variables of an external nature that affect the state of the system (abbreviated definition from Mackay et al., 1995).

concentration gradient (e.g., Trapp and Matthies, 1996; USEPA, 1982). The driving force for diffusion is the concentration gradient.

Diffusion is mathematically described by Fick's First Law, which assumes, (1) the medium within which it occurs and the direction in which it occurs remain constant, (2) the flux is perpendicular to the cross-sectional area of the boundary, and (3) the concentration gradient is constant (e.g., Trapp and Matthies, 1996; USEPA, 1982). Mathematically, molecular diffusion in one direction can be described as follows:

$$(2)\quad N_{diff\left[\frac{mol}{d}\right]} = A\left[m^2\right] \times \left( \frac{D\left[\frac{m^2}{d}\right]}{\Delta[m]} \times \left( C_2\left[\frac{mol}{m^3}\right] - C_1\left[\frac{mol}{m^3}\right] \right) \right)$$

where:
$N$ = net substance flux due to diffusion ($mol \cdot d^{-1}$)
A = the surface area
D = the diffusion coefficient
$C_2 - C_1$ = the concentration gradient
$\Delta$ = the "thickness" of the diffusion gradient

In reality, diffusion occurs in three directions simultaneously. Diffusion in the context of PCB transport within the environment is very slow compared to dispersion and advection. According to Lyman (1995), if advective water flow (i.e., current) is greater than $2 \times 10^{-3}$ $cm \cdot s^{-1}$ ($4 \times 10^{-5}$ knots), molecular diffusion can probably be ignored.

The importance of molecular diffusion within PRAM concerns "resistance" across media boundaries such as a pycnocline, surface water, and air interface, or the sediment bed – surface water interface (e.g., see Mackay et al., 1985; Mackay and Paterson, 1991; Trapp and Matthies, 1996). For this one-dimensional flux scenario Equation 2 (above) is appropriate. The quotient between the diffusion coefficient and diffusion length is termed "conductance" ($m \cdot d^{-1}$), a measure of the exchange velocity and termed the "transport parameter" for exchange of PCBs across a boundary. The inverse of conductance is resistance, which can impede the partitioning of PCBs to sediments, for example, within a steady-state modeling scheme such as that used for the PRAM. This potential impedance is why diffusion is considered a relevant and important forcing function within the PRAM.

The area, concentration gradient, and thickness of the boundary are model variables within the PRAM whereas the diffusion coefficient is a chemical parameter. Mackay and Paterson (1991) present a single diffusion coefficient for hexa-CBs in water (4 x $10^{-4}$ $m^2 \cdot hr^{-1}$), which was not considered appropriate as the PRAM attempts to model all ten PCB homolog series that differ among themselves regarding physicochemical properties, such as diffusion coefficients. Diffusion coefficients are proportional to temperature and inversely proportional to molar volume, which is related to the square root of the chemical molar mass (e.g., see USEPA, 1982; Trapp and Matthies, 1996), such that:

(3) $$D_i / D_j = \frac{\sqrt{M_j}}{\sqrt{M_i}}$$

where:
$D_i$ / $D_j$ = the ratio between the diffusion coefficients for chemicals *i* and *j*
$M_i$ and $M_j$ = molar mass ($g \cdot mol^{-1}$) for chemicals *i* and *j*, respectively

This relationship leads to an estimation method that is functional for PCB homolog series. Using oxygen as a reference chemical, the diffusion coefficient in water, based on the mean molecular mass for each series, is estimated as follows (Baumgarten et al., 1996, USEPA, 1982):

(4) $$D_{PCB-series} = 1.728 \times 10^{-4} \times \sqrt{\frac{32}{M_{PCB-series}}}$$

and for air (using steam as the reference chemical) is estimated as follows:

(5) $$D_{PCB-series} = 2.22 \times \sqrt{\frac{18}{M_{PCB-series}}}$$

#### 2.2.2.2 Dispersion

Molecular diffusion, in this context, occurs in perfectly quiescent media (water, air, sediment), which is rare in the environment. Turbulence occurs in open surface waters due to currents, in sediment beds via bioturbation by sediment-associated organisms and sheer stress from overlying water currents. Turbulent diffusion is the dominant forcing function in actual situations. Random turbulence (random physical movement in one or all directions) in the environment increases the apparent diffusion across physical boundaries such as those in the PRAM. Molecular diffusion, when supplemented by turbulence, is termed dispersion[11] (see Trapp and Matthies, 1996; USEPA, 1982). In effect, the additional physical movement to that of molecular diffusion leads into a greater velocity for the equilibration of chemical concentrations in space (i.e., increases the exchange velocity and thus impacts the transport parameter for exchange of PCBs across a physical boundary).

The physical movement component of dispersion differs from molecular diffusion; it almost always acts as a directional component associated with boundaries – for example, the water flow direction over a sediment bed where the turbulence is a consequence of the water current direction. Again, what is relevant for the PRAM is the exchange velocity of PCBs across the model boundaries where the velocities of media parallel to these boundaries (water-air, pycnocline, surface water-sediment bed) are much higher than the perpendicular exchange velocities across the boundary. In one dimension, dispersion can be described by the same equation (Equation 6) as that for molecular diffusion where:

$$(6)\quad N_{disp} = A\left[m^2\right] \times \left( \frac{D\left[\frac{m^2}{d}\right]}{\Delta[m]} \times \left( C_2\left[\frac{mol}{m^3}\right] - C_1\left[\frac{mol}{m^3}\right] \right) \right)$$

where:

$N_{disp}$ = net substance flux due to dispersion ($mol \cdot d^{-1}$)

A = the surface area

D = the dispersion coefficient

$C_2 - C_1$ = the concentration gradient

Δ = the “thickness” of the boundary or diffusion gradient

However, D in Equation 6 is a dispersion coefficient, which is the sum of the diffusion coefficient as described in the previous Diffusion subsection (Section 2.2.2.1), and dispersion ($m^2 \cdot d^{-1}$) due to turbulence, which within the PRAM is a function of environmental setting and derived from empiric estimation techniques.

[11] In meteorology the term “eddy diffusion” is used.

#### 2.2.2.3 Advection

By flowing movement of media such as water and/or air, PCBs contained within the media will be co-transported. This process is generally called advection (see Trapp and Matthies, 1996; Mackay et al., 1995; USEPA, 1982). Because volume and mass are conserved within each compartment of the PRAM, inputs of media (e.g., water) into a compartment must be balanced with output from the compartment either into another compartment or out of the model boundaries. The major advective flows within the PRAM include water current and air current. These currents are considered as overall averages since the PRAM is designed as a chronic exposure, steady-state model. Similarly, as long-term averages, these currents are considered to be unidirectional. Current within the sunken vessel is estimated based on the prevailing current within the surrounding water column, as a fraction of that current (e.g., 1%). Sunken vessels are known to "breathe" where water flows in and out of the open conduits. However, the PRAM assumes that, on average, there is a net advective flux of the PCBs from the interior of the vessel that is a consequence of the prevailing current exterior to the vessel.

The advection processes explicitly included in the PRAM are:

- Water currents that carry dissolved PCBs as well as PCBs absorbed onto suspended solids and PCBs bound to dissolved organic carbon within the water column.
- Air currents (wind) that carry PCBs that have volatilized into the air column above the surface of the water.
- Wet and dry PCB deposits from the air column.

The advection processes for particulate deposition from the water column onto the sediment bed and resuspension from the sediment into the water column are implicitly included in the PRAM (i.e., processes included within the model algorithms), but assumed to be balanced (where input and output of PCBs is equal or net flux equals zero). This assumption results in no burial or sequestration of PCBs within the sediment bed, which probably overestimates exposure.

### 2.2.3 Partitioning Coefficients

Within each of the PRAM compartments are phases, which refer to the ability of the material to mix with another (e.g., since water and oil do not mix completely, each is considered a "phase"). At a thermodynamic steady-state, PCBs will exhibit predictable relative concentrations between phases or media. Given an adequate amount of time, the relative concentrations in water and organic carbon, for example, will reveal a constant ratio, regardless of the relative concentrations of PCBs in that water and organic carbon. The physicochemical processes associated with the phenomena are highly complex. As discussed above, the complexity of these partitioning processes is part of the rationale for the use of a steady-state model. These values have been measured and derived by numerous authors using various methods within the scientific literature. These partitioning coefficients have many sources, so a process was developed to select or derive the coefficients that are incorporated into the PRAM. Three partitioning coefficients are used within the PRAM, the octanol-to- water partitioning coefficient ($K_{ow}$), the water-to-particulate organic carbon partitioning coefficient ($K_{oc}$), and the water-to-dissolved organic carbon partitioning coefficient ($K_{doc}$). The following scheme was used to select or derive the coefficients that are incorporated into the PRAM:

- Measured values as reported in reputable (peer-reviewed) documents from regulatory agencies (i.e., USEPA, US Fish and Wildlife, Agency for Toxic Substances and Disease Registry [ATSDR], and scientific journals) were preferred,
- Empirically validated estimation methods obtained from reputable (peer-reviewed) documents from regulatory agencies were used when no measured values were obtained,
- Quantitative structure activity relationship (QSAR) estimation methods as described by reputable and/or regulatory agencies were used when no measured values or empirically validated estimation methods were obtained.

This approach is consistent with the approach used in USEPA's *Draft Dioxin Reassessment Documents* (USEPA, 2003). This reassessment included evaluation of dioxin-like compounds, which included PCB congeners. USEPA developed a ranking system to evaluate the degree of confidence in reported values of physical parameters (including partitioning coefficients) used in the reassessment. A property value with a ranking of one is considered to have the highest level of confidence. These ranks continue down to a ranking of five, which is the lowest level of confidence. The ranking scheme is based on the premise that measured values are more definitive than estimated values. USEPA specifically indicates that ranking five includes values derived by QSAR methods.

The octanol-to-water partitioning coefficients ($K_{ow}$) used within the PRAM are derived from the congener values presented within Eisler and Belisle (1996). Eisler and Belisle (1996) present the most complete set for PCBs based on a comprehensive review of data in the peer-reviewed scientific literature. The congener values were subjected to statistical analysis to derive a mean value to represent each homolog group (Appendix B). Too few data are available for formal statistical analysis of the $K_{ow}$ values for mono-CBs (3 values), nona-CBs (3 values), and deca-CB (single value). For both the mono-CB and nona-CB series, a simple average of the values presented by Eisler and Belisle (1996) was used. Deca-CB is represented by the value reported by Eisler and Belisle (1996). Table 2 shows the derived homolog-specific $K_{ow}$s used in the PRAM.

The $K_{oc}$ values used in the PRAM were derived in two ways. For the mono-CB through hexa-CB homolog series, $K_{oc}$ measurements existed in the literature for congeners in these homolog series from which to calculate a $K_{oc}$ value to use in the PRAM. For the PRAM, we select the $K_{oc}$ values from Chou and Griffin (1986)[12] to calculate the representative $K_{oc}$ values for each of these homolog groups. The $K_{oc}$ values used for these homolog groups correspond to the geometric mean of the $K_{oc}$ values measured for the individual congeners within a homologous series. Insufficient measurements of $K_{oc}$ were found in the literature to allow determination of representative values for $K_{oc}$ for the hepta- octa-CB, nona-CB and deca-CB homologous series. Therefore, a QSAR approach was taken to estimating these values. Equation 7 from Lyman (1995) estimates $K_{oc}$ .

$$(7)\quad \log_{10} K_{oc} = 0.779 \times \log_{10} K_{ow} + 0.46$$

The values for $K_{ow}$ used in this calculation of $K_{oc}$ for the hepta-, octa-, nona-, and deca-CBs are the geometric means of the $K_{ow}$ values for all congeners within a given homologous series reported by Eisler and Belisle (1996) and are included on Table 2.

Partitioning of PCBs to dissolved organic carbon ($K_{doc}$) in water was related to the $K_{ow}$ of the chemical by USEPA (2002). USEPA reported a ratio between $K_{doc}$ and $K_{ow}$ of 0.074, which

is used to derive the $K_{doc}$ for use in the PRAM. These derived $K_{doc}$ values are presented in Table 2.
Note: Kow listed for PCB-126 in Appendix B (6.897) is slightly higher than Kow used in PRAM for pentachlorobiphenyls (6.4951). We mention this because the ERA analysis of dioxin-like congeners assumes that PCB-126 behaves like its homolog group (i.e. pentachlorobiphenyls).

### 2.2.4 Transformation

PCBs, as xenobiotics, may be subject to certain enzymatically-mediated biotransformation processes to form metabolites, which may be different in physicochemical properties from the parent compounds (Kleinow and Goodrich, 1993).

Transformations of PCBs depend on the degree of chlorination; the more chlorinated forms are much more resistant to transformations than the lesser-chlorinated forms (Safe, 1990)[13]. Photolysis can occur for some forms in air and/or water, e.g., sunlight may react directly with many organic contaminants and dissolved organic carbon to produce photoreactant intermediates (Cooper, 1989). For PCBs, the importance of this transformation (dechlorination) is not suggested to be overly important in the context of PCB fate and transport mechanisms (ATSDR, 2000). Similarly hydrolysis and oxidation appear to be insignificant processes for PCB fate and transport (ATSDR, 2000).

PCB transformations mediated though biological processes (bio-degradation) are cited as the most important processes for PCB fate and transport in the environment (ATSDR, 2000). Table 3 presents a sampling of the reported biodegradation rates from the peer-reviewed scientific literature. Biodegradation rates for PCBs are highly variable among the congeners due to the degree of chlorination and structural characteristics of the PCB molecule. Variable biodegradation rates for the same congener are also expressed in the scientific literature, which has been linked to microbial pre-exposure to PCBs or other PCB-like compounds, bioavailability, microbial exposure concentrations, temperature, available nutrients, and the presence of inhibitory compounds (ATSDR, 2000).

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[12] These data are reproduced in Appendix B.
[13] Safe (1990) showed that 2,4,5,2',4',5'-hexachlorinated biphenyl is recalcitrant to metabolism and very persistent in the environment. While with only 2 chlorines less than this compound, 3,4,3'4'-tetrachlorinated biphenyl is metabolized and less persistent in the environment. The net effect is that with time, both in the environment and in organisms, the predominant PCB congeners available for and contributed to bioaccumulation are those which resist degradation/transformation.

While biodegradation may be an important process for PCB fate and transport in the environment, this importance is limited to lesser-chlorinated forms and difficult to predict for any specific environmental setting such as that of an artificial reef. Therefore, within the PRAM, biodegradation is recognized and the model provides for rate inputs for each homolog series. The default condition of no biodegradation (or other transformation) is assumed to assure that the final exposure levels within the environment are not under-estimated.

## 2.3 ABIOTIC MODEL SELECTION OF PCB FATE AND TRANSPORT

This subsection describes the fugacity approach, the four levels of fugacity modeling, and the reasons for using fugacity level III in PRAM.

The Navy selected fugacity modeling for PRAM because it offers a steady state solution, is widely accepted in multimedia applications (Cowan et al., 1995), and there is regulatory precedent for its application. Level III Fugacity models are used by:

- California Environmental Protection Agency (Cal/EPA) to assist in assessing contaminated sites within the state (CalTOX, UC-Davis [UCD] and Lawrence Livermore National Laboratory [LLNL], 1994; McKone et al., 1997);
- USEPA in developing the ambient water criteria for the Great Lakes Water Quality Initiative (USEPA, 1995; Gobas, 1993);
- Health Canada to assist in evaluating regional pollutant issues within Canada;
- European Union Member States (European Centre for Ecotoxicology and Toxicology of Chemicals [ECETOC], 1994) for examining and evaluating pollutant risks.

What follows is a general description of the various fugacity modeling "levels" and the specific structure of the PRAM fugacity module that is based on the Level III fugacity construct.[14]

### 2.3.1 The Fugacity Multimedia Approach

Fugacity ($f$) is the "escaping tendency" of a chemical from a particular phase (Mackay and Paterson, 1981) with units of pressure (Pascals [Pa]). This fugacity can be related to the

[14] Version 1.3 of the PRAM used a level II fugacity modeling approach, while Version 1.4c of PRAM uses a level III fugacity modeling approach.

phase (e.g. environmental media) physically as the partial pressure or “escaping” potential exerted by a chemical in one compartment (physical phase such as water, sediment, air) on another. When a chemical is at equilibrium between two phases, the escaping tendency or “fugacity,” of the chemical is the same for the two phases.

There are four levels of fugacity modeling:

- Level I – a closed system at equilibrium (common fugacity) and at thermodynamic steady-state, with no chemical reactions.
- Level II – an open system at equilibrium (common fugacity), and at thermodynamic steady-state, with chemical reactions.
- Level III – an open system not at equilibrium (no common fugacity, except within compartments) while at thermodynamic steady-state, with chemical reactions.
- Level IV – an open system not at equilibrium (no common fugacity, except within compartments) and not at thermodynamic steady-state, with chemical reactions.

#### 2.3.1.1 Level I Fugacity Model

This subsection discusses Fugacity Level I because it illustrates the basic underpinnings of the fugacity concept and escaping tendency. However, it is not adequate for modeling PCBs being released from a sunken vessel because: (1) the sunken vessel is an open system, (2) no common fugacity occurs within the system except within compartments, and (3) chemical reactions may occur within the compartment (such as dechlorination/degradation).

Level I fugacity model is akin to a closed jar containing chemical and media (e.g., water, sediment, air). No inputs or outputs occur within the system aside from the starting conditions. A Level I fugacity model predicts the distribution of the chemical within these media at equilibrium, under steady-state conditions. This model, when used for a system that has only two media or phases (such as organic carbon and water), will result in a partition coefficient that is equal to the $K_{oc}$ as described previously, albeit derived differently. Using the fugacity concept and a common fugacity (*f*), which assumes equilibrium, this situation can be expressed mathematically as:

$$\frac{C_i}{C_j} = \frac{fZ_i}{fZ_j} = \frac{Z_i}{Z_j} = K_{ij}$$

Where C is the concentration of the chemical (mol·m$^{-3}$) in phase *i* or *j*, *f* is the common fugacity (Pa), Z is the fugacity "capacity" of phase *i* or *j*, with units of (mols ·m$^{-3}$· Pa$^{-1}$), and $K_{ij}$ equals the partitioning coefficient for the chemical and the respective phases of *i* and *j*. (see also Equation 17). Using fugacity capacities, the partitioning of multiple phases within the system is highly simplified. Consider, for example (per Mackay and Paterson, 1981), a 10-phase system in which potentially 90 partitioning coefficients may be defined independently (e.g., $K_{oc}$). As the ratios of the fugacity capacities are equivalent to the partition coefficients, the solution can be obtained with far greater ease. The dissection of equilibrium constants into individual fugacity capacities is a convenient method that facilitates calculation of a chemical's quantities via partitioning within variable multi-media systems regardless of whether it is a closed or open system.

The fugacity capacity for vapors, as discussed by Mackay and Paterson (1981), assuming standard atmospheric pressure, can be related back to the partial pressure and the ideal gas law. Thus, Z for air is represented as:

(8) $$Z_{air} = 1/(R \times T)$$

where:
R = Universal Gas Constant (8.31 Joules·mol$^{-1}$·°K$^{-1}$)
T = temperature (°K)

Particulate matter within the air column are considered to be aerosols (per Mackay and Paterson, 1991) with a fugacity capacity of:

(9) $$Z_{aerosols} = 6 \times 10^6 / (VP \times R \times T)$$

where:
VP = liquid vapor pressure (Pa)
R = Universal Gas Constant (8.31 Joules·mol$^{-1}$·°K$^{-1}$)
T = temperature (°K)

$6 \times 10^6$ = a constant as derived by Mackay and Paterson (1991) (Pa)

In PRAM, vapor pressures for individual PCB congeners were obtained from Fiedler, 2001; Oberg, 2001; and the ATSDR Toxicological Profile for PCBs, 2000. Where possible (i.e., sufficient number of values) statistical analysis was performed to derive a homolog-specific vapor pressure (Appendix C). The homolog vapor pressures used in the PRAM are presented in Table 2.

The fugacity capacity for water (as a pure phase), assuming a non-ionizable molecule (like PCBs), and invoking "infinite dilution" (see Mackay and Paterson, 1981), reduces to the reciprocal of the chemical's Henry's Law Constant (Pa · $m^3 \cdot mol^{-1}$).

(10) $$Z_{water} = {}^{1}\!/_{H}$$

Freshwater solubility is necessary to estimate the Henry's Law Constant per Mackay and Paterson (1981, 1991). Solubility of PCBs in freshwater were obtained from Chou and Griffin (1986). When solubility data were unavailable, the following estimation method presented by Lyman (1995) was used:

(11) $$\log S\left[\frac{mol}{L}\right] = -1.16 \times \log K_{OW} + 0.79$$

This equation was used to estimate the water solubility of octa-CB, nona-CB, and deca-CB. The solubility values used within the PRAM are presented in Table 2.

The vapor pressures and solubilities for the respective PCB homolog series were used to estimate the Henry's Law Constant (H) per equation 21 within Lyman (1995):

(12) $$H\left[\frac{Pa \cdot m^3}{mol}\right] = \frac{VP[Pa]}{S\left[\frac{mol}{m^3}\right]}$$

The Henry's Law Constant values for each PCB homolog series as used within the PRAM are presented in Table 2.

As pointed out above, partitioning coefficients can be related to the ratio of chemical fugacity capacities (for sorbed phases such as sediment, total suspended solids), and dissolved organic carbon (Mackay and Paterson, 1981, 1991):

(13) $$Z_{TSS} = \frac{(K_{oc} \times f_{oc-TSS}) \times \rho_{TSS}}{H}$$

(14) $$Z_{\text{sediment}} = \frac{(K_{oc} \times f_{\text{oc-sediment}}) \times \rho_{\text{sediment}}}{H}$$

(15) $$Z_{DOC} = \frac{K_{DOC} \times \rho_{DOC}}{H}$$

where:
TSS = total suspended solids
DOC = dissolved organic carbon
H = Henry's Constant (Pa $\cdot m^3 \cdot mol^{-1}$)
$K_{oc}$ = the organic carbon to water partitioning coefficient for PCBs (L$\cdot kg^{-1}$-oc)
$K_{DOC}$ = the dissolved organic carbon to water partitioning coefficient for PCBs (L$\cdot kg^{-1}$-DOC)
$f_{\text{oc-TSS}}$ or sediment = the fraction of organic carbon within the suspended solids or sediment (unitness)
$\rho_{\text{media}}$ (TSS, sediment, or DOC) = bulk density of the media (g$\cdot cm^{-3}$)

Using these fugacity capacities, partitioning within a system containing air, water, sediment, total suspended solids, and dissolved organic carbon can be predicted with a minimal amount of data requirements. This partitioning is relative in concentration such that volumes and mass are required to solve for absolute concentrations, which is derived from the total mass of chemical present and a common fugacity where:

(16) $$f = \frac{M_T}{\sum Z_i V_i}$$

Where $f$ is the common fugacity (equilibrium), $M_T$ is the total mass (mols) introduced into the closed system, $Z_i$ is the fugacity capacity for system phase or compartment $i$, and $V_i$ is the volume of the phase in $m^3$. The relationship between fugacity, fugacity capacity and chemical concentration, C [$mols \cdot m^{-3}$], is defined by:

(17) $C = Zf$

#### 2.3.1.2 Level II Fugacity Model

This subsection discusses Fugacity Level II because PRAM version 1.3 used it. However, reviewers criticized this level for its lack of refinement and the possible underestimation of water concentration and overestimation of other phase concentrations (e.g., sediment, DOC, and air).

Very few closed systems exist in the environment whereby there are no exchanges with the outside of the model construct (outside of the model boundaries). Level II fugacity models, like Level I models, assume system equilibrium and steady conditions. However, they are used to represent “open” systems where inputs to and outputs from the system compartments are included. This type of system has a chemical input into the system (e.g., emission or release), which is balanced by the system media trapping the chemical, reactive losses, and chemical output from the system. Thus, all of the inputs to and losses from the system are balanced (steady-state) as well as exchanges between the compartments (equilibrium). The Level II model is simplistic because it assumes a common fugacity (equilibrium) such that the exchanges between the compartments (e.g., water and sediment) are not subject to any transfer resistances. The advantage of this system is limited data requirements and a simple algebraic solution. The driving forces within such a system are limited to fate and transport between compartments, i.e., advection and chemical reactions in the sunken vessel environment. Advection in and out of the system compartments can be introduced into the Level II model as a first-order constant; as advective flow with units of $m^3 \cdot d^{-1}$ divided by the phase volume, e.g., water (V in $m^3$) with resultant units of $d^{-1}$. Additionally, other rate constants for reactive processes such as dechlorination/degradation can be included. By assuming equilibrium among compartment (phases) and steady-state conditions where input, output, and transfers among phases are balanced, a common fugacity can be calculated based on emission ($mol \cdot d^{-1}$) into the system (Mackay and Paterson, 1981):

(18) $$f = \frac{N}{\sum V_i Z_i K_i}$$

Where, as in the Level I fugacity model, *f* is the common fugacity, N is the mass emission (mols·d$^{-1}$) introduced into the system, Z is the fugacity capacity for the system phase or compartment *i*, $V_i$ is the volume of the phase in m$^3$, and $K_i$ is the advection and any additional first-order reactive rate constant occurring within the respective phase or compartment.

This equation can be rewritten to explicitly describe rates and transport using a D value to more explicitly represent transport mechanisms (Mackay and Paterson, 1991; Mackay et al., 1995):

$$(19) \quad N = f\left(\sum D_{Ai} + \sum D_{Ri}\right)$$

Here $\Sigma D_A$ is the sum of all advective processes and $\Sigma D_R$ is the sum of all reaction processes. Although this model can be used to simulate the release of PCBs from a sunken vessel, without accounting for the potential resistances associated with media transfers from water, the water concentration may be under-estimated while other phase concentrations (e.g., sediment, DOC, and air) may be over-estimated. Because of this and USEPA review comments on PRAM Version 1.3, the Level II modeling approach was not considered to be sufficiently refined. Therefore, PRAM Version 1.4c was developed based on the Level III fugacity modeling approach (PRAM Version 1.3 used a Level II fugacity modeling approach, e.g., see Goodrich et al., 2003).

#### 2.3.1.3 Level III Fugacity Model

PRAM version 1.4c uses a Level III fugacity model because:

- Unlike the Level II model, the Level III model does not assume equilibrium (a common fugacity) between the phases or compartments within the system;
- Transfer resistances control the exchange between the compartments within the system
- The model considers advection, reactive processes, and diffusion/dispersive processes;
- It is more refined for environmental modeling as true equilibrium among phases is considered rare within the real world and diffusive resistance can affect intermedia transfers at the respective boundaries.

Intermedia mass transfers can occur through advective processes and diffusive processes in Level III modeling. PCB transfers can be expressed as $D_{ij}f$ where the diffusivity $D_{ij}$ term includes those processes affecting diffusion, including resistance and *f* is the compartmental fugacity (see Mackay et al., 1985; Mackay and Paterson, 1991). The nomenclature for the D (transport) term within the Level III, as used here, is represented by $D_A$ and $D_R$, which are advective and reactive transport terms, respectively, while $D_{ij}$ refers to *total* (advective and diffusive) transport terms between media (phases and/or compartments) within the system. By invoking system steady-state conditions, a mass balance using the fugacity approach can be illustrated for each system compartment where inputs are balanced by outputs. This approach results in no net gain or loss of the chemical within the system, despite varied exchanges or non-common fugacities or "escape tendencies" between compartments (common fugacities are assumed to occur within individual compartments). This approach is represented by the following equation for delineating the transport mechanism in terms of mass emission, N [$mol \cdot d^{-1}$], across the entire system (see Mackay, 1985; Mackay and Paterson, 1991):

(20) $$N - f_i\left(\sum_j D_{ij} + D_{Ai} + D_{Ri}\right) + \sum_j \left(D_{ji} f_j\right) = 0$$

where:
*i* = compartment or phase *i*
$f_i$ = the fugacity of phase / compartment *i*
$f_j$ = the fugacity of phase / compartment *j*
$D_{ji}$ = the transport coefficient(s) from compartment *j* into compartment *i*

The foregoing equation is easily rearranged to solve for the compartmental fugacity ($f_i$):

(21) $$f_i = \frac{N + \sum_j \left(D_{ji} f_j\right)}{\sum_j \left(D_{ij} + D_{Ai} + D_{Ri}\right)}$$

Compartmental concentrations can then be calculated using the compartmental fugacity and Z value for the media just as previously described for the Level II model. Figure 6 shows the transport terms, which include diffusive transport, for the PRAM system coupled to the exchanges they represent.

#### 2.3.1.4 Model IV Fugacity Model

A Level IV fugacity model is a true dynamic model in that both space and time are modeled dynamically. The model system is not considered to be at equilibrium. Nor is it considered to be at steady-state. The exchanges are not assumed to balance because fluxes to and from compartments are not balanced. This is reflected in the fugacity equation where:

$$N - f_i\left(\Sigma j\left(D_{ij} + D_{Ai} + D_{Ri}\right)\right) + \Sigma j\left(D_{ji} f_j\right) \neq 0$$

(22) and as such :

$$V_i Z_i \frac{\partial f}{\partial t} = N^t - f_i\left(\Sigma j\left(D_{ij} + D_{Ai} + D_{Ri}\right)\right) + \Sigma j\left(D_{ji} f_j\right)$$

where $t$ = time

Solutions for the fugacity terms within Level IV cannot be made through simple algebra as for model Levels I, II, and III. The Level IV fugacity model requires significantly more data inputs than any of the preceding structures to describe fluxes within the system. While empiric equilibrium constants such as organic carbon partitioning coefficients ($K_{oc}$s) are functional in lower levels of fugacity modeling, time specific rates of for such processes are required for this model (e.g., rate of absorption and desorption). The Level IV model is mathematically and data intensive but does not appear to significantly differ from Level III in the model's ability to account for pollutant inventories (Hertwich, 2001). Further, in a direct comparison between a steady-state Level III and non-steady-state Level IV fugacity modeling approach, Hertwich (2001) concluded the important properties such as a dose, persistence and spatial distribution can be equally derived from the Level III as with the Level IV model. Based on such information, the additional data requirements, and the desire to, as stated by many (e.g., Trapp and Matthies, 1996; Mackay et al., 1995; and others) minimize model development complexity to assure confidence in data inputs and future validation, the Level IV model was not considered the most appropriate for the PRAM.

### 2.3.2 PRAM Level III Fugacity Model and Algorithms

In the PRAM Level III fugacity construct, PCB exchange occurs among five compartments (Figure 6):

- An air body bounded vertically by the atmosphere to water surface and laterally by a user input value[15]
- A water body above the pycnocline bounded by the water surface and laterally by a user input value
- A water compartment within the vessel interior
- A water compartment outside of the vessel bounded by a respective lateral user input value and vertically by the pycnocline,[16]
- A sediment bed bounded in depth and laterally by a user input value

PRAM treats these five compartments as bulk compartments within which there are sub-compartments of particles, water, and dissolved organic carbon, as appropriate (Section 2.1). These compartments are treated as bulk phases (e.g., see Mackay and Paterson, 1991), and as such, the fugacity capacity (Z value) of each phase is weighted by the fractional portion of the sub-compartments. For example, compartment 2 (upper water column) consists of water, suspended particles, and dissolved organic carbon. The fugacity capacity for the upper water column as a bulk phase is represented by the following equation:

$$(23) \quad Z_2 = \phi Z_{\text{water}} + \phi Z_{\text{suspended - sediment}} + \phi Z_{\text{dissolved organic carbon}}$$

Where $\phi$ is the volume fraction of the specific media within compartment 2 (the upper water column) and the Z is the respective fugacity capacity for the media listed.

A nomenclature using the compartment numbers can be used to simplify the description of this weighting process where the first subscript for the Z value represents the compartment and the second represents the media within that compartment[17] (A = air, W = water, SS = suspended particles, AE = aerosols, SD = sediment, and DOC = dissolved organic carbon).

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[15] This lateral input value defines the lateral "zone of influence or ZOI" for the artificial reef created by the sunken vessel.

[16] Per the November 17/18, 2004 TWG meeting, EPA recommended pycnocline to be used as the vertical boundary.

[17] Not all media listed are present in all compartments, e.g., no air is present in the sediment bed, etc.

Air Compartment

(24) $Z_1 = \phi_{1A} Z_A + \phi_{1AE} Z_{AE}$

Upper Water Column Compartment

(25) $Z_2 = \phi_{2W} Z_W + \phi_{2SS} Z_{SS} + \phi_{2DOC} Z_{DOC}$

Lower Water Column Compartment

(26) $Z_3 = \phi_{3W} Z_W + \phi_{3SS} Z_{SS} + \phi_{3DOC} Z_{DOC}$

Sediment Bed Compartment

(27) $Z_4 = \phi_{4SD} Z_{SD} + \phi_{4W} Z_W + \phi_{4DOC} Z_{DOC}$

Sunken Vessel Interior Compartment

(28) $Z_5 = \phi_{5W} Z_W + \phi_{5SS} Z_{SS} + \phi_{5DOC} Z_{DOC}$

Transfers of PCBs can occur between these compartments and through these compartments to the outside of the system (Level III fugacity model is an open system). Additionally, the sub-compartments can also carry PCBs into adjacent compartments via advection. Table 4 and Figure 6 show the mass transfers or exchanges of PCBs considered relevant for the PRAM.

#### 2.3.2.1 Non-Diffusive Transport Within the PRAM

The compartmental exchanges/transfers or "intermedia transfer parameters" are defined as transfer coefficients or D terms as described above. *Non-diffusive* transports (advective and reactive [biodegradation]) are described below for the PRAM compartments:

*Compartment 1 – Air compartment*
Non-diffusive transport within this compartment is enabled by precipitation, specifically:

Rain;

(29) $D_{QW} = A_{12} \times U_Q \times Z_W$

Wet particle deposition;

(30) $D_{DW} = A_{12} \times U_Q \times \phi_{1AE} Z_{AE}$

Dry particle deposition;

(31) $D_{PW} = A_{12} \times U_P \times \phi_{1AE} Z_{AE}$

Physical advection out of the compartment;

(32) $D_{A1} = G_A \times Z_1$

where:
$A_{12}$ = the surface area of the water – air interface ($m^2$)
$U_Q$ = the rain rate ($m^3$ rain·$m^{-2}$·$d^{-1}$)
$U_P$ = dry deposition velocity (m·$d^{-1}$)
$G_A$ = air flow through the air compartment ($m^3$·$d^{-1}$)
= [air current x cross-sectional area]
ϕ = the volume fraction of the specific media within compartment 1 and Z values as previously defined

*Compartment 2 – Upper water column compartment*

Physical advection out of the compartment;

(33) $D_{A2} = G_{W2} \times Z_2$

Biodegradation;

(34) $D_{R2} = K_W \times V_{2W} \times \phi_{2w} Z_W$

where:
$G_{W2}$ = water flow through the upper water column compartment ($m^3$·$d^{-1}$)
= [current x cross-sectional area]
$K_w$ = rate of biodegradation of PCB in water ($d^{-1}$)
$V_{2W}$ = the volume of pure water in compartment 2 ($m^3$)
ϕ = the volume fraction of the specific media within compartment 2 and Z values as previously defined

*Compartment 3 – Lower water column compartment*

Physical advection out of the compartment;

(35) $D_{A3} = G_{W3} \times Z_3$

Biodegradation;

(36) $D_{R3} = K_W \times V_{3W} \times \phi_{3w} Z_W$

where:
$G_{W3}$ = water flow through the lower water column compartment ($m^3 \cdot d^{-1}$)
= [current x cross-sectional area]
$K_w$ = rate of biodegradation of PCB in water ($d^{-1}$)
$V_{3W}$ = the volume of pure water in compartment 3 ($m^3$)
$\phi$ = the volume fraction of the specific media within compartment 3 and Z values as previously defined

*Compartment 4 – Sediment bed compartment*

Particulate deposition;

(37) $D_{DX} = A_{34} \times U_{DX} \times \phi_{3ss} Z_{SS}$

Particulate resuspension;

(38) $D_{RX} = A_{34} \times U_{RX} \times \phi_{4SD} Z_{SD}$

Sediment burial;

(39) $D_B = A_4 \times U_B \times \phi_{4SD} Z_{SD}$

Biodegradation;

(40) $D_{R4} = K_W \times V_{4W} \times \phi_{4sd} Z_W$

where:
$A_{34}$ = surface area for sediment bed – water column interface ($m^2$)
$U_{DX}$ = suspended solid deposition velocity ($m \cdot d^{-1}$)
$U_{RX}$ = sediment re-suspension solid velocity ($m \cdot d^{-1}$)
$A_4$ = surface area for sediment bed ($m^2$)
$U_B$ = sediment burial velocity ($m \cdot d^{-1}$)
$K_w$ = rate of biodegradation of PCB in water ($d^{-1}$)
$V_{4W}$ = the volume of pure water in sediment bed - compartment 4 ($m^3$)
$\phi$ = the volume fraction of the specific media within compartment 4 and Z values as previously defined

*Compartment 5 – Sunken vessel interior compartment*

Physical advection out of the compartment;

(41) $$D_{A5} = G_{W5} \times Z_5$$

Biodegradation;

(42) $$D_{R5} = K_W \times V_{5W} \times \phi_{5W} Z_W$$

where:
$G_{W5}$ = total flux from the interior vessel compartment ($m^3 \cdot d^{-1}$)
= [current x cross-sectional area]
$K_w$ = rate of biodegradation of PCB in water ($d^{-1}$)
$V_{5W}$ = the volume of pure water in compartment 5 ($m^3$)
$\phi$ = the volume fraction of the specific media within compartment 5 and Z values as previously defined

These non-diffusive transport coefficients are combined with the diffusive transport coefficients defined below to quantify total transport between compartments and ultimately the compartmental fugacities required to calculate each phase PCB concentration.

#### 2.3.2.2 Diffusive Transport Within the PRAM

Three diffusive exchanges are considered within the PRAM:

- PCB exchange between the upper water column (compartment 2) and air (compartment 1) across the water–air boundary layer,
- PCB exchange between the lower water column (compartment 3) and the upper water column (compartment 2) across the pycnocline, and
- PCB exchange between the lower water column (compartment 3) and the pore water within the sediment bed (compartment 4) across the sediment bed–surface water boundary layer.

These exchanges are bi-directional but the net flux of PCBs is based on the concentration gradient between the exchanging compartments. Exchange of PCBs between compartments involves both molecular diffusion and turbulent diffusion (dispersion). As described previously, the forcing process for diffusive flux across a boundary layer is the concentration gradient, which can be described as:

(6) $$N_{diff} = A\left[m^2\right]\times\left(\frac{D\left[\frac{m^2}{d}\right]}{\Delta[m]}\times\left(C_2\left[\frac{mol}{m^3}\right]-C_1\left[\frac{mol}{m^3}\right]\right)\right)$$

where:
$N$ = net substance diffusive flux due to diffusion and turbulence ($mol\cdot d^{-1}$)
A = the surface area
D = the diffusion coefficient
$C_2 – C_1$ = the concentration gradient
Δ = the “thickness” of the boundary or diffusion gradient

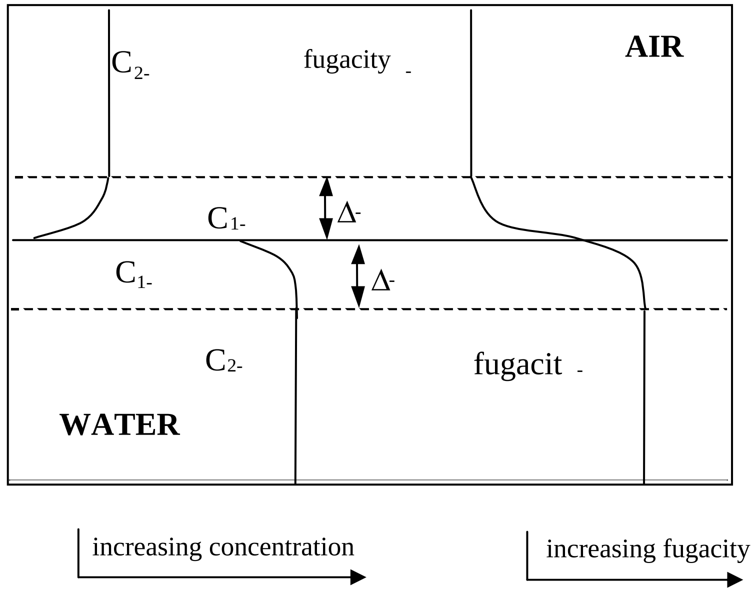
Salient for the modeling scheme here is a mass transfer coefficient (MTC), which is dissected from the above equation as D/Δ across a concentration gradient, and working at a level of flux per unit area where:

(43) $$N\left[\frac{mol}{m^2\cdot d}\right]=\frac{D}{\Delta}\left(C_2-C_1\right)=U\left(C_2-C_1\right)$$

where:
U = MTC = D/Δ

#### 2.3.2.3 Surface Water and Air Diffusive Boundary

An illustration of the boundary condition between upper water column (compartment 2) and air (compartment 1) is presented below (adapted from UCD and LLNL, 1994):




The air concentration above the laminar layer (represented by the dotted line above the water surface) is assumed to be well-mixed and homogenous in concentration. Similarly, the water concentration below the laminar layer just below the water surface is represented by a single concentration. These two well-mixed compartmental concentrations are related to the fugacity capacities of the compartments where diffusive processes are considered such that:

(44) $$N\left[\frac{mol}{m^2 \cdot d}\right] = Y_{aw}\left[\frac{mol}{m^2 \cdot Pa \cdot d}\right]\left(f_{air}[Pa] - f_{water}[Pa]\right)$$

where $Y_{aw}$ is the overall fugacity mass transfer coefficient per day

Considering that diffusive flux will occur in two directions at a boundary layer using the air–water boundary, the flux to the airside of the boundary from the water and from the air to waterside of the boundary must balance or:

(45) $$N = U_a\left(C_{2-air} - C_{1-air}\right)$$

*and*

(46) $$N = U_w\left(C_{2-water} - C_{1-water}\right)$$

where $C_{1\text{-air}}$, $C_{2\text{-air}}$, $C_{1\text{-water}}$, and $C_{2\text{-water}}$ are concentrations near the boundary layer as shown above.

Noting that at the surface the partitioning between water and air can be expressed in terms of their Z values:

$$(47)\quad \frac{C_{1-air}}{C_{1-water}} = \frac{Z_A}{Z_W}$$

and also noting that C = $fZ_1$ within each compartment, the foregoing equations can be manipulated to replace the concentration terms with Z values (see UCD and LLNL, 1994 for the specific algebraic manipulations):

$$(48)\quad Y_{aw} = \left( \frac{1}{Z_A \times U_a} + \frac{1}{Z_W \times U_w} \right)^{-1}$$

This overall fugacity mass transfer coefficient is related to the airside and waterside mass transfer coefficients where:

airside;

$$(49)\quad Y_{aw}^{a} = Z_A U_a = Z_A \left( \frac{D_a}{\Delta_a} \right)$$

waterside;

$$(50)\quad Y_{aw}^{w} = Z_W U_w = Z_W \left( \frac{D_w}{\Delta_w} \right)$$

The CalTOX model (UCD and LLNL, 1994) as well as the CemoS Model (Baumgarten et al., 1996) use an empiric method to estimate D/Δ based on the laboratory results of Southworth (1979). However, the data used by Southworth (1979) was specific to a large freshwater river (see Trapp and Harland, 1995). The approach suggested for open ocean is that of Liss and Slater (1974), which is specific to the air–ocean interface. Liss and Slater (1974) determined that the average transfer velocity (the combination of diffusion velocity and turbulence) for water across the seawater – air interface was 30 [$m \cdot hr^{-1}$].

Two other methods in addition to the Southworth and Liss and Slater methods were compared to field observations by Trapp and Harlan (1995), that of Mackay and Yeun (1983) which was developed for lake environments, and the method presented as the Langbein–Durum method (Tapp and Harland, 1995) for a river backwater situation. For perspective, in the seminal papers of Mackay (Mackay et al., 1985; Mackay and Paterson, 1991) a mass transport coefficient (U) of 3 $m \cdot hr^{-1}$ (72 $m \cdot d^{-1}$) for the airside U coefficient and 0.03 $m \cdot hr^{-1}$ (0.72 $m \cdot d^{-1}$) for the waterside U coefficient were used in modeling hexa-CB. According to Mackay and Paterson (1991), these values were selected based on best professional judgment without any further justification.

Given that the PRAM is attempting to model all ten homolog series with significantly different diffusion coefficients (D), the use of a single U for all seems too simplistic while the development of ten values based on best professional judgment seems too much of a task. It seems appropriate that the methods that could account for the variable chemical diffusivities of the PCBs as well as potentially, wind speed and water current, be considered as part of the PRAM development.

Trapp and Harland (1995) evaluated the aforementioned four estimation methods for a large river and a ship channel. Although neither situation is similar to the open ocean application anticipated for the PRAM, reference to the relative performances of the models is useful. The Liss and Slater method over-estimated the observed transport velocities for both situations (Trapp and Hartland, 1995). The Southworth and Langbein–Durum methods significantly under-estimated the velocities for the ship channel scenario but were accurate predictors of the river scenario. The Mackay and Yeun method significantly under-estimated the transport velocity for the river scenario and significantly over-estimated the velocity for the ship channel (Trapp and Hartland, 1995). The lone method for oceans appears to produce non-conservative results based on the limited attempt by Trapp and Hartland (1995) to validate the model. Although, as pointed out by Trapp and Hartland (1995), “It is unlikely that one universal empirical model is applicable to all cases and consequently no exact simulation can be expected,” it is believed that a conservative algorithm can be deduced. The Southworth method was consistently conservative or accurate in the validation scenarios reported by Trapp and Hartland, although overly conservative under certain situations of very low current speeds (Trapp and Hartland, 1995).

PRAM adopted the Southworth method because it apparently will tend to overestimate exposure and it has previously been used within CemoS and CalTOX. One perhaps significant uncertainty for the application of this approach is that the method was derived with chemicals with Henry’s Law Constants between 1 and 100 Pa- $M^3 \cdot mol^{-1}$ and some of the more chlorinated PCB homolog series have much higher Henry’s Law constants. The impact of this is unclear at this time.

Using the Southworth method, as described by UCD and LLNL (1994), the mass transfer coefficient on the waterside ($U_w$) is calculated as follows:

$$\text{(51) where current}\left[\frac{m}{s}\right] < 0.04 \times \text{wind}\left[\frac{m}{s}\right]^{0.67}; U_w = 0.24\left[\frac{m}{d}\right]$$

$$\text{where (51) is not true and where wind}\left[\frac{m}{s}\right] < 1.9\left[\frac{m}{s}\right] \text{(3.7 knots);}$$

$$\text{(52)} \quad U_w\left[\frac{m}{d}\right] = 5.64\left(\frac{\text{current}\left[\frac{m}{s}\right]^{0.969}}{\text{water depth }[m]^{0.673}}\right) \times \sqrt{\frac{32}{MW_{PCB-series}}}$$

$$\text{where (51) is not true and where wind}\left[\frac{m}{s}\right] > 1.9\left[\frac{m}{s}\right]$$

$$\text{(53)} \quad U_w\left[\frac{m}{d}\right] = 5.64\left(\frac{\text{current}\left[\frac{m}{s}\right]^{0.969}}{\text{water depth }[m]^{0.673}}\right) \times \sqrt{\frac{32}{MW_{PCB-series}}} \times e^{0.526(wind-1.9)}$$

Water depth in the context of the PRAM is the depth to the pycnocline, which represents a second boundary layer. $MW_{PCB\text{-}series}$ is the molecular weight for a particular homolog series.

For the airside mass transfer coefficient ($U_a$) according to Southworth (1979, as cited in UCD and LLNL, 1994):

$$\text{(54) where current}\left[\frac{m}{s}\right] + \text{wind}\left[\frac{m}{s}\right] < 0.5\left[\frac{m}{s}\right] \text{(0.97 knots);}$$

$$\text{(55)} \quad U_a\left[\frac{m}{d}\right] = 140\sqrt{\frac{18}{MW_{PCB-series}}}$$

$$\text{where current}\left[\frac{m}{s}\right]+\text{wind}\left[\frac{m}{s}\right]>0.5\left[\frac{m}{s}\right];$$

$$(56)\quad U_a\left[\frac{m}{d}\right]=273\left(\text{wind}\left[\frac{m}{s}\right]+\text{current}\left[\frac{m}{s}\right]\right)\sqrt{\frac{18}{MW_{PCB-series}}}$$

Diffusive transport across the air–surface water boundary in terms of the fugacity D value ($D_v$, in mol·Pa$^{-1}$·d$^{-1}$) requires a surface area for the interface (m$^2$) and is calculated as, using the nomenclature within the PRAM for compartmental exchanges:

$$(57)\quad D_v = 1 \Big/ \left[ 1 \big/ \left(U_{12} Z_A A_{12}\right) + 1 \big/ \left(U_{21} Z_W A_{12}\right) \right]$$

where $U_{12}$ is the airside mass transfer coefficient for the air-to-surface water boundary and $U_{21}$ is the waterside mass transfer coefficient for the surface water-to-air boundary.

#### 2.3.2.4 Lower Water Column and Upper Water Column Diffusive Boundary

No empiric method is available for estimating the mass transfer coefficients for the diffusive exchange of PCBs between the upper water column and lower water column across the pycnocline (PRAM compartments 2 and 3, respectively). There is, however, enough evidence for the transport of nutrients across the pycnocline that an effective diffusive value of 0.1 cm$^2$·s$^{-1}$ (0.864 m$^2$·d$^{-1}$) has been suggested. Additionally the thickness of the pycnocline is assumed to equal 1 meter and as such, the diffusion path for each side of this boundary is 0.5 m. The foregoing assumptions simplify the overall fugacity mass transport coefficient and D values to:

(58)

$$D_w = 1 \Big/ \left[ 1 \Big/ \left(0.864\left[\frac{m^2}{d}\right]\times\frac{1}{0.5}\left[\frac{1}{m}\right]\right)\left(Z_W A_{23}\right) + 1 \Big/ \left(0.864\left[\frac{m^2}{d}\right]\times\frac{1}{0.5}\left[\frac{1}{m}\right]\right)\left(Z_W A_{23}\right) \right]$$

#### 2.3.2.5 Lower Water Column and Sediment Bed Diffusive Boundary

The last boundary considered within the PRAM is that between the lower water column and the sediment bed (PRAM compartments 3 and 4, respectively). Diffusion will occur within the water phase within the sediment bed, which is affected by the void space within the sediment bed. Mackay and Paterson (1991) do not take into account any impact due to the presence of solids along the diffusion pathway. The CalTOX model does include a correction of the presence of particles within the sediment bed based on the work of Millington and Quirk (1961) that would reduce the efficiency of the diffusion process along a path where the effective diffusion ($D_{eff}$) is defined as:

(59) $$D_{eff} = \left( \omega^{10/3} / \phi^{2} \right) D_w$$

where:
ω = the void fraction of the media occupied by the liquid[18]
ϕ = the total void fraction within the media

In sediment, the entire void fraction is occupied by water such that the equation within the PRAM is stated as:

(60) $$D_S = \left( \phi^{10/3} / \phi^{2} \right) D_w = \phi^{\frac{4}{3}} DW$$

where $D_S$ is the effective diffusion within the sediment pore water.

The waterside and sediment-side mass transfer coefficients are then expressed as:

waterside;

(61) $$Y_{ws}^{w} = Z_W U_{34} = Z_W \left( \frac{D_W}{\Delta_{34}} \right)$$

sediment – side;

[18] The original equation is designed to account for the presence of additional liquids and air within the void space.

(62) $$Y_{ws}^{w} = Z_W U_{34} = Z_W \left( \frac{D_W}{\Delta_{34}} \right)$$

The interface between sediment and surface water can be diffuse where the thickness of the waterside boundary layer is difficult to define. The CalTOX model (UCD and LLNL, 1994) used a static value of 0.020 m, based on a study of radon transfers in the Hudson River (Hammond et al., 1975, as cited in UCD and LLNL, 1994). The use of a static value can constrain the analysis and as the value is based on a river study where sediment bed stability and currents above the bed may be quite different than that of an artificial reef environment, the CalTOX default value may not be applicable. Mackay et al. (1985) and Mackay and Paterson (1991) did not explicitly set the boundary thickness and used a transport coefficient (equivalent to $U_{34}$ here) of 0.01 $m \cdot hr^{-1}$. As with the CalTOX approach, this is a static value and while believed to be functional, it is less desirable as it will not account for the differences in diffusion coefficients for the ten PCB homolog series evaluated by the PRAM. Additionally, comments from the TWG suggest that the boundary thickness along the seafloor in the area of the ex-ORISKANY Memorial Reef would be just a few centimeters. Until more relevant data become available, the 0.020 m (2 cm) as used by the CalTOX model is assumed to be functional for the PRAM.

As for the sediment-side boundary layer thickness, Mackay and Paterson (1991) used half of the depth of the defined active sediment bed (i.e., the bioturburation zone, see Bosworth and Thibodeaux, 1990), which is a common practice (e.g., see USEPA, 1982; Trapp and Matthies, 1996).

The CalTOX model approached this issue differently where a functional relationship between outputs from the Jury et al. (1983) modeling approach for soils were regressed against a range of effective diffusion coefficients for chemicals with a wide range of $K_{oc}$s and Henry's constants (UCD and LLNL, 1994). The following relationship was established and is used by CalTOX to estimate the sediment-side boundary thickness:

(63) $$\Delta_{43}[m] = 318 \times D_S^{0.683}$$

There is some uncertainty associated with this approach because model results are used as inputs to a subsequent modeling scheme and the applicability of predicted soil results for sediment may not be valid. The appropriateness of this approach within the PRAM is unclear, as it would suggest the diffusion path length varies for each PCB homolog series.

Because of this, and given the uncertainties associated with the use of a soil-based model result, the CalTOX model was rejected for this purpose. The approach used by Mackay et al. (1985) and many others, where the diffusion path length or boundary thickness for sediment is set as half of the active sediment layer, is used within the PRAM.

Diffusive transport across the surface water – sediment bed boundary in terms of the fugacity D value ($D_v$, in mol·Pa$^{-1}$·d$^{-1}$) requires a surface area for the interface (m$^2$) and is calculated as follows, using the nomenclature with PRAM for compartmental exchanges:

$$(64)\quad D_Y = 1 \Big/ \left[ 1 \big/ \left(U_{34} Z_W A_{34}\right) + 1 \big/ \left(U_{43} Z_W A_{43}\right) \right]$$

where $U_{34}$ is the waterside mass transfer coefficient for the surface water to sediment bed boundary and $U_{43}$ is the sediment-side mass transfer coefficient for the sediment bed to surface water.

#### 2.3.2.6 Compartmental Fugacities and Media PCB Concentrations

By invoking steady-state conditions, a mass balance using the fugacity Level III approach can be illustrated (Figure 7) for each compartment where inputs are balanced by outputs as follows (see Mackay, 1985; Mackay and Paterson, 1991):

$$(65)\quad N - f_i \sum_j \left(D_{ij} + D_{Ai} + D_{Ri}\right) + \sum_j \left(D_{ji} f_j\right) = 0$$

Algebraic rearrangement results in a solution for the compartmental fugacity:

$$(66)\quad f_i = \frac{N + \sum_j \left(D_{ji} f_j\right)}{\sum_j \left(D_{ij} + D_{Ai} + D_{Ri}\right)}$$

Where there is no direct emission into the compartment[19] except for those transfers from adjacent compartments, the foregoing simplifies to:

[19] Compartment 5 (the vessel interior) is the only compartment within the PRAM that receives direct emissions of PCBs.

(67) $$f_i = \frac{\sum_j \left(D_{ji} f_j\right)}{\sum_j \left(D_{ij} + D_{Ai} + D_{Ri}\right)}$$

Thus, using Table 4, the individual fugacity (*f*) for each compartment (as a bulk media) can be calculated:

(68) $$f_5[\text{Pa}] = \frac{N_5\left[\frac{\text{mol}}{\text{hr}}\right]}{D_{A_5}\left[\frac{\text{mol}}{\text{Pa} \bullet \text{hr}}\right]}$$

Advection (DA) is considered to be the sole driving force for transporting the released PCBs from the interior of the vessel bulk water compartment (compartment 5) into the surrounding water column. It is notable that the advection term is for bulk water leaving the compartment that includes PCBs attached to suspended solids and dissolved organic carbon.

The lower water column (compartment 3, the bulk water below the pycnocline) receives the discharge of PCBs from the vessel interior:

(69) $$f_3 = \frac{D_{53} f_5 + D_{23} f_2 + D_{43} f_4}{D_{32} + D_{34} + D_{A_3} + D_{R_3}}$$

The release of PCBs from the interior of the vessel into the lower water column is an advection term for a physical/mass input into the lower water column. This water compartment loses and gains PCBs from the upper water column (water above the pycnocline) and the sediment bed via diffusion and dispersion and loses PCBs through advection and degradation.

The lower water compartment has functional[20] boundaries with the sediment bed and the upper water column such that diffusive transport into these compartments is a salient issue. The fugacity of the sediment bed compartment, in recognition of its connection with the lower column, is as follows:

(70) $$f_4 = \frac{D_{34} f_3}{D_{43} + D_{R_4} + D_{Bs}}$$

The bulk sediment bed (compartment 4) gains and loses PCBs via dispersive processes from the lower water column and loses PCBs through degradation and sediment burial.

PCBs, based on this model, are transported into the upper water column (compartment 2) from the lower water column via dispersive process across the pycnocline (2-way process) and across the boundary with bulk air (compartment 1) such that the fugacity of the upper bulk water column is algebraically described as:

(71) $$f_2 = \frac{D_{32} f_3 + D_{12} f_1}{D_{21} + D_{23} + D_{A_2} + D_{R_2}}$$

For bulk air (compartment 1) the compartmental fugacity is:

(72) $$f_1 = \frac{D_{21} f_2}{D_{12} + DA_1}$$

No reactive processes are assumed to occur in the atmosphere, which conserves PCBs. While the forgoing algebraic solutions are correct they are circular solutions such that extensive substitution is required to mathematically solve the equations.[21] The substitutions are provided in Appendix D and the solutions are as follows:

(73) $$f_3 = \frac{D_{53} f_5}{DT_3 - \frac{D_{23} D_{32} DT_1}{DT_1 DT_2 - D_{12} D_{21}} - \frac{D_{34} D_{43}}{DT_4}}$$

(74) $$f_4 = \frac{D_{34} f_3}{DT_4}$$

[20] No diffusive boundary is considered to be present between the vessel interior water compartment and the lower water column compartment.

[21] Matrix solutions are possible within the code of the program given the absolute values for the input parameters using Gaussian elimination matrix techniques, what is presented here and in Appendix D is a pure algebraic solution.

(75) $$f_2 = \frac{D_{32} f_3}{DT_2 - \frac{D_{12} D_{21}}{DT_1}}$$

(76) $$f_1 = \frac{D_{21} \times \frac{D_{32} f_3}{DT_2 - \frac{D_{12} D_{21}}{DT_1}}}{DT_1}$$

Given the fugacity for each compartmental phase (air, upper water column, lower water column, sediment, and vessel interior water), the bulk concentrations and intracompartmental media concentrations can be calculated. Bulk compartmental concentrations are calculated per equation 17, where concentration (mols·m$^{-3}$) is defined by: $C$ = Z$f$. Thus, in the context of the bulk concentrations for each compartment and each PCB homolog series:

(77) $$\text{PCB}_{1-\text{air}}\left[\frac{mg}{L}\right] = Z_1 \times f_1 \times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]$$

(78) $$\text{PCB}_{2-\text{upper}-\text{water}}\left[\frac{mg}{L}\right] = Z_2 \times f_2 \times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]$$

(79) $$\text{PCB}_{3-\text{lower}-\text{water}}\left[\frac{mg}{L}\right] = Z_3 \times f_3 \times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]$$

(80) $$\text{PCB}_{4-\text{sedimentbed}}\left[\frac{mg}{L}\right] = Z_4 \times f_4 \times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]$$

(81) $$\text{PCB}_{5-\text{vessel-interior}}\left[\frac{mg}{L}\right] = Z_5 \times f_5 \times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]$$

The specific media concentrations within each compartment are calculated using the compartmental fugacity, the media fugacity capacities, and densities (ρ in g·mol$^{-1}$) of the media where:

In compartment 1 (the air compartment)

(82) $$\text{PCB}_{air}\left[\frac{g}{m^3}\right] = Z_A \times f_1 \times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]$$

(83) $$\text{PCB}_{aerosols}\left[\frac{mg}{kg}\right] = \left(Z_{AE}\, f_1 \times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]\right) \Big/ \rho_{aerosols}\left[\frac{g}{cm^3}\right]$$

In compartment 2 (the upper water column)

(84) $$\text{PCB}_{Water}\left[\frac{mg}{L}\right] = Z_W \times f_2 \times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]$$

(85) $$\text{PCB}_{\text{Suspended Solids}}\left[\frac{mg}{kg}\right] = \left(Z_{SS} \times f_2 \times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]\right) \Big/ \rho_{\text{SS}}\left[\frac{g}{cm^3}\right]$$

(86) $$\text{PCB}_{\text{Dissolve Organic Carbon}}\left[\frac{mg}{kg}\right] = \left(Z_{DC} \times f_2 \times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]\right) \Big/ \rho_{\text{DC}}\left[\frac{g}{cm^3}\right]$$

The formats for the media concentrations in compartment 3 (the lower water column) are the same as those for the upper water column (compartment 2) except that the fugacity used is specific to compartment 3 ($f_3$). For compartment 4 (the sediment bed), the media concentrations are calculated as:

(87) $$\text{PCB}_{\text{Sediment}}\left[\frac{mg}{kg}\right] = Z_{SD} \times f_4 \times \text{PCB Molecular weight}\left[\frac{g}{mol}\right] \Big/ \rho_{\text{Sediment}}\left[\frac{g}{cm^3}\right]$$

(88) $$\text{PCB}_{Pore-water}\left[\frac{mg}{L}\right] = Z_W \times f_4 \times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]$$

$$(89)\quad PCB_{\text{DOC in pore water}}\left[\frac{mg}{kg}\right]=\left(Z_{DC}\times f_4\times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]\right)\Big/\rho_{\text{DC}}\left[\frac{g}{cm^3}\right]$$

and within the sunken vessel (compartment 5)

$$(90)\quad PCB_{Water}\left[\frac{mg}{L}\right]=Z_W\times f_5\times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]$$

$$*(91)\quad PCB_{\text{Suspended Solids}}\left[\frac{mg}{kg}\right]=\left(Z_{SS}\times f_5\times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]\right)\Big/\rho_{\text{SS}}\left[\frac{g}{cm^3}\right]$$

(92)

$$PCB_{\text{Dissolved Organic Carbon}}\left[\frac{mg}{kg}\right]=\left(Z_{DOC}\times f_5\times \text{PCB Molecular weight}\left[\frac{g}{mol}\right]\right)\Big/\rho_{\text{DOC}}\left[\frac{g}{cm^3}\right]$$

## 2.4 THE PRAM FOOD WEB AND TROPHIC TRANSFERS OF PCBS

The PRAM models the transfer of PCBs from abiotic media into biota mechanistically. The structure of the food web within which the released PCBs are transferred is treated as a closed system. That is, all of the components (organisms) are assumed to be resident within the model construct, and do not spend any time or obtain any food outside the influence of the sunken vessel. For sessile organisms and less mobile organisms associated with the reef structure and nearby sediment bed, this assumption is probably accurate. However, for mobile organisms such as fish, this approach overestimates their exposure because many fish move from reef to reef and undergo seasonal and/or life-stage migrations. This is especially true for pelagic organisms, a major community modeled by PRAM, where the vast majority of such species undergo large oceanic movements over their lifetime.

### 2.4.1 Food Web Communities Considered Within the PRAM

PRAM models three biological communities: a reef community, a benthic community, and a pelagic community. Inclusion of these communities in the model accounts for differences in habitat and dietary exposure anticipated among different groups of marine organisms near an artificial reef. They also include the apparent distribution of sport fish found at artificial reefs such as the ex-VERMILION.[22]

The literature on local hard bottom communities (Thompson et al., 1999) and the broader area (e.g., Bortone et al., 1997) indicates substantial variability in biotic community composition with depth and shape of submerged structures. The reviewed literature (Svane and Petersen, 2001) indicates that it is difficult to predict the exact biological structure of artificial reef communities. PRAM assumes that the sunken vessel will host a range of transient and resident fishes.

*A Trophic Level Approach*

Each of the three communities within the PRAM has four trophic levels:

- Trophic Level I includes the primary producers
- Trophic Level II are animals that feed directly on the primary producers;
- Trophic Level III animals are those that feed upon Trophic Level II animals;
- Trophic Level IV animals are those that feed on Trophic Level III animals.

PRAM used this construct because it is well recognized as a method to describe the flow of energy within the food web (e.g., see Parsons et al., 1977), and the exchange and "flow" of PCBs within the system follows the same pathways as energy (e.g., see Newman, 1998).

Figure 8 shows the organizational structure of the food web within the PRAM using the organism types from the following matrix.

| | **Pelagic Community** | | **Reef Community** | | **Benthjic Community** | |
|---|---|---|---|---|---|---|
| **Trophic Level** | **General Group** | **Examples** | **General Group** | **Examples** | **General Group** | **Examples** |

[22] In performing the human health risk assessment for the ex-VERMILION artificial reef off the coast of South Carolina, the Navy, assisted by the Marine Resources Division/Department of Natural Resources (SCDNR), conducted a fish consumption survey of local anglers, and estimated the fraction ingested (FI) term that relates to the potential fraction of fish caught from the ex-VERMILION that the anglers may ingest out of the total amount of fish they may consume per year (NEHC, 2004).

| | | | | | | |
|---|---|---|---|---|---|---|
| **I** | Phytoplankton | | Attached Algae | | None due to depth | |
| **II** | Zooplankton | Copepods, Krill | Sessile Filter Feeders<br><br>Invertebrate Omnivores | Barnacles, Bivalves<br><br>Echinoderms | Infaunal Macroinvertebrates<br><br>Epifaunal Macroinvertebrates | Polychaetes<br><br>Amphipods, Echinoderms |
| **III** | Planktivorous Fish | Herring, Snappers | Mobile Invertebrates<br><br>Vertebrate Foragers | Crustaceans, Echinoderms<br><br>Trigger Fish | Foragers | Crabs, Lobsters |
| **IV** | Piscivorous Fish | Jacks | Predators | Groupers, Barracuda, Morays, Sharks | Predators | Flounder, Flatfish, Skates, Rays, Sea Basses |

As with any classification scheme, not all organisms will fit neatly into the trophic scheme. The model accounts for the progression of diets over the life stage within a given species, resulting in a change of trophic status as the animal ages.

*PCB Transfer and Trophic Level Approach*

It is important to note that the PRAM does not attempt to describe the explicit reef trophic structure. Rather, it uses representative species at various trophic levels and from various feeding types to represent the major functional aspects of a pelagic community, reef community, and benthic community. It describes and tracks the accumulation and transfers of PCBs along trophic pathways.

The PRAM food web construct is simplistic relative to the true trophic structure of an artificial reef and its associated communities, but fully functional for illustrating the movement and potential accumulation of PCBs in those organisms that may be consumed by people or relevant ecological receptors (i.e., functional for its end purpose–risk assessment). By focusing on the PCBs, the chemical-physical properties that control PCB environmental fate, and the subsequent potential exposure pathways, the community food web structure can be simplified without loss of the detail required to make risk estimates that probably overestimate exposure. For example, certain parasites can be considered predators, some at the trophic level IV, but they probably do not represent a significant PCB transport mechanism.

A more significant example involves the reef-associated trophic level III consumers. There are many fish within this trophic level. Those species that feed extensively on the epifaunal reef organisms, such as the trigger fish, would be expected to be more exposed to the PCBs as they leach out of the vessel and accumulate into the encrusted reef organisms. In contrast, the more mobile and generalist trophic level III organisms that forage away from the vessel (e.g., bigeye) would be less exposed, and as such, not as relevant as a more closely associated species such as the triggerfish.

Thus, not all species or even species assemblages need be modeled in the PRAM to assure it's utility as a risk assessment tool. The artificial reef community is illustrated conceptually in the context of potential PCB exposures in Figure 8.

### 2.4.2 PRAM Food Web Community Structure

PRAM uses a representative species approach within each trophic level to attempt to capture the structural and functional complexity of each community. PRAM attempts to represent several feeding types within each community. These feeding types include:

- Herbivores;
- Detritivores;
- Omnivores;
- Primary Carbivores;
- Top Carnivores.

#### 2.4.2.1 Representative Herbivores

Herbivores are those animals that consume only plants. Most marine herbivores are invertebrates. The following matrix (adapted from Adey and Loveland, 1991) shows the major groups of herbivorous invertebrates that may or may not be present within the communities modeled within the PRAM.

The feeding behaviors are the key element shown in the matrix, for modeling purposes. Selective filtering, rasping and "cell sucking" appear to be the most representative for the entire group of invertebrates. In pelagic forms, selective filtering is the most common feeding behavior. Rasping and filtering best represent the likely reef dwelling animals. The benthic invertebrates seem to focus on rasping and cell sucking. In terms of PCB transfers, the protozoans are thought to behave much like the algae (see Spacie et al., 1995; Connolly, 1991).

**General Representative Marine Invertebrate Herbivores**

| Phylum | Class or Order | Frequency of Herbivory within Group | Example Common name | Example Species[23] | Example of Tissue Eaten | Mode of Feeding | Predominant Community |
|---|---|---|---|---|---|---|---|
| Protozoa | Several | Many | Amoeba | *Amoeba dudia* | Diatoms | Cytoplastic engulfing | All |
| Nematoda | Several | Many | Nematodes | *Dorylaimida* | Algae | Sucking of cell contents | Benthic |

[23] The examples may or may not be applicable to a specific reef community, but are presented as+ representative for the taxa, as adapted from Adey and Loveland (1991).

| Phylum | Class or Order | Frequency of Herbivory within Group | Example Common name | Example Species[23] | Example of Tissue Eaten | Mode of Feeding | Predominant Community |
|---|---|---|---|---|---|---|---|
| Echinodermata | Echinoidea | Many | Sea-urchins | *Echinus esculentus* | Seaweeds | Rasping | Reef and Benthic |
| Mollusca | Amphineura | Virtually all | Chitons | *Ischnochiton ruber* | Algal turfs, corallines | Rasping | Reef and Benthic |
| Arthopoda | Copepoda | Most | Copepods | *Calanus* | Phytoplankton | Selective filtering | Pelagic |
| | Isopoda | Some | Slaters | *Ligia oceanica* | Seaweed | Chewing | Benthic |
| | Euphausiacea | Most | Krill | *Euphausia superba* | Phytoplankton | Selective filtering | Pelagic, Reef |

This matrix suggests that the significant pathways for PCB transfers within the:

- Pelagic invertebrate community will come from the filtering of algae from the water;
- Reef invertebrates will come from the rasping of attached algae on the sunken vessel;
- Benthic community will come from rasping of benthic algae and/or consumption of algae falling out of the water column onto the sediment bed.

*Pelagic Herbivores*

Larval fish that feed on phytoplankton, and some smaller adult fishes such as herring, who also feed heavily on zooplankton, are examples of fish herbivores within the pelagic community. Most pelagic planktivores and larval fish snatch or grab individual planktors, but some species, such as herrings, are true filter feeders. In all cases, the algae diet occurs only during some of the fish's life history, or represents only a part of its diet. These fish are better classified as omnivores (an animal that consumes both plant and animal tissues).

The primary point of PCB entry into the biological food web from a sunken vessel is through the release to water and adsorption onto suspended particles and algae. The vast majority of fish within the pelagic zone that exhibit some herbivory do so as larvae. At this stage in life, many consider these fish as part of the macroplankton, or in the context of modeling PCB transfers, zooplankton. The inclusion of these fish within Trophic Level II is not necessary to trace the transfer(s) of PCBs from primary producers to, or through, Trophic Level II of the pelagic community food web, because they are accounted for within the zooplankton compartment of the PCB transfer model. Adult filter-feeding or particle-grabbing fishes, such as herring, are best characterized as omnivorous because they prey primarily on zooplankton and secondarily on algae. The foregoing suggests that, in the pelagic community, the zooplankton are the most appropriate group of organisms to trace PCB transfers from the primary producers into the pelagic food web.

*Reef Herbivores*

The most significant primary producers directly associated with the reef community would be attached algae. While floating algae may be present, water currents would relegate these organisms to more of a pelagic environment, such that the relevant PCB exposure would be associated with pelagic waters rather than reef waters, where the attached algae would reside.

Within the reef community, the parrot fish (*Scarids*), tangs (*Acanthurids*), and to a lesser extent, the damselfish (*Pomacentrids*), are thought to represent the vertebrate herbivores. Parrot fish are true grazers, while the tangs are better classified as browsers. The damselfish that are primarily herbivores tend to browse mostly on benthic algae attached to rocky outcrops. While the parrot fish eats a significant amount of attached algae, its diet also includes a large amount of coral. While coral contains a significant amount of symbiotic zooxanthellae cells (i.e., algae), the majority of coral tissue consists of animal tissue (i.e., *Coelenterata*). In this sense the parrot fish is not a "true" herbivore, but rather, is more akin to an omnivore.

Transfers from the reef community primary producers directly to true vertebrate herbivores are limited to species like the tangs. Tangs are poorly represented in the assemblages of reef fishes observed in and near the location of the proposed ex-ORISKANY Memorial Reef (Bortone et al., 1997). Of the reported 564 sampling events, *Acanthurins* (tangs) were observed 10 times (i.e., not quite 2% of the total number of samples) (Bortone et al., 1997). Only 20 individual fish were actually observed on and around the artificial reefs (Bortone et al., 1997). This suggests that while a true vertebrate herbivore population may be present at low density, the contribution towards any significant PCB transfer up to Trophic Level III or IV due to predation is unlikely. Those predators present on the artificial reef would not receive a significant loading of PCBs from preying on a very small population of herbivorous vertebrates.

The most significant pathway for PCBs from the primary producers directly associated with the reef community would be through the grazing/foraging (mobile) invertebrate herbivores, such as urchins and mollusks.

*Benthic Herbivores*

There will be no benthic herbivores at the ex-ORISKANY site because the sandy bottom and the depth of the ex-ORISKANY Memorial Reef site location prevents the growth of plants.

#### 2.4.2.2 Representative Detritivores

Detritivores are animals that primarily consume dead biological tissue or excreta. Most of these are benthic animals, but filter feeders on a reef feeding on suspended particles could be classified as detritivores. Some macroinvertebrates like annelid worms, mollusks, and arthropods can be classified as detritivores. To a certain extent, scavenging organisms such as many crabs, shrimp, and some fish (e.g., hagfish, sharks, etc.) can also be classified as detritivores.

Detritivores that fall into the Trophic Level II or III position within the food web are relevant for the PRAM. Large carrion feeders, in the context of PCB modeling, effectively act as top predators, as their diet generally includes many Trophic Level III/IV animals. On the other extreme are the very small carrion feeders such as bacteria and other micro/macro invertebrates. Here in the context of PCB modeling, the biomass associated with the carrion of larger Trophic Level III/IV organisms is small relative to Trophic Level I or II biomass (e.g., see Parsons et al., 1977). This carrion PCB transfer pathway should be considered at the trophic III level to assure that the pathway is not "missed" in the model. Detritivores that fall within the Trophic Level II position must also be considered, and are best represented by deposit feeder and filter feeder guilds, in the sense of food web dynamics and biomass (e.g., Parsons et al., 1977; Adey and Loveland, 1991). In a general sense, many filter feeders are not true detritivores, given that they consume a significant amount of living material. However, for evaluating PCB transfers, given that part of their diets are known to include fecal pellets and seston, filter feeders can be used to represent the PCB transfers from detritus derived from lower trophic level carrion. It is important to note that the greatest mass of detritus/carrion is derived from Trophic Levels I and II biomass (e.g., see Parsons et al., 1977).

*Pelagic Detritivores*
Within the pelagic community the detrital pathway can/should be accounted for utilizing zooplankton and/or planktivorous fish by adjusting their diets to include some detritus (as suspended particles representing Trophic Level I/II carrion) within their matrix.

*Reef Detritivores*
Within the reef community the sessile filter feeders such as bivalves and barnacles would be expected to consume organic-rich suspended particles such as phytoplankton/zooplankton carrion along with live plankton. Mobile epifaunal species, such as crabs and shrimps, feed

on carrion. Such crustaceans are known to forage opportunistically, commonly ingesting carrion, living organisms, and even plant material. These crustaceans are probably more appropriately classified as omnivores than detritivores, and the next subsections reconsider them as omnivores or 1st order carnivores. The most significant consumers of detritus derived from Trophic Level I and II organisms are the filter/ deposit feeders on the reef, as represented by bivalves and barnacles.

*Benthic Detritvores*

Within the benthic community the detritivores represent the largest biomass relative to all other guilds. Most of these detritivores are bacteria, fungi, microbenthos (<0.1 mm), meiobenthos (0.1 mm to 0.5 mm) and macrobenthos (>0.5 mm).[24] However, in the context of the transfers into the food web, other larger forms (the macrobenthos or macroinvertebrates with the micro and meiobenthos, hereafter referred to as microinvertebrates) represent the major predators or consumers of their community. These macroinvertebrates represent the transfer pathway out of the sediment bed and into the food web to top predator fish consumed by humans and/or relevant ecological receptors. Although microinvertebrates are far more numerous than macroinvertebrates per unit area, typically the biomass of macroinvertebrates is far greater than that of the microinvertebrates per unit area. For example, Parsons et al. (1977) report a study that revealed an overall abundance ratio of 1:70 for macrobenthos and meiobenthos, respectively in number of individuals, but a biomass ratio of 24:1 by fresh weight. Additional data collected from the scientific literature at that time (Parsons et al., 1977, Table 34) showed a consistently higher biomass for the macrobenthos, even if ciliates were considered over a significant range of geographical areas and sediment bed types in the ocean.

Two types of benthic (sediment-associated) macroinvertebrates are considered within the PRAM, infaunal and epifaunal forms. Infaunal refers to those macroinvertebrates that live *within* the sediment bed itself, whereas the epifaunal forms live *upon* the sediment bed (e.g., see Parsons et al., 1977). There is significant overlap among the many species at issue here. Some species build tubes within the bed but feed from the sediment bed surface, while other tube builders will migrate into the water column to feed and return to their tubes for shelter from predation. Many of the epifaunal forms such as shrimp and scallops make extensive movements into the water column (e.g., see Parsons et al., 1977). By considering where maximum PCB exposure would or could occur, the relevant invertebrate forms can be identified.

[24] Benthos classification after Levinton (1982) as cited in Adey and Loveland (1991).

Certain infaunal benthic forms, such as the true worms (annelids, i.e., the burrowing polychaete worms), do not build tubes nor do they migrate out of the sediment bed to any significant degree. They consume organic-rich sediment particles (detritus) that are coated with the bacteria and microinvertebrates, as discussed above. Clearly these benthic macroinvertebrate forms are significant in the context of PCB transfers from the sediment into the food web, as these organisms also represent a significant forage base for higher trophic level animals. To capture the transfer of PCBs into the detrital food web, infaunal macroinvertebrate worms are the best representative group of infaunal benthic organisms.

Epifaunal benthos include both macro- and mega-invertebrates, such as nudibrancs, echinoderms, mollusks, and crustaceans. The majority of these mega-invertebrates are predators and thus not relevant to detrital pathways, although many of the mollusks are filter or deposit feeders. As noted previously, the greatest input of biomass and energy into the detrital food web is derived from the pelagic primary producers and pelagic primary consumers. Thus, the most significant pathway to trace in order to follow the trophic transfers of PCBs is to identify the major consumers of this type of detritus. The epifaunal deposit and filter feeders represent the primary consumer guild in this context and as such, the relevant guild for tracing PCB transfers. Typical representatives include nematodes, polychaetes (deposit feeders) and bivalves (filter feeders).

#### 2.4.2.3 Representative Omnivores

Omnivores are animals that consume plant and animal tissue, generally in a fresh state. For purposes of modeling the PCB transfers within the food web, however, consumption of carrion and detritus is considered relevant for them. There are many taxonomic representatives among omnivores for invertebrates and vertebrates. Omnivores are between Trophic Level II (primary consumers) and Trophic Level III (secondary consumers).

*Pelagic Omnivores*

As discussed above on the pelagic community, planktivores such as herring will consume floating algae as part of their diet. Additionally, there are invertebrates in the pelagic water column, such as species of shrimp that consume both algae and zooplankton. Consumption of dead algae and zooplankton has been identified as a potentially relevant and significant transfer pathway for PCBs. However, PRAM does not incorporate the pelagic omnivore pathway.

*Reef Omnivores*

Within the reef community there are numerous examples of vertebrate and invertebrate omnivores. The parrot fish, discussed previously, can be classified as an omnivore. Sea urchins, also mentioned earlier, consume significant quantities of algae, but also consume animal tissues. Many shrimps are also omnivorous. The representative detritivores identified as important in the context of PCB transfers, the filter feeders, are also omnivores. These filter feeders however, do not feed upon any attached algae directly associated with the sunken vessel, whereas organisms such as urchins and some crustaceans would. Sea urchins are an appropriate representative of reef omnivores because they capture the transfer of PCBs from attached algae, and hydroids.

#### 2.4.2.4 Representative Primary Carnivores

First order carnivores consume animals that are primarily herbivorous or in the case of the detrital food web, those detritivores that consume primarily detritus derived from algae and zooplankton. Organisms within this guild are considered to represent Trophic Level III within the PRAM.

*Pelagic Primary Carnivores*

Planktivorous fish are the primary group for consideration in modeling PCB transfers from Trophic Level II within the pelagic community. These animals consume mostly zooplankton, which represent the primarily consumers within the community, and represent a significant food source for higher trophic level predators.

*Reef Primary Carnivores*

While planktivorous fish would be expected to reside in the reef community as well, uptake into organisms such as filter feeders and urchins would be expected to represent the major PCB uptake pathway from lower trophic levels (filter feeders – see the discussion of detritivores, e.g., bivalves and rasping echinoderms such as urchins, see discussion of herbivores and omnivores). Both fish and other invertebrates will prey upon these organisms. Fish such triggerfish, and invertebrates such as crabs, are typical representatives for the predators of sessile filter feeders and crawling invertebrates such as urchins. Both of these types of predators forage along the reef. In addition, crabs will consume carrion, which was identified as a potentially relevant pathway for PCB transfers.

*Benthic Primary Carnivores*

The infaunal and epifaunal macroinvertebrate detritivores, in the context of the PRAM benthic community food web (detrital food web), occupy Trophic Level II as primary consumers of detritus. Many organisms, both vertebrates and larger invertebrates, will prey upon these detritivores. Those predators close to the sediment bed that probe or sieve the sediment for these organisms would be expected to have a higher PCB exposure than those predators that capture the organisms as they move out of the sediment. Sediment probing and sieving predators of the macroinvertebrate detritivores include nudibrancs, crustaceans (e.g., crabs and lobsters), echinoderms, and skates, drums, and hogfish. Most fish, including those mentioned move extensively in the water column. The invertebrates, such as the nudibrancs, crabs, lobsters, and echinoderms, are in much closer contact with the sediment, and as such, are more likely to receive a higher exposure to any PCBs directly associated with the sediment than the more mobile fish or invertebrates such as squid.

Thus, the most relevant first-order predators for tracing PCBs within the benthic community are those foraging invertebrates that probe or sieve the sediment for macroinvertebrate detritivores, such as the crustaceans.

#### 2.4.2.5 Representative Top Carnivores

Top carnivores consume herbivores, carnivores, and omnivores. These are Trophic Level IV organisms.

The PRAM has been designed as a tool for human health risk assessment and as such, sports fish (primarily top predators-finfish and shellfish) sought after and consumed by humans are the focus. The approach used in PRAM, as discussed above, has been taken to increase the probability of overestimating the transfer of PCBs into sports fish.

*Pelagic Top Carnivores*

Within the pelagic food web, this trophic level is dominated by fish such as jacks, tuna, and sharks. Although some invertebrates, such as squid, could be considered to be at this level, they are generally not taken by recreational anglers. Of the typical pelagic fish taken by anglers, the jacks are perhaps the most representative given their, albeit slight, fidelity to structure.

*Reef Top Carnivores*
Certain top predators on the artificial reef, such as eels and barracuda, are not commonly considered sports fish. Groupers are among the more popular sports fish on artificial reefs, and are top predators (Trophic Level IV).

*Benthic Top Carnivores*
A similar situation is present in the context of the benthic top carnivores, where organisms such as toadfish, skates, and sharks are true top carnivores; top carnivores such as the flatfish (e.g., flounder) are commonly sought and consumed by anglers. Other sport fish such as some snappers and sea bass forage extensively within the benthic community, but return to the reef for shelter when not foraging. This will reduce their direct exposure levels to the sediment bed and in the context of PCB transfers decrease their overall exposure level, at least to the sediment-associated PCBs. These carnivores are not presently considered viable representatives because their exposure is mitigated by this migration on and off the reef.

### 2.4.3 Generalized Representative Dietary and Water Exposures for Use in Modeling PCB Food Web Transfers

This subsection summarizes the dietary and water exposures of the pelagic, reef, and benthic communities. Each discussion presents a representative organism and its generalized diet and exposure profile.

The PRAM does not attempt to model the trophic dynamics within and among the three biological communities but rather calculates PCB accumulation along the most efficient pathways within each community separately. Such calculations probably overestimate exposure within each community because the implicit assumption is that each community has access to all the PCBs in the abiotic media even though these PCBs will be distributed among all three communities in reality.

#### 2.4.3.1 Pelagic Community

*Phytoplankton*
The primary producers (Trophic Level I) within the pelagic community are the phytoplankton. The PRAM accounts for the fact that a pycnocline forms within the water column that will affect the dissolved PCB water concentrations. While algae may sink

through this boundary, they are not expected to remain as living cells but rather as falling particles, as the light attenuation with depth would limit algal growth and survival at depth.

Water column Exposure: For algae, the relevant water exposure to PCBs is that concentration above the pycnocline, in well-lit waters.

*Zooplankton*

The crustacean zooplankton represents the largest group, in terms of feeding habits and biomass, in most ocean waters (e.g., see Parsons et al., 1977), and as such, are the most relevant in considering the potential for accumulation of PCBs. Most of these zooplankton are selective filter feeders that graze on the phytoplankton (e.g., Parsons et al., 1977). The dietary makeup for most of these zooplankton is most often characterized by particle size rather than prey type (e.g.algae, bacteria, and/or particulate organic carbon).

Dietary Exposure: Considering PCB accumulation, bacteria, algae, and organic particulates are modeled as simple sorption materials (see Spacie et al., 1995; Connolly, 1991). The dietary breakout is not overly significant, except in the context of the relative sorption capacity of these dietary components. Within the PRAM this simplifies the available diet for this trophic level to suspended particles, which includes bacteria and suspended organic solids.

Water Column Exposure: Zooplankton are expected to migrate across the pycnocline and be exposed to PCB concentrations above and below it. Feeding is expected to occur primarily in the upper water column where the phytoplankton are expected to be concentrated. Below the pycnocline only minimal feeding on suspended solids is predicted (Table 5).

*Planktivores*

Planktivores (modeled as a herring-like fish) are assumed to feed exclusively on the zooplankton (Table 5).

Dietary Exposure: The assumption of 100% zooplankton diet is used to assure that the planktivore PCB concentration is not underestimated.

Water Column Exposure: Predation on the zooplankton will occur for most planktivores visually and assumes a limited foray into the lower water column (time breakout, 80:20, Table 6).

*Top Carnivore*

Dietary Exposure: The top carnivore (modeled as a jack-like fish) is assumed to feed almost exclusively (90%) on the planktivores with a small fraction of the diet consisting of zooplankton (10%) to account for the changes in diet over the fish's life stages (Table 5). This diet is in keeping with what has been reported for jacks (e.g., see Weaver et al., 2001).

Water Column Exposure: These predators are expected to follow the planktivores through the pycnocline so that their water exposure regime mirrors the planktivores (80:20, Table 6).

#### 2.4.3.2 Reef Community

*Primary Producers*

The primary producers directly associated with the artificial reef are attached algae. Given the depth of the ex-ORISKANY Memorial Reef, the algae will likely be limited to the upper portions of the prospective reef due to their light requirement. Nevertheless, these waters are predicted to be below the pycnocline.

Water Column Exposure: The water exposure level for attached algae is set as such (Table 6).

*Primary Consumers - Filter Feeders and Rasping Echinoderms*

PRAM uses two groups of primary consumers to estimate PCB uptake through the reef community food web. The first group is the filter feeders, which are modeled as bivalves. Although Trophic Level II organisms are generally herbivores, PRAM used an omnivorous diet to provide a higher estimate of exposure than a purely herbivorous diet offers.

Dietary Exposure: Bivalve mollusks and barnacles mostly feed upon algae with some suspended solids, but other filter-feeders on the prospective reef would feed on zooplankton (e.g., hydroids, etc.) as well. To reflect this fact, the filter feeder diet includes floating algae (80%), a fraction of zooplankton (10%), with a relatively small fraction of suspended solids (10%). This diet is not specific to any bivalve species, but rather, reflects the filter feeding community expected to occur on the artificial reef.

Dietary Exposure: The second group of primary consumers modeld in PRAM are omnivorous rasping echinoderms (modeled as an urchin). A generalized diet for these echinoderms emphasizes the herbivorous forms to reflect a Trophic Level II position and importance of the PCB transfer from attached algae into the reef food web (80% of diet), but also sessile organisms such as the hydroids (20% of diet, Table 5).

Water Column Exposure: Exposure of these organisms is limited to the lower water column because the reef is not expected to extend above the pycnocline nor are the urchins expected to migrate across it. Therefore these organisms would be exposed to PCB concentrations in the lower water column of the model system, and potentially waters within the vessel if the organism(s) used the vessel interior. The sessile filterers are unlikely to extend into the vessel interior because it is assumed to have low oxygen and low food availability. However, the mobile animals, such as the echinoderms, may use the vessel interior as a place of shelter from predation. PRAM assumes that these animals are exposed 20% of the time in the vessel interior and 80% of the time in the lower water column (Table 6).

*Foraging Invertebrates and Fish*

Carnivorous crustaceans (modeled as crabs) were identified as a relevant pathway for tracing PCB transfers within the reef community. Foraging crustaceans within the reef community would be highly opportunistic in their dietary preferences.

Dietary Exposure: PRAM assumes a diet of 50% echinoderms, 35% bivalve filter feeders, and to account for a limited input from the pelagic community as infrequent visitation and/or as carrion 5% zooplankton, 5% pelagic planktivorous fish, and 5% suspended solids (sorption materials, including bacteria, organic matters, and detached algae).

Dietary Exposure: The fish forager within the reef community would have a diet again of the sessile filter feeders (modeled as bivalves) and invertebrate omnivorous foragers (modeled as urchins). For this type of fish (modeled as trigger fish), the dietary components include some planktivorous fish (19%), reef carnivorous invertebrate foragers (22%), modeled as a crab, omnivorous echinoderms (15%), modeled as an urchin, sessile filter feeders (19%), modeled as bivalves, epifaunal benthos (12.5%), and infaunal benthos (12.5%) (Table 5). This dietary breakout is in keeping with reports for the gray trigger fish (e.g., see Nelson and Bortone, 1996), and the TWG recommendations.

Water Column Exposure: Both the foragers are assumed to be present only within the reef community and as the prospective reef will be below pycnocline, water exposure would be of the water PCB concentration within the lower water column and/or water interior to the sunken vessel as used for potential shelter from predation (Table 6). The percentage of vessel interior respired waters (30%) is slightly higher than that for the echinoderm omnivores (20%) due to the behavior associated with these predators (i.e., more time spent resting in nooks and crannies along the artificial reef than foraging omnivores such as urchins).

*Top Carnivore*

A top reef carnivore consumes primarily Trophic Level III organisms from the reef. Not all top carnivores that reside on the reef prey exclusively on reef organisms. For example, the gag grouper, while considered to be a reef resident, preys heavily on pelagic planktivorous fish.

Dietary Exposure: The top reef carnivore is assumed to prey primarily (60%) on reef Trophic Level III fish (modeled as trigger fish) and Trophic Level III invertebrates (15%) (modeled as crabs) (Table 5).

Water Column Exposure: PRAM assumes that these top carnivores have less need for shelter within the vessel, remain on the reef, and have no exposure to the PCB water concentrations in the upper water column (Table 6).

#### 2.4.3.3 Benthic Community

No primary producers are expected to occur along the sediment bed associated with the ex-ORISKANY Memorial Reef due to the depth of the water and light attenuation at that depth.

*Detritivores*

The infaunal organisms (modeled as polychaetes) that burrow into and reside within the sediment bed are assumed to consume sediment that is coated with bacteria and microbenthos associated with the sediment particles.

Dietary Exposure: The diet of these organisms is represented in Table 5 where the animals consume 50% sediment particles, 30% algal cells and 20% zooplankton that have fallen from the water column.

The epifaunal macroinvertebrates (modeled as nematodes) are represented as primarily deposit feeders with representative predators (e.g., *Euncida* and *Phyllodocida*) of other worms and small infaunal organisms with a fractionated diet made up of 25% sediment, 30% deposited algae, 20% deposited zooplankton, and 25% infaunal macroinvertebrates to reflect benthic predators within this guild (Table 5).

Water Column Exposure: Infaunal and epifaunal macroinvertebrates exposure to sediment pore water is germane. The sediment pore water concentrations of PCBs may be higher than the concentration in the overlying water due to desorption for the sediment particles and diffusive impedance from the pore water into the overlying waters. In modeling the transport of PCBs, the infaunal macroinvertebrate, for the most part, rarely move into the overlying water but this is not to say they do not respire overlying waters (e.g., see Chapman et al., 2002).

PRAM assumes that the water exposures for infaunal invertebrates is 80% pore water and 20% overlying surface water below the pycnocline (Table 6). The epifaunal macroinvertebrates live at the interface between the surface water and the sediment such that they respire predominantly overlying water. Nevertheless during feeding and disturbing the sediment bed, they would have a significant potential for pore water exposure. For epifauna, the fractional water exposure for PCB accumulation via respiration is 50% pore water PCB concentrations and 50% surface water (below the pycnocline; see Table 6).

*Primary Carnivores*

The relevant first order carnivores within the benthic community in the context of maximal exposure levels are those that forage directly on the sediment and dig, probe or sieve the sediment for their prey. Among this group are organisms that are directly consumed by humans such as crabs and lobsters. Recognizing this and the objective for the PRAM (human health risk assessment), the lobster is a logical representative species.

The diet of lobsters includes mostly epifaunal macroinvertebrates such as gastropods, echinoderms, and bivalves (e.g., see FMRI, 2003).

Dietary Exposure: PRAM assumed the lobster's diet (Table 5) is approximately an equal distribution of infaunal (50%) and epifaunal (45%) organisms and that the animal will incidentally consume sediment as it digs or probes into the sediment for these prey items (5%). Exposure to pore water concentrations of the PCBs would also be expected because the lobster forages along the sediment bed.

Water Column Exposure: To account for this exposure while recognizing that most of the water respired by an animal above the sediment will be of overlying water, the fraction of pore water respired is 25% of the total with 75% of the water respired being at the PCB concentration of the lower water column (Table 6).

*Top Carnivores*

Top carnivores within the benthic community include rays or skates, sharks, flatfish, toadfish, certain species of snappers, and others. Of note here are the sports fish that may be sought after and consumed by humans. Those organisms that feed heavily on Trophic Level III benthic animals (modeled as the lobster) would be exposed to the highest concentration of PCBs. The more common sports fish are flat fish (e.g., flounders).

Dietary Exposure: A dietary makeup of 58% Trophic Level III carnivores, 20% epifaunal macroinvertebrates, and 20% infaunal macroinvertebrates represents a diet that probably does not underestimate PCB exposure. PRAM assumes an incidental sediment ingestion of 2% (Table 5).

Water Column Exposure: As these fish (modeled as a flounder) would be expected to be in close contact with the sediment while feeding and resting, they would be expected to be exposed to some level of higher PCB concentrations in the water. To account for these increased exposure concentrations the top benthic carnivores are assumed to respire 10% sediment pore water and 90% water below the pycnocline (Table 6).

## 2.5 PRAM PCB TROPHIC TRANSFER METHODS AND ALGORITHMS

Bioconcentration of PCBs by aquatic organisms from *water* can be described as a one-compartment, first-order kinetics model (e.g., see Equation 10 in Spacie and Hamelink, 1995; Equation 3.19 in Newman, 1998):[25]

$$(93)\ \frac{\Delta C_i}{\Delta t} = \text{uptake - loss} = \left( Ku_i \left[ \frac{L}{kg_{lp} \cdot d} \right] \times C_w \left[ \frac{mg}{L} \right] \right) - \left\{ \left( Ke_i \left[ \frac{1}{d} \right] + G_i \left[ \frac{1}{d} \right] \right) \times C_i^t \left[ \frac{mg}{kg_{lp}} \right] \right\}$$

where:

$\Delta C_i$ = change in tissue concentration for organism *i* [$mg \cdot kg_{lp}^{-1}$]

$\Delta t$ = change in time [d]

$Ku_i$ = uptake rate constant for water in organism *i*

$C_w$ = concentration of PCB in water (surface water and/or sediment pore water)

[25] Spacie and Hamelink (1995) combine the two loss terms (Ke and G) as a first order rate constant for depuration denoted as $K_d$.

$Ke_i$ = elimination rate constant (sum of elimination and metabolism) for organism *i*
$G_i$ = growth rate for organism *i*
$C_i^t$ = PCB concentration in organism *i* at time *t*
kg = kilogram
mg = milligram
L = liter
d = day
lp = lipid [26]

Uptake and accumulation of PCBs by aquatic organisms from *food* can also be described with a simple one-compartment, first-order kinetics model (e.g., see equation 34 in Spacie and Hamelink, 1995; equation 3.24 in Newman, 1998):

$$(94)\quad \frac{\Delta C_i}{\Delta t} = \alpha\, I_{i,j}\left[\frac{1}{d}\right] C_j \left[\frac{mg}{kg_{lp}}\right] - \left\{\left(Ke_i\left[\frac{1}{d}\right] + G_i\left[\frac{1}{d}\right]\right) \times C_i^t \left[\frac{mg}{kg_{lp}}\right]\right\}$$

where:
$\Delta C_i$ = change in tissue concentration for organism *i* [$mg \cdot kg_{lp}^{-1}$]
$\Delta t$ = change in time [d]
$\alpha$ = assimilation efficiency of COC across digestive tract of organism *i* [fraction]
$I_{i,j}$ = ingestion rate of dietary item *j* for organisms *i*
$kg_{lp \cdot j}/kg_{lp \cdot i}$ = kilogram lipid of dietary item *j* consumed per kilogram lipid of organism *i*
$C_j$ = COC concentration in the dietary item *j*
$Ke_i$ = elimination rate constant (sum of elimination and metabolism) for organism *i*
$G_i$ = growth rate for organism *i*
$C_i^t$ = COC concentration in organism *i* at time *t*

Equation 94 can be combined with Equation 93 to estimate tissue concentrations of aquatic organisms contributed via water, sediment, and food assuming that a steady-state[27] condition

[26] All concentrations are normalized by lipid content in keeping with the approach presented by Thomann (1981) and others.

has been reached and, as such, the change in chemical concentration (lipid-based) over time becomes zero. At equilibrium, the rate at which the chemical enters the organism and the rate at which the chemical is eliminated or metabolized are balanced. Equation 94 assumes only one dietary item, which for the aquatic animals within the PRAM is not appropriate. To account for multiple dietary items, Equation 94 is modified and combined with Equation 93 as follows:

$$(95)\quad \frac{\Delta C_i}{\Delta t} = 0 = \left(Ku_i \times C_w\right) + \sum_{j=1}^{n}\left(\alpha I_{i,j} C_j^{ss}\right) - \left[\left(Ke_i + G_i\right) \times C_i^{ss}\right]$$

where:

$\Delta C_i$ = change in tissue concentration for organism *i*

$\Delta t$ = change in time [d]

$Ku_i$ = uptake rate constant for water in organism *i*

$C_w$ = concentration of PCB in water (surface water and/or sediment pore water)

$\alpha$ = assimilation efficiency of PCB in dietary item *j* across digestive tract of organism *i*

$I_{i,j}$ = ingestion rate of dietary item *j* by organism *i*

$C^{ss}_j$ = concentration of PCB in dietary item *j* at thermodynamic steady-state

$Ke_i$ = elimination rate constant (sum of elimination and metabolism) for organism *i*

$G_i$ = growth rate for organism *i*

$C^{ss}_i$ = concentration of PCB in organism *i* at thermodynamic steady-state

n = number of dietary items

j = specific dietary item *j*

Equation 95 is equivalent to the governing equation(s) used by Gobas (1993), Connolly (1991), and Thomann et al. (1992). As described above, the first term represents the direct uptake of PCB by the animal from water, the second term represents the flux of PCB into the animal through feeding, and the third term is the loss of PCB due to metabolism and excretion plus the change in concentration due to growth.

[27] Thermodynamic equilibrium, or "steady-state," is defined as when uptake and loss are balanced such that the change in tissue concentration is zero, as depicted in Equation 95.

According to Spacie et al. (1995) and others, the uptake of chemicals (i.e., PCBs) into aquatic animals should be based on the "freely dissolved"[28] fraction of the chemical in water. Given the organic carbon (oc) fraction and the particulate organic carbon content in the water column ($f_{oc}$), dissolved organic carbon can be calculated. Spacie et al. (1995, Equation 9) provides the following equation from which a freely dissolved water concentration can be derived:

$$(96)\quad C_{dw} = \frac{C_{tw}}{1 + f_{oc} \times K_{oc} + f_{doc} \times K_{doc}}$$

where:

$C_{dw}$ = freely dissolved COC concentration in water
$C_{tw}$ = total COC concentration in water
$f_{oc}$ = fraction of particulate organic carbon within the water column
$K_{oc}$ = organic carbon-water partition coefficient
$f_{doc}$ = fraction of dissolved organic carbon within the water column
$K_{doc}$ = dissolved organic carbon-water partition coefficient

The fraction freely dissolved PCB concentration = $f^{fd} = \frac{C_{dw}}{C_{tw}}$

Therefore,

$$(97)\quad f^{fd} = \frac{1}{1 + \left( f_{oc}\left[\frac{kg}{L}\right] \times K_{oc} \right) + \left( f_{doc}\left[\frac{kg}{L}\right] \times K_{doc} \right)}$$

where:

$f^{fd}$ = fraction of PCB concentration that is freely dissolved
$f_{oc}$ = fraction of particulate organic carbon within the water column
$f_{doc}$ = fraction of dissolved organic carbon within the water column
$K_{oc}$ = organic carbon – water partition coefficient
$K_{doc}$ = dissolved organic carbon – water partition coefficient

[28] Freely dissolved refers to the total concentration of a PCB in surface water minus that fraction adsorbed to suspended particulate organic carbon and dissolved organic carbon (see Spacie et al., 1995; USEPA, 1995).

### 2.5.1 Equations that Describe Food Transfers of PCBs

Estimates of uptake and accumulation of PCBs from the diet of aquatic animals requires a description of the food web or food chain within which the PCBs are interacting. As described above, the food web within the PRAM consists of three inter-related communities: the benthic (sediment bed-associated), reef-associated (vessel-associated), and pelagic (water column-associated) communities.

As previously described, PCBs will enter the food web via uptake across the respiratory tissues of aquatic animals and across the digestive tract of those animals that consume organic carbon within the sediment (bedded or suspended in the water column) as an energy source. These PCBs can then be transferred within the food web via consumption of aquatic biota (e.g., from aquatic worms feeding on sediment into bottom foraging fish or other invertebrates). If the accumulation of PCBs is highly efficient, but the depuration rate is low (i.e., not readily excreted or metabolized), the relative concentrations of the PCB among the trophic levels depicted above can become significantly elevated along the food chain. This phenomenon is commonly referred to as biomagnification (e.g., see Newman, 1998).

Biomagnification is quantified within PRAM by the calculation of two separate factors, the bioconcentration factor (BCF) and the bioaccumulation factor (BAF). Both factors represent the ratio between the PCB concentration in the organism's tissues and the PCB concentration in the water. The difference between the factors is in the source of the PCBs; the BCF represents only the PCBs collected directly from the water, while the BAF represents PCBs collected from water plus PCBs collected from food (and therefore includes an organism's BCF as one of its components).

The governing equation (Equation 95) was developed specifically to describe the movement of organic chemicals such as PCBs within an aquatic food chain (Thomann, 1981, 1989; Connolly, 1991; Thomann et al., 1992). The following sections describe how Equation 95 was adapted to describe the movement of PCBs in the PRAM by extension to the ex-ORISKANY Memorial Reef.

#### 2.5.1.1 Bioconcentration Factors

BCFs represent the PCBs taken by an organism directly from the water, and therefore do not include food sources. Restating equation 95 without the food sources, we have the steady-state concentration of PCBs contributed directly from the water:

(98) $$\frac{\Delta C_i}{\Delta t} = 0 = \left(Ku_i \times C_w\right) - \left[\left(Ke_i + G_i\right) \times C_i^{ss}\right]$$

We can then solve for the BCF as follows:

(99) $$BCF_i\left[\frac{L}{kg_{lp}}\right] = \frac{C_i^{ss}}{C_w} = \frac{Ku_i\left[\frac{L}{kg_{lp} \cdot d}\right]}{Ke_i\left[\frac{1}{d}\right] + G_i\left[\frac{1}{d}\right]}$$

PRAM uses equation 99 to calculate the BCF of all organisms except the algae. Algae (free floating or attached to the sunken vessel) are assumed to act primarily as sorption material for PCBs freely dissolved in the water column. As such, the concentration within algae is dependent on the adsorbent (lipid) concentration within the algae, which can be directly related back to the PCB's octanol-water partition coefficient ($K_{ow}$ – e.g., see Thomann, 1989). However, for chemicals with a log$K_{ow}$ greater than 5.0, the algal BCF becomes constant (see Spacie et al., 1995; Connolly, 1991):

(100)
$$\begin{aligned}
&\textit{if} \quad \log K_{ow} \le 5.0 \\
&\textit{then}; \\
&BCF_{ag}\left[\frac{L}{kg_{lp}}\right] = K_{ow} \\
&\textit{if} \quad \log K_{ow} > 5.0 \\
&\textit{then}; \\
&BCF_{ag}\left[\frac{L}{kg_{lp}}\right] = 10^5
\end{aligned}$$

where:

$BCF_{ag}$ = bioconcentration factor for algae (*ag*) exposed to freely dissolved PCB water concentrations

$K_{ow}$ = octanol-water partition coefficient

The floating algae are considered to be solely exposed to PCBs dissolved in the water above the pycnocline ($C_{wu}$) whereas attached algae on the sunken vessel are assumed to be exposed solely to PCBs dissolved in the water below the pycnocline ($C_{wl}$).

#### 2.5.1.2 Tissue Concentrations

The concentration of PCBs in an organism's tissue is derived from Equation 95 and utilizes the BCF term calculated in Equation 99. First, Equation 95 is solved for the steady-state concentration of PCBs in tissue:

$$(101)\; C_i^{ss} = \frac{Ku_i \times C_w}{Ke_i + G_i} + \frac{\sum_{j=1}^{n}\left(\alpha I_{i,j} C_j^{ss}\right)}{Ke_i + G_i}$$

Substituting the BCF from Equation 99 into Equation 101 we have the governing equation for calculation of tissue concentrations in PRAM:

$$(102)\; C_i^{ss}\left[\frac{mg_{PCB}}{kg_{lp}}\right] = BCF_i\left[\frac{L}{kg_{lp}}\right] \times C_{w,i}\left[\frac{mg_{PCB}}{L}\right] + \frac{\alpha[unitless]}{\left(Ke_i\left[\frac{1}{d}\right] + G_i\left[\frac{1}{d}\right]\right)}\sum_{j=1}^{n}\left(I_{i,j}\left[\frac{1}{d}\right]C_j^{ss}\left[\frac{mg_{PCB}}{kg_{lp}}\right]\right)$$

where:

$C_{w,i}$ = weighted average of all water concentrations to which organism *i* is exposed

For Trophic Level I primary producers, who consume no other organisms (n = 0), this equation is a function of only the water concentration and the $BCF_{ag}$ term presented in equation 100. For all other organisms, the tissue concentrations of the prey organisms they consume must be computed first and entered into equation 102.

In Equation 102, it is necessary to utilize a weighted average of all PCB water concentrations to which an organism is exposed since most species spend their time in multiple compartments with different water concentrations. For example, most pelagic species spend time both above and below the pycnocline. The weighted average is calculated from the fraction of time spent in each compartment as follows:

$$(103)\ C_{w,i}\left[\frac{mg_{PCB}}{L}\right]=\sum_{c=1}^{n}\left(f_{c,i}[unitless]\times C_{w,c}\left[\frac{mg_{PCB}}{L}\right]\right)$$

where:

$c$ = compartment of unique water concentration (above pycnocline, below pycnocline, inside vessel or sediment pore water)

$n$ = number of compartments to which an organism is exposed

$f_{c,i}$ = fraction of time organism $i$ spends in compartment $c$

$C_{w,c}$ = concentration of PCBs in water of compartment $c$

Since all tissue concentrations in PRAM are calculated on a lipid-normalized basis, the concentrations of the PCB homologs in the whole organism are calculated from equation 102 as follows:

$$(104)\ C_{ww,i}^{ss}\left[\frac{mg_{PCB}}{kg_{ww}}\right]=C_{lp,i}^{ss}\left[\frac{mg_{PCB}}{kg_{lp}}\right]\times f_{lp,i}\left[\frac{kg_{lp}}{kg_{dw}}\right]\times\left(1-f_{moist,i}\right)\left[\frac{kg_{dw}}{kg_{ww}}\right]$$

where:

$C^{ss}_{ww,i}$ = steady-state concentration of PCBs in whole organism $i$

$C^{ss}_{lp,i}$ = steady-state concentration of PCBs in lipid tissue of organism $i$ ($C^{ss}_{i}$ term from equation 102)

$f_{lp,i}$ = fraction of lipids in dry tissue of organism $i$ (see Table 7)

$f_{moist,i}$ = fraction of water in organism $i$ (see Table 7)

#### 2.5.1.3 Bioaccumulation Factors

BAFs are similar to BCFs since they both represent the ratio between the PCB concentration in the organism's tissue and the PCB concentration in the surrounding water; however, the BAFs represent the PCBs contributed to the organism's tissues by both the surrounding water and the food eaten by the organism. By including both major PCB sources, the BAF term serves as an indicator of the total PCB accumulation in the organism's tissues. PRAM calculates BAFs directly by utilizing the lipid-based tissue concentrations from Equation 102 and the average water concentrations from Equation 103:

$$(105)\ BAF_i\left[\frac{L}{kg_{lp}}\right] = \frac{C_i^{ss}\left[\frac{mg_{PCB}}{kg_{lp}}\right]}{C_{w,i}\left[\frac{mg_{PCB}}{L}\right]}$$

### 2.5.2 Derivation of Rate Constants

The concentrations of the various food web components described above are all based on either a wet-weight or lipid-weight basis. To convert to either a lipid-based or a dry weight-weight basis, values presented in Table 7 are used.

The algorithms previously described are based on thermodynamic kinetics and, as such, require rate constants. Specifically these rate constants include:

- Ingestion rates and dietary assimilation efficiencies.
- Growth rates.
- Uptake rate constants and assimilation efficiencies for water exposure.
- Elimination and metabolism rate constants.

#### 2.5.2.1 Oxygen Consumption Rates, Dietary Ingestion Rates, and Bioenergetics

To estimate the dietary ingestion rates and growth rates for the animals within the PRAM, daily energy (calorie) requirements are calculated based on oxygen consumption. The total energy consumption, or maintenance energy budget (energy in = energy out), of an organism is described by the following relationship (e.g., see Jobling, 1994 and Welch, 1968):

$$(106)\ Cn\left[\frac{kcal}{d}\right] = G\left[\frac{kcal}{d}\right] + R\left[\frac{kcal}{d}\right] + F\left[\frac{kcal}{d}\right] + U\left[\frac{kcal}{d}\right]$$

where:
Cn = metabolic energy consumption of the organism
G = metabolic energy usage for production (i.e., growth and reproduction) – not to be confused with the growth rate (G) term presented in Equations 93 – 95
R = metabolic energy usage by tissues (derived from respiration)
F = energy loss due to fecal excretion

U = energy loss due to urinary excretion
d = day
kcal = kilocalories

The ingestion rate of an aquatic animal must meet these energy requirements to survive. Welch (1968) and Parsons et al. (1977) provide the energy budgets for aquatic animals [note that Welch (1968) combined energy loss due to fecal (F) and urinary (U) excretion as total excretion (EX)] as presented in Table 7. Using the energy budget, oxygen consumption rates can be used to estimate metabolic rates, which in turn can be used to estimate food ingestion rates (e.g., see USEPA, 1993).

Oxygen consumption rates are temperature-dependent and weight-dependent in aquatic animals, and can be calculated using allometric regressions derived from experimental data (see Connolly, 1991; Altman and Dittmer, 1971; Hewett and Johnson, 1992; USEPA, 1993, Barber, 2003; Thurston and Gehrke, 1993; and Kline, 2004). PRAM respiration rates are based upon the equation presented by Connolly (1991, Equation 10), which calculates respiration as a metabolic rate with units of ($d^{-1}$). Except for benthic foraging invertebrates, represented by the lobster, respiration for all invertebrate compartments in the food web is based solely on temperature and normalized to body weight. For these species the $\beta_1$ term in Equation 107 is zero. All of the vertebrate compartments within the food web, and the benthic foraging invertebrate, are represented by a regression that includes a weight as well as temperature component. For these species the $\beta_1$ term in Equation 107 is non-zero. The governing equation for respiration of all species is:

(107) $$r\left[\frac{1}{d}\right] = \alpha W[g]^{\beta_1} e^{\beta_2 \left(T\left[{}^{o}C\right]\right)}$$

where:
$r$ = oxygen consumption rate [$d^{-1}$]
W = organism body wet weight in grams [g]
T = temperature [$^{o}$C]
$\alpha$ = allometric intercept
e = the base of the natural logarithm
$\beta_1$, $\beta_2$ = allometric slopes for body weight and temperature, respectively

PRAM uses direct respiration rates with units of $g_{O2}\cdot kg_{lp}^{-1}\cdot d^{-1}$; therefore, the rate provided by Equation 107 must be converted from a metabolic rate. The conversion is done by using the three factors presented in Equation 108: $a_{oc}$, $a_c$, and f. Values for $a_{oc}$ and $a_c$ have been obtained from Thomann (1989). The conversion has been calculated in PRAM as follows where the subscript *i* represents organism *i*:

(108) $$r'_i\left[\frac{gO_2}{kg_{lp}\cdot d}\right]=r\left[\frac{1}{d}\right]\times\frac{a_{oc}\left[\frac{gO_2}{gC}\right]\times a_c\left[\frac{gC}{g_{dw}}\right]\times\left(\frac{1000g_{lp}}{kg_{lp}}\right)}{f_{lp,i}\left[\frac{g_{lp}}{g_{dw}}\right]}$$

where:

$r'_i$ = oxygen consumption rate [$g_{O2}\cdot kg_{lp}^{-1}\cdot d^{-1}$]
$g_{O2}$ = oxygen [g]
$kg_{lp}$ = mass of lipids in fish (kg)
$a_{oc}$ = stoichiometric oxygen/carbon ratio (2.67 $g_{O2}\cdot g_C^{-1}$ for all species)
$a_c$ = fraction of carbon in dry weight (0.45 $g_C\cdot g_{dw}^{-1}$ for all species)
$f_{lp,i}$ = fraction lipids in dry tissue of organism *i* (see Table 7)

Table 8 and Appendix E provide allometric intercepts and slopes compiled or derived from the peer-reviewed scientific literature for the food web compartments.

Rather than calculating metabolic energy consumption rates or food ingestion rates directly from Equation 106, they can instead be estimated from respiration metabolic rates based on kilocalories. The oxygen consumption rates developed from Equation 108 are converted to a kilocalories basis (Equation 109) using: (1) the molar volume of oxygen under average site conditions,[29] and (2) an approximate conversion factor of 4.8 calories = 1 mL of $O_2$ (USEPA, 1993). The overall metabolic energy consumption rate is then estimated from the respiration metabolic rate by dividing by the fraction of metabolism dedicated to respiration:

[29] At standard ambient temperature and pressure (SATP; 25°C and 1atm), the molar volume of an ideal gas equals 24.47L. Therefore, there are $4.087\times10^{-5}$ moles per mL of an ideal gas at SATP. Given the molecular weight of $O_2$ (~32g/mol), there are 0.00131g of $O_2$ per mL $O_2$ at SATP.

$$(109)\quad Cn_i\left[\frac{kcal}{kg_{lp}\cdot d}\right]=\frac{r_i^{'}\left[\frac{gO_2}{kg_{lp}\cdot d}\right]\times\frac{1mLO_2}{0.00131gO_2}\times\frac{0.0048kcal}{1mLO_2}}{f_{resp,i}}$$

where:

$f_{resp,i}$ = fraction of organism's energy budget devoted to respiration (see Table 7). Per Welch (1968), the energy budget (Equation 106) can be thought of as fractions where Cn = 1 and each energy component is less than 1.

To calculate the respective oxygen consumption rates for each of the food chain organisms, temperature and body weights are required. Additionally, since the goal is to first estimate the ingestion rates of the animals within the food chain model on a mass basis, caloric densities of prey organisms are required and are presented along with body weights in Table 7.

For example, assuming a lower water column temperature of 19.5°C, the following respiration rates and total energy consumption estimates are calculated for flounder:

$$r_{flounder}\left[\frac{1}{d}\right]=0.0046(3000)^{-0.24}e^{(0.067\times19.5)}=0.00249\left[\frac{1}{d}\right]$$

$$(110)\quad r_{flounder}'\left[\frac{gO_2}{kg_{lp}\cdot d}\right]=0.00249\left[\frac{1}{d}\right]\times\frac{2.67\times0.45\times1000}{0.22}=13.58\left[\frac{gO_2}{kg_{lp}\cdot d}\right]$$

$$Cn_{flounder}=\frac{\frac{13.58\,gO_2}{kg_{lp}\cdot d}\times\frac{0.0048}{0.00131}}{0.6}=82.9\left[\frac{kcal}{kg_{lp}\cdot d}\right]$$

#### 2.5.2.2 Total Energy Consumption and Ingestion Rates

To convert energy consumption to a mass ingestion rate requires converting food calories to food mass:

$$(111)\quad I\left[\frac{kg_{lp}}{kg_{lp}\cdot d}\right]=\frac{Cn\left[\frac{kcal}{kg_{lp}\cdot d}\right]}{\left(\lambda\left[\frac{kcal}{kg_{lp}}\right]\times AE\right)}$$

where:

I = mass ingestion rate (i.e., $[kg_{lp(food)}\cdot kg_{lp(body)}{}^{-1}\cdot d^{-1}]$)

$C_n$ = caloric ingestion rate

λ = caloric density of food item

AE = assimilation efficiency or fraction metabolizable calories of food item

To estimate the caloric content of sediment and suspended sediment within the system and consumed by filter feeders and other detritivores, the composition of the sediment and its edible fraction (detritus) need to be considered. In littoral zones, flowing rivers, and wetlands, detritus is primarily composed of vascular plant material, while in estuaries, bays, and the open ocean, detritus is derived largely from algae (e.g., see Mason and Varnell, 1996; Valiela, 1995; Parsons et al., 1977). Caloric content of salt marsh bulrush ranges from 3.2 kcal·g-dry weight$^{-1}$ to 4.8 kcal·g-dry weight$^{-1}$ (USGS, 2002), which compares well with the aquatic vascular plant caloric contents as reported by USEPA (1993), 4.0 to 4.3 kcal·g-dry weight$^{-1}$. Algae are reported to have a much lower caloric content (2.36 kcal·g-dry weight$^{-1}$; USEPA, 1993). For the artificial reefs, PRAM assumes that the detritus present is derived from algae. According to Mason and Varnell (1996), the half-life for the decomposition of plant material in a salt marsh ranges from 18 to 350 days depending on the local conditions. To increase the probability of overestimating exposure, the detritus present is considered to be at 50% of its original caloric content as algae or 1.18 kcal·g-dry weight$^{-1}$ (1,180 kcal·kg-dry weight$^{-1}$).

Given a dry-weight lipid content for algae of 0.103 kg-lipid·kg-dry weight$^{-1}$ (Table 7), the caloric content of sediment-associated detritus within the PRAM is approximately 11,456 kcal·kg-lipid$^{-1}$ (1,180 kcal·kg-dry weight$^{-1}$ ÷0.103 kg-lipid·kg-dry weight$^{-1}$). It is further assumed that one-kilogram of lipid is equivalent to one-kilogram of organic carbon

(Thomann et al., 1992 and others); thus the caloric content of organic carbon in the sediment is estimated to be 11,456 kcal·kg-organic carbon$^{-1}$.

On a lipid basis, total ingestion is expressed by denoting each dietary preference as a fraction of the total diet as $f_{\text{diet}}$ (decimal fraction) as follows:

$$(112)\quad I_i = \sum_{j=1}^{n} I_{i,j}\left[\frac{kg_{lp}}{kg_{lp}\cdot d}\right] = \sum_{j=1}^{n}\left(\frac{Cn_i\left[\frac{kcal}{kg_{lp}\cdot d}\right]\times f_{diet\,i,j}}{\lambda_j\left[\frac{kcal}{kg_{lp}}\right]\times AE_j}\right)$$

where:

$I_{i,j}$ = mass ingestion rate of dietary item *j* by organism *i* (i.e., [$kg_{lp(food)}\cdot kg_{lp(body\ weight)}{}^{-1}\cdot d^{-1}$])

$Cn_i$ = caloric ingestion rate of organism *i*

$f_{diet\ i,j}$ = fraction of dietary item *j* in *i* diet

$\lambda_j$ = caloric density of dietary item *j*

n = number of dietary items in *i* diet

j = specific dietary item *j*

$AE_j$ = assimilation efficiency or fraction metabolizable calories of dietary item *j*

Using the flounder diet as an example, 2% is bottom sediments, 20% is polychaete, 20% is nematode, and 58% is lobster. Furthermore, using the caloric densities derived from Table 7 data, the caloric density of sediments as calculated above, the assimilation efficiencies (Fraction Metabolizable Energy from Gross) given in Table 7, and the flounder caloric ingestion rate of 82.9 [kcal $\cdot kg_{lp}{}^{-1}\cdot d^{-1}$] from Equation 110; we calculate the flounder ingestion rates as follows:

$$(113)\quad I_{fl,oc} = \frac{\dfrac{82.9\,kcal}{kg_{lp}\cdot d}\times 0.02}{\dfrac{11{,}456\,kcal}{kg_{oc}}\times 0.60} = 0.000241\left[\frac{kg_{oc}}{kg_{lp}\cdot d}\right]$$

$$I_{fl,nt} = \frac{\dfrac{82.9\,kcal}{kg_{lp}\cdot d}\times 0.20}{\dfrac{76{,}923\,kcal}{kg_{lp}}\times 0.65} = 0.000332\left[\frac{kg_{lp}}{kg_{lp}\cdot d}\right]$$

$$I_{fl,pc} = \frac{\dfrac{82.9\,kcal}{kg_{lp}\cdot d}\times 0.20}{\dfrac{76{,}923\,kcal}{kg_{oc}}\times 0.65} = 0.000332\left[\frac{kg_{lp}}{kg_{lp}\cdot d}\right]$$

$$I_{fl,lb} = \frac{\dfrac{82.9\,kcal}{kg_{lp}\cdot d}\times 0.58}{\dfrac{29{,}412\,kcal}{kg_{lp}}\times 0.65} = 0.000252\left[\frac{kg_{lp}}{kg_{lp}\cdot d}\right]$$

#### 2.5.2.3 Assimilation Efficiencies Across Gastrointestinal Tracts

The assimilation efficiency ($\alpha$) used in the governing equation (Equation 95) is specific to the chemical being assimilated and is not necessarily directly related to the assimilation efficiency of foodstuffs[30] (e.g., see Gobas et al., 1988; Endicott et al., 1991; Connolly, 1991; and Fisk et al., 1998). All of these authors have attempted to develop a relationship between a chemical octanol-to-water partition coefficient ($K_{ow}$) and the assimilation of the chemical across the gastrointestinal tract. Based on data collected by Gobas et al. (1988) for various hydrophobic organic compounds, the following non-linear regression was developed (Gobas et. al, 1988; Equation 2):

$$(114)\quad 1/\alpha = 5.3\times 10^{-8} K_{OW} + 2.3$$

[30] Matrix effects associated with the assimilation of chemicals have been identified, but the process of actually crossing the gastrointestinal tract is believed to be most associated with lipidophilicity (see Spacie and Hamelink, 1995; Kleinow and Goodrich, 1993).

where:

$\alpha$ = assimilation efficiency across gastro-intestinal tract (fraction)

$K_{ow}$ = octanol-to-water partition coefficient [$L \cdot kg^{-1}$]

Endicott et al. (1991, Equations 38a, 38b, and 38c) found the following relationships based on a review of the available data collected from the scientific literature, again hydrophobic organic compounds. Where the chemical $\log_{10}K_{ow}$ was below 6, $\alpha$ was equal to 0.90. For $\log_{10}K_{ow}$'s between 6 and 6.6 the following relationship was described:

$$(115)\ \alpha = 37.9 - 11.216\log_{10} K_{ow} + 0.8409(\log_{10} K_{ow})^2$$

For chemicals with a $\log_{10}K_{ow}$ greater than 6.6, Endicott et al. (1991) found that $\alpha$ was equal to 0.50. The degree of fit of the data and the relationships described by Endicott et al. (1991) is graphically presented but not extensively discussed in the manuscript. It is notable that no chemicals with a $\log_{10}K_{ow}$ below 4 appear to have been evaluated by Endicott et al. Further, the fit associated with chemicals with a $\log_{10}K_{ow}$ greater than 7 are very poor.

Fisk et al. (1998) similarly attempted to fit the relationship between $K_{ow}$ and growth-adjusted $\alpha$ through regression analysis. These investigators recognized that assimilation efficiency data collected from the scientific literature might be affected by variable experimental designs, especially in consideration of foodstuff types, feeding rates, and complications associated with potential water exposures in addition to exposure through the food. These investigators used data collected from their experimentation only to develop a regression between $K_{ow}$ and dietary assimilation. The form of the regression developed was parabolic with the form:

$$(116)\ \log_{10} \alpha = -1.8 + \log_{10} Kow - (0.08\log_{10} Kow^2)$$

This regression was statistically significant (p=0.004), but the explained variation was low ($r^2$ = 0.53 where only 53% of the variation of $\alpha$ is explained by the regression).

It is clear that the methods and results described above are very different. It is notable that the efficiencies reported by Fisk et al. (1998) were specific to dietary exposures only, while many of the studies used by Endicott et al. (1991) relied on field observations. Figure 9 presents these estimation regressions across a range of $K_{ow}$s. The significant difference that lies within the $\log_{10}K_{ow}$ range from 5 to 7 is particularly troublesome. This range encompasses the majority of the bioaccumulative PCBs at issue within the PRAM.

Review of the raw data suggested that the form of the relationship between $K_{ow}$ and $\alpha$ is perhaps best described as a parabolic function. A parabolic function was calibrated such that virtually all of the reported assimilation efficiencies fell below the predicted values. This probably tends to result in overestimates of exposure. The resultant algorithm is presented below and graphically compared to the observed values reported by Gobas et al. (1988), Thomann (1989), and Fisk et al. (1998) in Figure 9.

$$(117)\ \alpha = \frac{10^{-1.8+1.08\log Kow-0.08\log Kow^2}}{100}$$

### 2.5.2.4 Uptake Rate Constants and Assimilation Efficiencies Across Respiratory Tissues

The uptake rate ($Ku_i$) of a PCB can be calculated based on the respiration of the organism (r’) and the relative assimilation efficiency between a chemical and oxygen (E) across respiratory tissue (e.g., see Thomann, 1989; Connolly, 1991):

$$(118)\ Ku_i\left[\frac{L}{kg_{lp}\cdot d}\right] = E\times\frac{r_i'\left[\frac{gO_2}{kg_{lp}\cdot d}\right]}{C_{O_2}\left[\frac{gO_2}{L}\right]}$$

where:

$Ku_i$ = uptake rate constant for water in organism *i*

E = ratio between the assimilation efficiency for a chemical across respiratory tissue over the assimilation efficiency for oxygen across respiratory tissue (dimensionless)

$r_i'$ = oxygen consumption rate

$C_{O2}$ = dissolved oxygen concentration in water

The ratio between the assimilation efficiency for oxygen and that for a chemical has been related to the octanol-water partition coefficient ($K_{ow}$) of the chemical (Thomann, 1989, Equation 22), such that E can be derived from the chemical $\log_{10}K_{ow}$ and the body weight (wet weight) range of the organism(s). For chemicals with a $\log_{10}K_{ow}$ between 2 and 5 and organisms weighing less than 100 grams, E can be calculated using the following relationship (Thomann, 1989):

$$(119)\ \log_{10} E = -2.6 + 0.5 \log_{10} Kow$$

Where the $\log_{10}K_{ow}$ is between 5 and 6 and the organism is less than 100 grams in body weight, E is equal to 0.80. Where the $\log_{10}K_{ow}$ is between 6 and 10, E can be calculated as follows:

$$(120)\ \log_{10} E = 2.9 - 0.5 \log_{10} Kow$$

A different set of relationships between $\log_{10}K_{ow}$ and E apply for organisms greater than 100 grams in body weight (Thomann, 1989). Where $\log_{10}K_{ow}$ is between 2 and 3:

$$(121)\ \log_{10} E = -1.5 + 0.4 \log_{10} Kow$$

Where the $\log_{10}K_{ow}$ is between 3 and 6, E is equal to 0.50, and where the $\log_{10}K_{ow}$ is between 6 and 10:

$$(122)\ \log_{10} E = -1.2 + 0.25 \log_{10} Kow$$

This approach to estimate the efficiency of the transfers of PCBs across respiratory tissues for invertebrates, however, is not the most accurate and theoretically appropriate for fish (Barber, 2003). Barber (2003) suggests a correction to the uptake rate that is appropriate for fish and has been incorporated into the PRAM:

$$(123)\quad Ku_{fish-i}\left[\frac{\mathrm{cm}^3}{\mathrm{g}_{\mathrm{ww}}\cdot d}\right] = 0.343 \times \left(\frac{1400\mathrm{W}[\mathrm{g}-\mathrm{ww}]^{-0.4}\,\mathrm{K}_{\mathrm{ow}}}{100+\mathrm{K}_{\mathrm{ow}}}\right)^{1.048}$$

where:

| | | |
|---|---|---|
| $Ku_{fish\text{-}i}$ | = | uptake rate constant for water in fish *i* |
| W | = | fish body weight in grams wet weight (ww) |

Unit conversions of Barber's uptake rate are accomplished in PRAM as follows:

$$(124)\quad \mathrm{Ku}_{fish-i}\left[\frac{\mathrm{L}}{\mathrm{kg}_{\mathrm{lp}}\cdot \mathrm{d}}\right]=\mathrm{Ku}_{fish-i}\left[\frac{\mathrm{cm}^3}{\mathrm{g}_{ww}\cdot \mathrm{d}}\right]\times\left(\frac{1}{(1-\mathrm{f}_{moist,i})}\frac{\mathrm{g}_{\mathrm{ww}}}{\mathrm{g}_{\mathrm{dw}}}\right)\times\left(\frac{1}{\mathrm{f}_{lp,i}}\frac{\mathrm{g}_{\mathrm{dw}}}{\mathrm{g}_{lp}}\right)\times\left(\frac{1000\ g_{lp}}{kg_{lp}}\right)\times\left(\frac{1\,L}{1000\ cm^3}\right)$$

2.5.2.5 Depuration Rates (Elimination and Metabolism)

Depuration is the sum of the loss due to metabolism and/or excretion of the PCB. When assuming no growth, the lipid-based elimination rate ($Ke_i$) can be related to the $K_{ow}$ (Thomann, 1989; also Connolly, 1991) and the uptake rate constant such that:

$$(125)\ Ke_i\left[\frac{kg_{PCB}}{kg_{lp}\cdot d}\right]=\frac{Ku_i}{Kow}$$

This excretion rate does not account for any metabolism of the chemical by the animal. For certain PCBs (e.g., the heavy PCB series such as hepta-CB, octa-CB, etc.), such an assumption is valid, but for less chlorinated forms (e.g., mono-CBs, di-CBS, and tri-CBs), this assumption is not valid. To account for at least a minimal metabolism of the PCBs, the following $K_{ow}$ – elimination ($Ke$) regression based on larval saltwater fish was evaluated (obtained from Petersen and Kristensen, 1998, Table 4):

$$(126)\ \log_{10} Ke\left[\frac{1}{d}\right]=3.25-0.66\times\log_{10} Kow$$

The metabolic activities of larval fish are quite limited (Peterson and Kristensen, 1998) and the modeled metabolism would be underestimated for many of the more juvenile and adult forms.

A similar approach was taken where additional elimination rate constants, as obtained from the literature, were evaluated in the context of the algorithm obtained from Peterson and Kristensen (1998) to assure that the algorithm produces conservative estimates. A new regression of elimination rates (Figure 10) reported by Peterson and Kristensen (1998), Thomann (1989) and Fisk et al. (1998) result in slightly lower predicted Ke than that of Petersen and Kristensen (1998):

$$(127)\ \log_{10} Ke\left[\frac{1}{d}\right] = 1.065 - 0.4131 \times \log_{10} Kow$$

In spite of the metabolism that occurs in many species for the less chlorinated PCBs, the most conservative approach to modeling bioaccumulation in PRAM is to ignore such metabolism in all species. Gobas and Mackay (1987) developed estimates of several bioenergetic parameters by analyzing data from several other researchers. For the estimation of elimination rates, exclusive of metabolism, Gobas and Mackay derived the following relationship between $K_{ow}$ and $Ke_i$:

$$(128)\ \frac{1}{Ke_i\left[\frac{kg_{PCB}}{kg_{lp} \cdot d}\right]} = 0.00089 Kow + 0.075$$

Gobas and Mackay compared this equation to experimental data obtained by other researchers for PCBs in fish and found that it fit the data well. Although it does not include any metabolism of the PCBs, equation 128 has been used in PRAM to estimate depuration rates.

#### 2.5.2.6 Derivation of Growth Rates from Bioenergetic Budget

To estimate the temperature-related growth rate of an organism (G), the bioenergetic budgets of the organism are once again used. The growth rate (G) is calculated from the relationship between Cn and G (assuming G includes reproduction – see Welch, 1968) and the caloric density ($\lambda$) of the organism:

$$(129)\ G_i\left[\frac{\mathrm{kg_{lp}}}{\mathrm{kg_{lp}} \cdot \mathrm{d}}\right] = \frac{\left(Cn_i\left[\frac{kcal}{kg_{lp} \cdot d}\right] \times f_{grow,i}\right)}{\lambda_i\left[\frac{kcal}{kg_{lp}}\right]}$$

To reiterate the energy budget for flounder, 20% is used for production (growth and reproduction – Table 7). Thus, the flounder growth rate, for example, is calculated as follows:

$$(130)\ G = \frac{\dfrac{82.9\ kcal}{kg_{lp} \cdot d} \times 0.20}{\dfrac{22{,}272\ kcal}{kg_{lp}}} = 7.44 \times 10^{-4} \left[\frac{1}{d}\right]$$

## 2.6 SENSITIVITY ANALYSES

The purpose of a sensitivity analysis is to demonstrate a model's responses to alterations in uncertain input parameters. A sensitivity analysis provides the data necessary to rank the input parameters according to their influence on the model results. By ranking the parameters, one can identify those variables that require further investigation and define those variables to be used in an uncertainty analysis. Such a sensitivity analysis was performed on earlier versions of PRAM.

### 2.6.1 PRAM Version 1.1 Testing

Based on the sensitivity testing performed in 2001 on an earlier version of PRAM, which predated the review of the model, the parameters that were among the most sensitive for all types of fish were:

- $Log_{10}K_{ow}$ (log of the octanol to water partitioning coefficient)
- $Log_{10}K_{oc}$ (log of the organic carbon to water partitioning coefficient)
- Zone of influence - multiplier
- Sediment fraction organic carbon

Overall, the parameter groups that seemed to be the most sensitive were PCB inputs and environmental inputs.

### 2.6.2 PRAM Version 1.2 Testing

A more detailed sensitivity analysis was conducted for Version 1.2 of PRAM. PRAM Version 1.2 included refinements on several model variables, but the greatest improvement was the incorporation of additional exposure associated with the interior of the vessel. This version of PRAM contained 82 parameters:

- 18 human health exposure assumptions, oral reference doses, and cancer slope factors (Parameters 1 to 18 of the model);
- 17 bio-energetic inputs and dietary preferences for representative fish and shellfish species (Parameters 66 to 82 of the model); and
- 47 physical characteristics, PCB chemical properties, and biological characteristics (Parameters 19 to 65 of the model).

The first 18 parameters were not tested in the sensitivity analysis. A baseline PRAM scenario was designated as a benchmark. During the sensitivity analysis, each of the remaining parameters was varied from their respective baseline values one at a time over a range of values representative of the parameter. For each sensitivity scenario, the reasonable maximum exposure (RME) and central tendency exposure (CTE) for both cancer and non-cancer risks were calculated. This sensitivity analysis was conducted in a three-phased approach:

- **<u>Physical/Chemical Inputs</u>**. Sensitivity of calculated risk/hazard to each physical and chemical model input (Parameters 19 to 65) was evaluated in the first phase. Results were ranked for each species using a sensitivity coefficient:

$$S = \frac{|\partial R|}{(|\partial P| \;/\; P)}$$

where:

S is the normalized sensitivity coefficient which is a measure of the average change in the predicted variable per fraction change in the input variable. The higher the value of S, the more sensitive the input parameter.

$\partial$R is the difference in the predicted risk between the base case and sensitivity case

$\partial$P is the change in the input parameter between the base case and sensitivity case

P is the base input parameter value

Results were also evaluated based on a percent change in model-projected carcinogenic risk and non-carcinogenic hazard.

- **Bio-energetics/Food web.** Sensitivity of calculated risk/hazard to each bio-energetic input and dietary preference (Parameters 66 to 82) was evaluated in the second phase. These parameters consist of a series of dependent variables that had to be considered separately from the independent variables evaluated in the first phase. Results were evaluated for each type of fish using percent difference in projected carcinogenic risk or non-carcinogenic hazard:

$$PercentDifference = \frac{|\partial R|}{R}$$

where:
$\partial R$ is the change in the risk from the base case to sensitivity case
R is the base model risk value

- **PCB-Laden Materials**. Sensitivity of calculated risk/hazard to changes in the amount of PCB-laden material on board the vessel was evaluated in the third phase. Both the amount of material and the PCB release rates for each type of material were evaluated. Results were evaluated using a percent difference ranking similar to that employed in the second phase.

The sensitivity analysis conducted on PRAM Version 1.2 qualitatively ranked the degree of impact on model results stemming from relatively equivalent variations in each of the parameters evaluated. The following parameters were identified as having the greatest impact on the PRAM-calculated risk/hazards:

- Zone of influence
- Partitioning coefficients Kow and Koc
- Fraction of organic carbon in sediment and suspended solids
- Active sediment depth
- Biodegradation rate constants (PRAM default is for no biodegradation)
- Release rate of PCBs from PCB-laden materials

The results from the sensitivity analysis conducted on PRAM Version 1.2 suggested a greater propensity to decrease rather than increase risk/hazard when looking at the range of potential inputs. This indicates that the default values in the baseline case of the model probably overestimate exposure. However, it is also important to note that multiple organisms in the food chain are each affected by variables associated with both bio-energetics and dietary preferences. Some additivity among food chain components may occur, particularly to higher trophic level species. Potential additivity was not represented in the PRAM Version 1.2 sensitivity analysis.

The analysis concerning the amount of PCB-containing material indicates a link to the release rate of the material. If the individual amount of material is changed, the risk is affected by a percentage directly related to the release rate. The greatest change in risk/hazards stemming from PCB-containing materials involved felt gasket material.

### 2.6.3 PRAM Version 1.4c Testing

PRAM Version 1.4c is an enhanced version of PRAM Version 1.2. Several significant enhancements have been made to the model; however, the basic governing equations within the model itself have not changed. Therefore, knowledge gained from the extensive sensitivity analysis testing performed on previous versions of PRAM has been used to design the sensitivity analysis testing program for PRAM Version 1.4c. Two categories of input parameters were considered for the PRAM Version 1.4c sensitivity analysis:

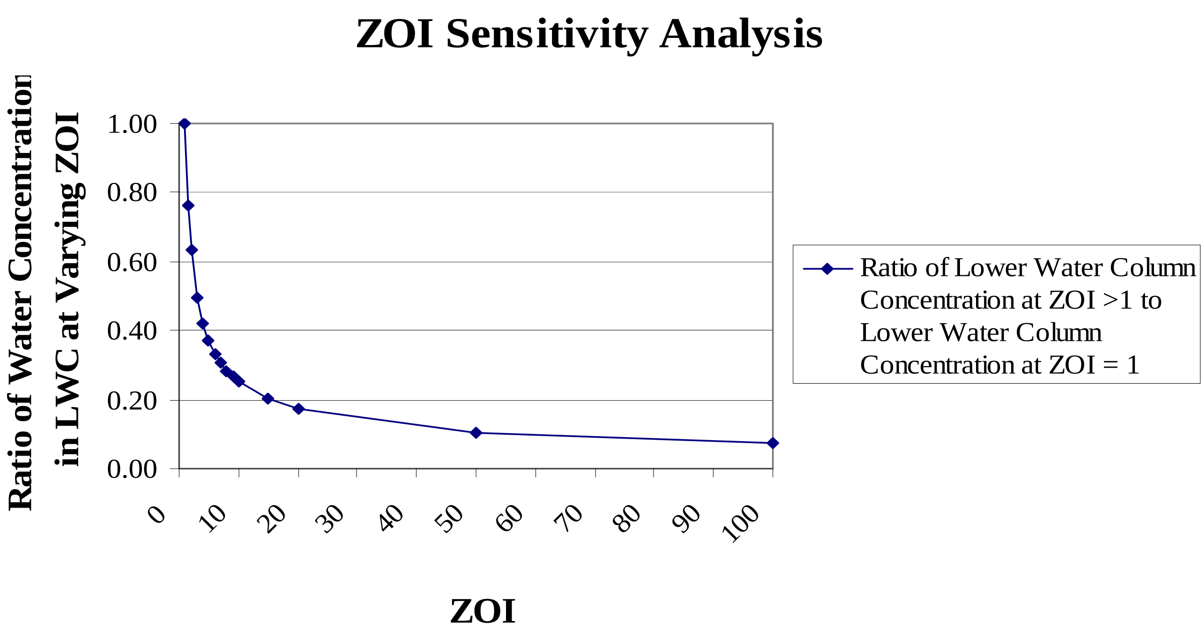
- **Abiotic Inputs**. This category includes the physical/chemical inputs and the PCB-laden materials factors that were evaluated during the PRAM Version 1.2 sensitivity analyses.
- **Bio-energetics/Food web**. This category includes the same biological parameters that were evaluated during the PRAM Version 1.2 sensitivity analyses.

**Abiotic Sensitivity Analysis**

Variations in the abiotic input parameters in PRAM Version 1.4c are expected to produce relatively similar changes in model results as occurred during the sensitivity analyses of the earlier versions of PRAM, particularly Version 1.2. Given that variation in most abiotic parameters decreased, rather than increased, the risk/hazard in PRAM Version 1.2, the sensitivity analysis for PRAM Version 1.4c focused on the model parameter that exerted the greatest effect on the PCB concentrations in the water, the Zone of Influence (ZOI). The ZOI was identified as the parameter having the greatest impact on model results in the sensitivity analyses conducted for PRAM Version 1.2 and one of the highest for PRAM Version 1.1. Also, selecting the ZOI is probably the most subjective parameter input entered into the PRAM because the ZOI artificially establishes limits within which PCB concentrations are presumed to affect the biota. For these reasons, the sensitivity analysis for abiotic parameters was limited to the ZOI.

The concept of the ZOI is explained graphically in Figure 13. The ZOI represents a volume established by extending the area of a horizontal ellipse vertically through the various layers or columns – sediment, lower water column, upper water column, and air – where the model results will be calculated. The vessel emitting the PCBs is centered within this horizontal ellipse resting on top of the sediment at the bottom of the lower water column (LWC). The resulting volume of the elliptical cylinder is determined by the area of the horizontal ellipse. The minimum volume ZOI is determined by applying the “footprint” or area of the vessel, assuming it is resting upright on the sea floor. Therefore, the minimum ZOI, or ZOI = 1, represents an ellipse with the area created by multiplying the length and the width of the vessel. The minimum ZOI must encompass the maximum horizontal area of the vessel for all of the PCB source to be included within the ZOI. Larger ZOI designations are referenced to the number of multiples of the maximum horizontal area of the vessel included within the ellipse forming the elliptical cylinder. Therefore, a ZOI = 2 means that the area of the horizontal ellipse forming the elliptical cylinder is twice the maximum horizontal vessel area; ZOI = 3 means the area is three times the vessel area; etc. The axes of the horizontal ellipse are expanded equally to produce the larger areas as the ZOI expands as shown in Figure 13.

As the ZOI expands, the resulting PCB concentrations in the various columns decline because the mass entering the system from the source (the vessel) remains constant while the volume of the elliptical cylinder increases. The impact on PCB concentrations of varying the ZOI is displayed in the following graph.




The horizontal or x-axis represents the ZOI increasing from a value of 1 which represents the minimum ZOI. The vertical or y-axis represents the ratio of the PCB concentration in the LWC at the given ZOI value divided by the maximum PCB concentration in the LWC that occurs when the ZOI = 1. The ratio represents the fractional amount of the original PCB concentration remaining as the ZOI increases. Subtracting the ratio from one provides the fractional amount that the original PCB concentration has decreased as the ZOI increases. The applicable percentages can be determined by multiplying the respective fractions by 100.

As displayed in the graph, most of the reduction in PCB concentrations occurs when the ZOI expands from 1 to 10, then the rate of PCB concentration reduction diminishes significantly as the ZOI increases to 100. At a ZOI = 1.5, the resulting ratio is approximately 0.76 indicating the original PCB concentration has decreased by about 24% when the base of the ZOI has been expanded by just 50%. When the ZOI = 3, the ratio is close to 0.50 showing that approximately 50% of the original PCB concentration is eliminated by expanding the base of the ZOI to encompass three times the maximum horizontal area of the vessel.

**Bio-energetics/Food web Sensitivity Analysis**

Five parameters involving bio-energetics and/or food web considerations were examined during the biological sensitivity analysis. These five parameters include:

- Octanol to water partition coefficient, $K_{ow}$;
- Respiration rate regression parameter β2;
- Depuration rate, Ke;
- Growth rate, G; and
- Assimilation efficiency, α.

$K_{ow}$ was identified as one of the parameters having great impact on the PRAM-calculated risks/hazards during sensitivity analyses of the earlier versions of PRAM. The respiration rate was investigated because it directly influences the degree to which aquatic organisms take up PCB constituents from other than dietary sources. The depuration rate and the growth rate were selected for sensitivity analyses because of their significant impact on the Biological Concentration Factor (BCF). The BCF represents the tendency of species to take up PCB constituents from factors other than diet. Similarly, the assimilation efficiency was chosen for sensitivity analysis due to its influence on the Biological Accumulation Factor (BAF). The BAF represents the tendency of species to take up PCB constituents from all sources, including diet.

**Octanol-to-water partition coefficient, $K_{ow}$.** The $K_{ow}$ represents the affinity PCB constituents have for entering lipids (fat tissue) in preference to remaining dissolved in water. The higher the $K_{ow}$ is, the more PCB constituents tend to be taken up by biota rather than remaining dissolved in the surrounding water. Each PCB homolog group has a specific $K_{ow}$ value as indicated in Table 2. A sensitivity analysis was conducted by varying the $K_{ow}$ from the base case ($K_{ow}$ x 1) by decreasing the value to half the base case ($K_{ow}$ x 0.5) and also by doubling the value ($K_{ow}$ x 2). The resulting percent difference in Central Tendency Exposure (CTE) risk from the base case was determined. The percent differences for cancer risk and non-cancer hazard were the same for the species included in the sensitivity analysis. The results for this sensitivity analysis are shown in the following chart:

| **CTE RISK ESTIMATES**<br>**Species** | **$K_{ow}$ x 0.5**<br>**Percent Difference** | **$K_{ow}$ x 2**<br>**Percent Difference** |
|---|---|---|
| Benthic fish TL-IV (flounder) | -23.0 | +10.6 |

| | | |
|---|---|---|
| Benthic shellfish TL-III (lobster) | -7.4 | +3.8 |
| Pelagic fish TL-IV (jack) | -33.1 | +25.8 |
| Reef fish TL-IV (grouper) | -43.1 | +43.2 |
| Reef fish TL-III (triggerfish) | -27.6 | +17.8 |
| Reef shellfish TL-III (crab) | -12.7 | +1.9 |

As depicted in the chart, reducing the $K_{ow}$ values to half the base case values for the species represented reduced the resulting PCB risks/hazards by 7% to 43%. Similarly, doubling the $K_{ow}$ values from the base case increased the resulting PCB risks/hazards by 2% to 43%. Considering that the higher trophic levels (TL-IV) tend to consume the lower trophic levels (TL-III), particularly within a specific community of biota (benthic, pelagic, or reef), the percent differences in risks stemming from variations in the $K_{ow}$ values generally are larger in the higher trophic species.

**Respiration rate regression parameter, β2.** The respiration rate represents the amount of oxygen taken up by a particular aquatic species per mass of lipids content within a single day. The respiration rate for a given species is determined by regression analysis on laboratory measurements of actual oxygen consumption. Depending on the species, this regression analysis yields either two or three coefficients that can be used with an exponential equation to estimate the respiration rate for the species as a function of temperature. Of these coefficients, the parameter designated as β2 has the most significant impact on the calculation because it is multiplied by the exponential term in the equation. Therefore, the higher the value of β2 is, the higher the respiration rate is for that particular species at a given temperature. As the respiration rate increases, the amount of PCBs taken up by the aquatic organism also increases. A sensitivity analysis was conducted by varying the β2 value from the base case (β2 x 1) by decreasing the value to half the base case (β2 x 0.5) and also by doubling the value (β2 x 2). The resulting percent difference in CTE risk from the base case was determined. The percent differences for cancer risk and non-cancer hazard were the same for the species included in the sensitivity analysis. The results for this sensitivity analysis are shown in the following chart:

| **CTE RISK ESTIMATES**<br>**Species** | **β2 x 0.5**<br>**Percent Difference** | **β2 x 2**<br>**Percent Difference** |
|---|---|---|
| Benthic fish TL-IV (flounder) | -31.1 | +55.4 |
| Benthic shellfish TL-III (lobster) | -20.0 | +25.5 |
| Pelagic fish TL-IV (jack) | -58.4 | +149.4 |

| | | |
|---|---|---|
| Reef fish TL-IV (grouper) | -41.0 | +140.7 |
| Reef fish TL-III (triggerfish) | -25.4 | +66.6 |
| Reef shellfish TL-III (crab) | -28.7 | +55.4 |

As depicted in the chart, reducing the β2 values to half the base case values for the species represented decreased the resulting PCB risks/hazards by 20% to 58%. Similarly, doubling the β2 values from the base case increased the resulting PCB risks/hazards by 25% to 149%. Considering that the higher trophic levels (TL-IV) tend to consume the lower trophic levels (TL-III), particularly within a specific community of biota (benthic, pelagic, or reef), the percent differences in risks stemming from variations in the β2 values generally are larger in the higher trophic species.

The corresponding respiration rates [$g_{O2} \cdot kg_{lipid}^{-1} \cdot d^{-1}$] varied from -45% to -76% when β2 values were reduced to half the base case values. When β2 values were doubled from the base case, the resulting respiration rates varied from +229% to +1,689%.

**Depuration rate, Ke.** The depuration rate represents the rate at which PCB constituents entering an aquatic species are eliminated from the biota rather than taken up in lipids or fat tissue. The higher the depuration rate is, the lower the BCF is for that particular species, and the resulting PCB concentrations in the biota are lower. A sensitivity analysis was conducted by varying the depuration rate from the base case (Depuration x 1) by decreasing the value to half the base case (Depuration x 0.5) and also by doubling the value (Depuration x 2). The resulting percent difference in CTE risk from the base case was determined. The percent differences for cancer risk and non-cancer hazard were the same for the species included in the sensitivity analysis. The results for this sensitivity analysis are shown in the following chart:

| **CTE RISK ESTIMATES**<br>**Species** | **Depuration x 0.5**<br>**Percent Difference** | **Depuration x 2**<br>**Percent Difference** |
|---|---|---|
| Benthic fish TL-IV (flounder) | +35.9 | -34.4 |
| Benthic shellfish TL-III (lobster) | +16.6 | -19.6 |
| Pelagic fish TL-IV (jack) | +57.1 | -43.4 |
| Reef fish TL-IV (grouper) | +76.1 | -52.0 |
| Reef fish TL-III (triggerfish) | +44.6 | -38.8 |

| CTE RISK ESTIMATES<br>Species | Depuration x 0.5<br>Percent Difference | Depuration x 2<br>Percent Difference |
|---|---|---|
| Reef shellfish TL-III (crab) | +27.5 | -27.2 |

As depicted in the chart, reducing the depuration rates to half the base case values for the species represented increased the resulting PCB risks/hazards by 17% to 76%. Similarly, doubling the depuration rates from the base case decreased the resulting PCB risks/hazards by 20% to 52%. Considering that the higher trophic levels (TL-IV) tend to consume the lower trophic levels (TL-III), particularly within a specific community of biota (benthic, pelagic, or reef), the percent differences in risks stemming from variations in the depuration rates generally are larger in the higher trophic species.

The corresponding water BCF values varied from +1% to +16% when depuration rates were reduced to half the base case values. When depuration rates were doubled from the base case, the resulting water BCF values varied from -2% to -22%.

**Growth rate, G.** The growth rate is the rate at which aquatic species increase in mass as they age. The higher the growth rate is, the lower the BCF is for that particular species, and the resulting PCB concentrations in the biota are lower. A sensitivity analysis was conducted by varying the growth rate from the base case (Growth x 1) by decreasing the value to half the base case (Growth x 0.5) and also by doubling the value (Growth x 2). The resulting percent difference in CTE risk from the base case was determined. The percent differences for cancer risk and non-cancer hazard were the same for the species included in the sensitivity analysis. The results for this sensitivity analysis are shown in the following chart:

| CTE RISK ESTIMATES<br>Species | Growth x 0.5<br>Percent Difference | Growth x 2<br>Percent Difference |
|---|---|---|
| Benthic fish TL-IV (flounder) | +526.4 | -77.8 |
| Benthic shellfish TL-III (lobster) | +302.1 | -66.5 |
| Pelagic fish TL-IV (jack) | +294.6 | -73.2 |
| Reef fish TL-IV (grouper) | +302.3 | -72.5 |
| Reef fish TL-III (triggerfish) | +206.5 | -66.0 |
| Reef shellfish TL-III (crab) | +124.2 | -56.5 |

As depicted in the chart, reducing the growth rates to half the base case values for the species represented increased the resulting PCB risks/hazards by 124% to 526%. Similarly, doubling the growth rates from the base case decreased the resulting PCB risks/hazards by 57% to 78%. Considering that the higher trophic levels (TL-IV) tend to consume the lower trophic levels (TL-III), particularly within a specific community of biota (benthic, pelagic, or reef), the percent differences in risks stemming from variations in the growth rates generally are larger in the higher trophic species.

The corresponding water BCF values varied from +57% to +96% when growth rates were reduced to half the base case values. When growth rates were doubled from the base case, the resulting water BCF values varied from -42% to -49%.

**Assimilation efficiency.** The assimilation efficiency represents the degree to which various species take up PCB constituents from their diets. As the assimilation efficiency increases, the more PCB constituents magnify in the food chain. This results in higher PCB concentrations in higher trophic species. The base case represented close to the maximum assimilation efficiency that could be expected for the species represented. Some of the species could not have their assimilation values doubled without exceeding 100%. Therefore, a sensitivity analysis was conducted by decreasing the assimilation efficiency first by 50% (Assimilation x 0.5) from the base case (Assimilation x 1) and then by 75% (Assimilation x 0.25). The resulting percent difference in CTE risk from the base case was determined. The percent differences for cancer risk and non-cancer hazard were the same for the species included in the sensitivity analysis. The results for this sensitivity analysis are shown in the following chart:

| **CTE RISK ESTIMATES**<br>**Species** | **Assimilation x 0.5**<br>**Percent Difference** | **Assimilation x 0.25**<br>**Percent Difference** |
|---|---|---|
| Benthic fish TL-IV (flounder) | -67.7 | -84.2 |
| Benthic shellfish TL-III (lobster) | -42.8 | -56.5 |
| Pelagic fish TL-IV (jack) | -69.3 | -84.9 |
| Reef fish TL-IV (grouper) | -66.2 | -81.7 |
| Reef fish TL-III (triggerfish) | -51.0 | -68.8 |
| Reef shellfish TL-III (crab) | -29.8 | -44.5 |

As depicted in the chart, reducing the assimilation efficiencies to half the base case values for the species represented decreased the resulting PCB risks/hazards by 30% to 69%. Similarly, decreasing the assimilation efficiencies to 25% of the base case decreased the resulting PCB risks/hazards by 44% to 85%. Considering that the higher trophic levels (TL-IV) tend to consume the lower trophic levels (TL-III), particularly within a specific community of biota (benthic, pelagic, or reef), the percent differences in risks stemming from variations in the assimilation efficiencies generally are larger in the higher trophic species.

The corresponding BAF values varied from -33% to -80% when assimilation efficiencies were reduced to half the base case values. When assimilation efficiencies were to a quarter of the base case, the resulting BAF values varied from -49% to -93% of the corresponding species base case BAF values.

## 2.7 MODEL UNCERTAINTIES AND LIMITATIONS

In environmental risk management, the confidence in a model, such as PRAM, to provide useful input for decision-making will increase if the model has certain attributes. These attributes may include: that the model follows USEPA guidance; has been peer reviewed; and has incorporated peer-reviewed and/or scientifically valid algorithms, and site-specific input, and that model assumptions are reasonable and plausible. The Navy has pursued these goals in the design and construction of PRAM. Moreover, a model is limited by the variables that we can account for, and the possibility that a significant variable has been missed or misrepresented. In developing the PRAM, all variables believed relevant and applicable have been incorporated, to the best of the ability of the modelers and Navy contractors. Nevertheless, the PRAM is limited by some attributes that have been incorporated as improvements and others that are intrinsic to all models and computer simulations.

### 2.7.1 Strength

The PRAM, as with any computer simulation, is limited by the quality and quantity of information upon which the predicted outcomes are based. The site-specific information provided by the Navy and its contractors concerning the type and mass of PCB-containing materials, and by the State of Florida and Escambia County concerning the environmental setting for the ex-ORISKANY, should be considered a strength for the predictions made here.

More generally, the PRAM contains a significant number of attributes that can be considered strengths:

- Leach rates data based on experiments that simulated the environment (temperature, pressure, and salinity), in which leaching of PCB from the product materials in seawater is expected to take place.

- Algorithms used for predicting the fate and transport of PCBs in the aquatic environment are well established and generally accepted by the scientific community (e.g., same basic algorithms as those used by the USEPA in the development of the PCB water quality standard for the Great Lakes).
- PCBs are modeled as homologs or groups of PCBs with similar physical, chemical, and biouptake/bioaccumulation properties, resolving the difficult issue of assessing the impacts of PCBs as a mixture in the products.
- The ability to address various classes of ships with variable amounts and types of PCB-containing bulk product materials onboard with variable PCB concentrations.
- The ability to make scenario analysis to ascertain risk-reduction benefits from a hypothetical level of mitigation of PCB-containing bulk product material.
- The design of PRAM is based on consensus reached among scientists in the TWG, resolving such issues as ZOI (horizontal and verticality extent), and diet-water compositions for various relevant species in different trophic levels.
- Relatively easy to use with the help of the GUI, and can be used to support the assessment of risks during the "transient" or pulse-release period.

The model has been checked for mathematical correctness, structure, and underlying premises. In addition to the USEPA, the Navy is also requesting review and comment from its independent reviewer, RTI.

The greatest strength of the PRAM is its capability to serve as a predictive model or tool to assist in the decision-making process associated with the use of decommissioned Navy vessels as artificial reef building material.

### 2.7.2 Limitations

"All models are wrong, but some are useful" is a common saying within the fate and transport and risk modeling community. This observation is appropriate in emphasizing to risk managers that a model is a tool for decision-making. While models attempt to predict or mimic reality based on scientific principles and assumptions, they are, in and of themselves, not faultless predictive tools. Uncertainties or limitations of PRAM include:

- The PRAM requires boundaries for the modeled environment (i.e., the PRAM models an "oval-shaped column" around the sunken vessel within the ocean – as based on the ZOI). The ZOI dimensions are based on TWG consensus and scientific justifications (Appendix F).
- The vessel is assumed and modeled as a porous material where the PCBs are moving from the interior to the exterior uniformly around the reef established on the ship.
- The PRAM assumes steady-state conditions are present.
- The PRAM does not account for the importation of water or suspended sediment containing PCBs from outside the system being modeled.
- The PRAM does not account for variable life histories of the animals within the system whereas some fish may have accumulated PCBs from juvenile rearing in ports and bays.
- The food web module in PRAM is not intended to be all encompassing; although it is based on consensus within the TWG, only significant and relevant or representative species in the food web pathway are included for biouptake/bioaccumulation.
- The PRAM has not been calibrated with empirical data, has not been updated to perform probabilistic risks to assess uncertainties, and has not been upgraded to perform multiple sunken vessel risk modeling.[31]

Uncertainties are always associated with exposure scenario and parametric variability in risk assessment modeling. Overall, PRAM is considered a useful risk management tool for the Navy REEFEX program because the program follows USEPA risk assessment methodology,

[31] Calibration against actual data (e.g., PCB concentrations in marine organisms within selected tropic levels) should help improve model accuracy and/or confidence in the model. Calibration could be achieved by adjusting bioenergetic algorithms, e.g., gastrointestinal absorption efficiency. Performance of probabilistic risk simulations is a requirement per EPA guidance to present a full-spectrum of risks, not just high-end and central tendency risks. Performance of a multiple sunken-vessel scenario would be needed if there is a plausible need to perform such risk calculations (e.g., a cluster of sunken vessels documented or purported to have PCB-containing materials is to be sunk at a specific locality). In addition, if PRAM is to be used to estimate ecological risks for comparison with benchmark values, incorporation of a more representative food web would be necessary. PRAM could also be improved to assess the risk-reduction impact of various

uses algorithms and structure accepted by the scientific community, has been validated (i.e., they were used successfully in previous applications [e.g., Connolly, 1991; USEPA, 1995]), and has undergone independent review. PRAM could be further improved, to reduce uncertainty, by calibration against empirical data.

remedial options, particularly to address the uncertainty associated with PCB-containing materials that have bi-modal or non-normally distributed data.

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**TABLES**

# Table 1

## Summary of Analysis of PCB Release Rate (Leachate) Data for Materials Found Onboard Ex-US Navy Vessels (Adapted from R. George, SSC-SD, 2004)

| Rates are presented as ng PCB/g PCB/g Material/day | Mono-chlorobiphenyls | Di-chlorobiphenyls | Tri-chlorobiphenyls | Tetra-chlorobiphenyls | Penta-chlorobiphenyls | Hexa-chlorobiphenyls | Hepta-chlorobiphenyls | Octa-chlorobiphenyls | Nona-chlorobiphenyls | Deca-chlorobiphenyls |
|---|---|---|---|---|---|---|---|---|---|---|
| **Aluminized Paint** | | | | | | | | | | |
| **PCB = 0.04%** | | | | | | | | | | |
| Maximum Rate | 0 | 0 | 261 | 1165 | 2240 | 1333 | 7191 | 0 | 0 | 0 |
| Median Rate | 0 | 0 | 0 | 283 | 1150 | 0 | 0 | 0 | 0 | 0 |
| Maximum Occurs - | --- | --- | 21 days | 7-days | 21-days | 71-days | 1-day | --- | --- | --- |
| No. Detections | 0 | 0 | 1 | 13 | 10 | 5 | 3 | 0 | 0 | 0 |
| No. Non-detections | 15 | 15 | 14 | 2 | 5 | 10 | 12 | 15 | 15 | 15 |
| *Regression Analysis* | | | | | | | | | | |
| ln(Intercept) | --- | --- | --- | 8.09E+00 | 9.74E+00 | 8.69E+00 | 8.85E+00 | --- | --- | --- |
| Slope | --- | --- | --- | -4.96E-01 | -5.70E-01 | -3.69E-01 | -7.19E-01 | --- | --- | --- |
| alpha | --- | --- | --- | 1.92E-03 | 1.67E-01 | 3.88E-01 | 1.37E-01 | --- | --- | --- |
| r2 | --- | --- | --- | 0.5985 | 0.2538 | 0.2472 | 0.9546 | --- | --- | --- |
| rate at 2-years | --- | --- | SD | 123 | NS | NS | NS | --- | --- | --- |
| ***Rate used for the PRAM*** | 0 | 0 | 261 | 123 | 2240 | 1333 | 7191 | 0 | 0 | 0 |
| **Electrical Cable** | | | | | | | | | | |
| **PCB = 0.12%** | | | | | | | | | | |
| Maximum Rate | 0 | 203 | 1.14 | 38.8 | 73 | 24.1 | 14.7 | 0 | 1.51 | 0.84 |
| Median Rate | 0 | 0 | 0 | 23 | 42 | 0 | 0 | 0 | 0 | 0 |
| Maximum Occurs - | --- | 6-days | 125-days | 40-days | 40-days | 125-days | 6-days | --- | 125-days | 125-days |
| No. Detections | 0 | 0 | 1 | 13 | 10 | 5 | 3 | 0 | 0 | 0 |
| No. Non-detections | 15 | 15 | 14 | 2 | 5 | 10 | 12 | 15 | 15 | 15 |
| *Regression Analysis* | | | | | | | | | | |
| ln(Intercept) | --- | 7.11E+00 | --- | 5.60E-01 | 5.93E+00 | 7.61E+00 | 4.00E+00 | --- | --- | --- |
| Slope | --- | -1.16E+00 | --- | -2.62E-01 | -4.62E-01 | -9.45E-01 | -6.10E-01 | --- | --- | --- |
| alpha | --- | 3.22E-01 | --- | 3.30E-02 | 3.05E-02 | 1.20E-01 | 2.52E-01 | --- | --- | --- |
| r2 | --- | 0.7655 | --- | 0.3794 | 0.3880 | 0.7741 | 0.8515 | --- | --- | --- |
| rate at 2-years | --- | NS | --- | 15.7 | 18.0 | NS | NS | --- | --- | --- |
| ***Rate used for the PRAM*** | 0 | 203 | 1.14 | 15.7 | 18.0 | 24.1 | 14.7 | 0 | 1.51 | 0.84 |

# Table 1

## Summary of Analysis of PCB Release Rate (Leachate) Data for Materials Found Onboard Ex-US Navy Vessels (Adapted from R. George, SSC-SD, 2004)

| Rates are presented as ng PCB/g PCB/g Material/day | Mono-chlorobiphenyls | Di-chlorobiphenyls | Tri-chlorobiphenyls | Tetra-chlorobiphenyls | Penta-chlorobiphenyls | Hexa-chlorobiphenyls | Hepta-chlorobiphenyls | Octa-chlorobiphenyls | Nona-chlorobiphenyls | Deca-chlorobiphenyls |
|---|---|---|---|---|---|---|---|---|---|---|
| **Bulkhead Insulation** | | | | | | | | | | |
| **PCB = 0.044%** | | | | | | | | | | |
| Maximum Rate | 0 | 8209 | 8259 | 158137 | 286990 | 53159 | 34568 | 0 | 0 | 0 |
| Median Rate | 0 | 0.0 | 2091 | 53427 | 95598 | 17305 | 0 | 0 | 0 | 0 |
| Maximum Occurs - | --- | 14-days | 7-days | 21-days | 21-days | 69-days | 1-day | --- | --- | --- |
| No. Detections | 0 | 8 | 16 | 16 | 16 | 15 | 6 | 0 | 0 | 0 |
| No. Non-detections | 17 | 9 | 1 | 1 | 1 | 2 | 11 | 17 | 17 | 17 |
| *Regression Analysis* | | | | | | | | | | |
| ln(Intercept) | --- | 1.16E+01 | 1.00E+01 | 1.38E+01 | 1.46E+01 | 1.45E+01 | 9.97E+00 | --- | --- | --- |
| Slope | --- | -1.51E+00 | -4.85E-01 | -5.89E-01 | -6.21E-01 | -8.69E-01 | -4.24E-01 | --- | --- | --- |
| alpha | --- | 8.18E-04 | 4.14E-07 | 2.63E-05 | 6.54E-04 | 1.37E-03 | 2.43E-02 | --- | --- | --- |
| r2 | --- | 0.8646 | 0.8593 | 0.8117 | 0.6672 | 0.6976 | 0.7568 | --- | --- | --- |
| rate at 2-years | --- | 5.36 | 944 | 20704 | 37917 | 6762 | 1303 | --- | --- | --- |
| ***Rate used for the PRAM*** | 0 | 5.36 | 944 | 20704 | 37917 | 6762 | 1303 | 0 | 0 | 0 |
| **Rubber Material (also used for ventilation gaskets)** | | | | | | | | | | |
| **PCB = 0.16%** | | | | | | | | | | |
| Maximum Rate | 184 | 1267 | 239 | 922 | 638 | 0 | 167503 | 0 | 0 | 0 |
| Median Rate | 57.1 | 43.5 | 82.9 | 284 | 248 | 0 | 0 | 0 | 0 | 0 |
| Maximum Occurs - | 7-days | 14-days | 14-days | 14-days | 69-days | --- | <1 day | --- | --- | --- |
| No. Detections | 12 | 14 | 14 | 14 | 14 | 0 | 4 | 0 | 0 | 0 |
| No. Non-detections | 4 | 2 | 2 | 2 | 2 | 16 | 12 | 16 | 16 | 16 |
| *Regression Analysis* | | | | | | | | | | |
| ln(Intercept) | 5.81E+00 | 7.09E+00 | 5.99E+00 | 8.50E+00 | 1.07E+01 | --- | 7.40E+00 | --- | --- | --- |
| Slope | -3.17E-01 | -6.55E-01 | -2.97E-01 | -5.36E-01 | -9.95E-01 | --- | -8.78E-01 | --- | --- | --- |
| alpha | 2.88E-08 | 7.83E-02 | 4.98E-02 | 2.22E-05 | 4.47E-03 | --- | 7.51E-03 | --- | --- | --- |
| r2 | 0.9591 | 0.2552 | 0.3063 | 0.8007 | 0.6567 | --- | 0.9850 | --- | --- | --- |
| rate at 2-years | 41.4 | NS | 56.6 | 144 | 63.1 | --- | 5.04 | --- | --- | --- |
| ***Rate used for the PRAM*** | 41.4 | 1267 | 56.6 | 144 | 63.1 | 0 | 5.04 | 0 | 0 | 0 |

# Table 1

## Summary of Analysis of PCB Release Rate (Leachate) Data for Materials Found Onboard Ex-US Navy Vessels (Adapted from R. George, SSC-SD, 2004)

| Rates are presented as ng PCB/g PCB/g Material/day | Mono-chlorobiphenyls | Di-chlorobiphenyls | Tri-chlorobiphenyls | Tetra-chlorobiphenyls | Penta-chlorobiphenyls | Hexa-chlorobiphenyls | Hepta-chlorobiphenyls | Octa-chlorobiphenyls | Nona-chlorobiphenyls | Deca-chlorobiphenyls |
|---|---|---|---|---|---|---|---|---|---|---|
| **Aroclor 1254 (used for lubricants)** | | | | | | | | | | |
| **PCB = 10%** | | | | | | | | | | |
| Maximum Rate | 554 | 1576 | 1103 | 22679 | 26356 | 2636 | 71.7 | 0 | 0 | 0 |
| Median Rate | 83.2 | 340.3 | 344.2 | 5373 | 2778 | 347 | 0 | 0 | 0 | 0 |
| Maximum Occurs - | 1-day | 1-day | 69-days | 69-days | 69-days | 69-days | 230-days | --- | --- | --- |
| No. Detections | 14 | 14 | 14 | 14 | 13 | 12 | 1 | 0 | 0 | 0 |
| No. Non-detections | 1 | 1 | 1 | 1 | 2 | 3 | 14 | 15 | 15 | 15 |
| *Regression Analysis* | | | | | | | | | | |
| ln(Intercept) | 6.96E+00 | 7.80E+00 | 1.05E+01 | 1.44E+01 | 1.57E+01 | 1.31E+01 | --- | --- | --- | --- |
| Slope | -5.17E-01 | -4.02E-01 | -9.18E-01 | -1.12E+00 | -1.40E+00 | -1.30E+00 | --- | --- | --- | --- |
| alpha | 1.97E-06 | 1.70E-06 | 5.02E-04 | 7.49E-04 | 1.57E-03 | 4.18E-03 | --- | --- | --- | --- |
| r2 | 0.8581 | 0.8614 | 0.8407 | 0.8218 | 0.7811 | 0.7131 | --- | --- | --- | --- |
| rate at 2-years | 34.7 | 172 | 89.7 | 1082 | 660 | 94 | --- | --- | --- | --- |
| ***Rate used for the PRAM*** | 34.7 | 172 | 89.7 | 1082 | 660 | 94 | 71.7 | 0 | 0 | 0 |

where:

SD = A significant number of detections were not observed to perform statistical analyses. Maximum measured rate is used.

NS = Statistical regression not significant. Maximum measured rate is used.

# Table 2

## Physical-Chemical Parameters for PCB Homologs Used in the Prospective Risk Assessment Model (PRAM)

| Chemical Parameter | Source | Mono-CB | Di-CB | Tri-CB | Tetra-CB | Penta-CB | Hexa-CB | Hepta-CB | Octa-CB | Nona-CB | Deca-CB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| log10Kow = | 1 | 4.474 | 5.236 | 5.521 | 5.922 | 6.4951 | 6.9761 | 7.19 | 7.696 | 8.351 | 9.603 |
| log10Koc = | 2 | 3.66 | 4.06 | 4.63 | 4.65 | 4.94 | 6.08 | 6.34 | 6.45 | 6.97 | 7.94 |
| log10Kdoc = | 3 | 3.34 | 4.11 | 4.39 | 4.79 | 5.36 | 5.85 | 6.06 | 6.57 | 7.22 | 8.47 |
| Molecular Weight (g/mol) | 4 | 188.65 | 223.1 | 257.54 | 291.99 | 326.43 | 360.88 | 395.32 | 429.77 | 464.21 | 498.66 |
| Solubility (mg/L) | 5 | 2.91E+00 | 6.78E-01 | 8.14E-02 | 6.67E-02 | 2.61E-02 | 9.50E-04 | 2.30E-04 | 2.11E-08 | 4.02E-09 | 1.69E-10 |
| Solubility (mol/$m^3$) | | 1.54E-02 | 3.04E-03 | 3.16E-04 | 2.28E-04 | 8.00E-05 | 2.63E-06 | 5.82E-07 | 4.91E-11 | 8.65E-12 | 3.38E-13 |
| Vapor Pressure (Pa) | 6 | 6.32E-01 | 1.41E-01 | 2.44E-02 | 2.08E-02 | 2.96E-03 | 3.43E-03 | 2.56E-04 | 8.65E-05 | 2.77E-05 | 1.41E-05 |
| Henry's (Pa-$m^3$/mol) VP/Sol | 7 | 4.10E+01 | 4.65E+01 | 7.70E+01 | 9.10E+01 | 3.70E+01 | 1.30E+03 | 4.40E+02 | 1.76E+06 | 3.20E+06 | 4.18E+07 |

1 Based on statistical analysis of data reported by Eisler and Belisle (1996)
2 Geomeans from Chou and Griffin (1986)
  hepta, octa, nona, and deca-CB are based on regression presented by Lyman (1995; equation #10)
3 Per USEPA (2002) Kow Kdoc ratio (0.074)
4 Sawhney (1986) in PCBs and the Environment
5 Geomeans from Chou and Griffin (1986) in PCBs and the Environment
  hepta, octa, nona, and deca-CB were estimated using Equation #1 in Lyman (1995)
6 Based on statistical analysis of data reported by Fiedler (2001),
  mono, hepta, octa, nona, and deca-CB based on the geomean of data reported by Oberg (2001)
7 Calculated (VP/sol) per Lyman (1995, equation #21)

# Table 3

## Example PCB Degradation Rates in Surface Water

| | Biodegradation Rate | Units | Water type | Reference | Half life | Units | Water type | Reference |
|---|---|---|---|---|---|---|---|---|
| **Homolog** | | | | | | | | |
| Monochlorobiphenyl | 2 - 5 | days for 50% biodegradation | Fresh | Bailey et al. 1983 | 1.4 - 4.9 | days | Fresh (Lake Michigan) | Neely 1983 |
| | 7.0E-08 | nmol/cell/hour | Bacterial culture with Acinetobacter | Furukawa et al. 1978 | 2 - 3 | days | Fresh | Bailey et al. 1983 |
| Dichlorobiphenyl | 2 - 3 | days | Fresh | Bailey et al. 1983 | 2 - 3 | days | Fresh | Bailey et al. 1983 |
| | 6.0E-08 | nmol/cell/hour | Bacterial culture with Acinetobacter | Furukawa et al. 1978 | | | | |
| Trichlorobiphenyl | 5.0E-08 | nmol/cell/hour | Bacterial culture with Acinetobacter | Furukawa et al. 1978 | | | | |
| Tetrachlorobiphenyl | 2.5E-08 | nmol/cell/hour | Bacterial culture with Acinetobacter | Furukawa et al. 1978 | | | | |
| | 0 | 98 day river dieaway test | Fresh | Bailey et al. 1983 | | | | |
| Pentachlorobiphenyl | | | | | | | | |
| Hexachlorobiphenyl | 1.5E-05 | $hour^{-1}$ | Not given | Mackay and Patterson 1991 | | | | |

## Table 3

## Example PCB Degradation Rates in Surface Water

| | Biodegradation Rate | Units | Water type | Reference | Half life | Units | Water type | Reference |
|---|---|---|---|---|---|---|---|---|
| **Commercial Aroclor Mixtures** | | | | | | | | |
| Aroclor 1221 | 3E-09 to 3E-12 | ml/cell/hour | transformation rate by bacteria in water | Mabey et al. 1982 | | | | |
| Aroclor 1232 | 3E-09 to 3E-12 | ml/cell/hour | transformation rate by bacteria in water | Mabey et al. 1982 | | | | |
| Aroclor 1016 | 3E-09 to 3E-12 | ml/cell/hour | transformation rate by bacteria in water | Mabey et al. 1982 | 9.9 | hours | At 1m depth in $1m^3$ water | Paris et al. 1978 |
| Aroclor 1242 | 3E-09 to 3E-12 | ml/cell/hour | transformation rate by bacteria in water | Mabey et al. 1982 | 12 | hours | Not given | Paris et al. 1978 |
| | | | | | 12 | hours | Volatilization half life at 1m depth in $1m^3$ water | Mackay and Leinonen 1975 |
| Aroclor 1248 | 3E-09 to 3E-12 | ml/cell/hour | transformation rate by bacteria in water | Mabey et al. 1982 | 10 | hours | Volatilization half life at 1m depth in $1m^3$ water | Mackay and Leinonen 1975 |
| Aroclor 1254 | 3E-09 to 3E-12 | ml/cell/hour | transformation rate by bacteria in water | Mabey et al. 1982 | 10 | hours | Volatilization half life at 1m depth in $1m^3$ water | Mackay and Leinonen 1975 |
| Aroclor 1260 | 0 | 12 weeks | Biodegradation rate, water type not given | Oloffs et al. 1972 | 7.53 | hours | Evaporation half life in 1m water | Mackay and Leinonen 1975 |
| | 3E-09 to 3E-12 | ml/cell/hour | transformation rate by bacteria in water | Mabey et al. 1982 | 10 | hours | Volatilization half life at 1m depth in $1m^3$ water | Mackay and Leinonen 1975 |
| | | | | | 52 | days | Volatilization half life in river water | Oloffs et al. 1972 |

# Table 3

## Example PCB Degradation Rates in Surface Water

| | Biodegradation Rate | Units | Water type | Reference | Half life | Units | Water type | Reference |
|---|---|---|---|---|---|---|---|---|
| **Individual Congeners** | | | | | | | | |
| Biphenyl | 9.3 - 9.8 | nmol/L-day | Marine with initial water conc. of 4.4-4.7µmol/L | Reichardt et al. 1981 | 1.5 | days | Fresh | Bailey et al. 1983 |
| | 3.2 | nmol/L-day | Marine with initial water conc. of 2.9 µmol/L | Reichardt et al. 1981 | | | | |
| 2-chlorobiphenyl | 1.1 - 3.7E-04 | $day^{-1}$ | Sunlight photolysis rate in unspecified surface water | Dulin et al. 1986 | 1.4 | days | Fresh | Neely 1983 |
| | 63 | $year^{-1}$ | Microbial degradation rate in unspecified surface water | Wong and Kaiser 1975 | 2 - 3.5 | days | 50% degradation of 1-100 µg/L in river dieaway test | Bailey et al. 1983 |
| | 4.1 | nmol/L-day | Marine with initial water conc. of 1.5 µmol/L | Reichardt et al. 1981 | 18 | years | Photolysis half life in unspecified surface water | Dulin et al. 1986 |
| | 1.2 | nmol/L-day | Marine with initial water conc. of 4.5 µmol/L | Reichardt et al. 1981 | | | | |
| | 1.1 | µg/ml/day | Degradation rate in fresh water with 30 µg/ml initial conc. | Kong and Sayler 1983 | | | | |
| 3-chlorobiphenyl | 2.6 | nmol/L-day | Marine with initial water conc. of 3.6 µmol/L | Reichardt et al. 1981 | 3 - 4 | days | 50% degradation of 1-100 µg/L in river dieaway test | Bailey et al. 1983 |
| | 1.1 | µg/ml/day | Degradation rate in fresh water with 30 µg/ml initial conc. | Kong and Sayler 1983 | | | | |
| 4-chlorobiphenyl | 0.115 - 2.3E-04 | $day^{-1}$ | Sunlight photolysis rate in unspecified surface water | Dulin et al. 1986 | 4.9 | days | Fresh | Neely 1983 |
| | 38 | $year^{-1}$ | Microbial degradation rate in unspecified surface water | Wong and Kaiser 1975 | 8.2 | years | Photolysis half life in unspecified surface water | Dulin et al. 1986 |
| | 3.1 | nmol/L-day | Marine with initial water conc. of 2.9 µmol/L | Reichardt et al. 1981 | 2 - 5 | days | 50% degradation of 1-100 µg/L in river dieaway test | Bailey et al. 1983 |
| | 2.0 | µg/ml/day | Degradation rate in fresh water with 30 µg/ml initial conc. | Kong and Sayler 1983 | | | | |

# Table 3

## Example PCB Degradation Rates in Surface Water

| | Biodegradation Rate | Units | Water type | Reference | Half life | Units | Water type | Reference |
|---|---|---|---|---|---|---|---|---|
| **Individual Congeners (continued)** | | | | | | | | |
| 2,2'-dichlorobiphenyl | 0.65 | $year^{-1}$ | Not given, microbial degradation 1st order rate constant | Furukawa et al. 1978 | 34.5 | days | Fresh | Neely 1983 |
| 2,4-dichlorobiphenyl | <2.0E-08 | $sec^{-1}$ | Sunlight photolysis rate constant in unspecified surface water | Dulin et al. 1986 | >400 | days | Photolysis half life in unspecified surface water | Dulin et al. 1986 |
| 4,4'-dichlorobiphenyl | | | | | 57.5 | days | Fresh | Neely 1983 |
| 2,2',5-trichlorobiphenyl | | | | | 43.1 | days | Fresh | Neely 1983 |
| 2,4,4'-trichlorobiphenyl | 2.2E-08 | $sec^{-1}$ | Sunlight photolysis rate constant in unspecified surface water | Dulin et al. 1986 | 133 | days | Photolysis half life in unspecified surface water | Dulin et al. 1986 |
| 2,2',4,4'-tetrachlorobiphenyl | 0 | 98 days | Fresh, river dieaway test | Bailey et al. 1983 | 49.2 | days | Fresh | Neely 1983 |
| | 0.055 - 0.553 | $day^{-1}$ | Summer sunlight photolysis rate constant in unspecified surface water | Dulin et al. 1986 | 13 | days | Summertime photolysis half life in unspecified surface water | Dulin et al. 1986 |
| | 5E-08 | $day^{-1}$ | Winter sunlight photolysis rate constant in unspecified surface water | Dulin et al. 1986 | 170 | days | Wintertime photolysis half life in unspecified surface water | Dulin et al. 1986 |
| 2,2',5,5'-tetrachlorobiphenyl | 0.1 | $year^{-1}$ | Pseudo first order rate constant in unspecified surface water | Furukawa et al. 1978 | 19.7 | days | Fresh | Neely 1983 |
| 3,3',4'4'-tetrachlorobiphenyl | | | | | 805 | days | Fresh | Neely 1983 |
| 2,2',3,4,5-pentachlorobiphenyl | 0.005 | $year^{-1}$ | Pseudo first order rate constant in unspecified surface water | Furukawa et al. 1978 | 108 | days | Fresh | Neely 1983 |
| 2,2',4,5,5'-pentachlorobiphenyl | 1.5E-08 | nmol/cell/hour | Bacterial culture with Acinetobacter | Furukawa et al. 1978 | | | | |
| 2,2',4,4',5,5'-hexachlorobiphenyl | | | | | 25 - 53 | minutes | Aqueous solution purged at flow rate of 1 L/min | Coates 1984 |

# Table 3

## Example PCB Degradation Rates in Surface Water

**Literature cited for PCB degradation rates in surface water**


Bailey, R.E., S.J. Gonsior and W.L. Rhinehart. 1983. Biodegradation of the monochlorobiphenyls and biphenyl in river water. Environ. Sci. Technol. 17:617-621.

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Dulin, D., H. Drossman and T. Mill. 1986. Products and quantum yields for photolysis of chloroaromatics in water. Environ. Sci. Technol. 20:72-77.

Furukawa, K, K. Tonomura and A. Kamibayashi. 1978. Effects of chlorine substitution on the biodegradability of polychlorinated biphenyls. Appl. Enviorn. Microbiol. 35:223-227.

Kong, H.L. and G.S. Sayler. 1983. Degradation and total mineralization of monohalogenated biphenyls in natural sediment and mixed bacterial culture. Appl. Environ. Microbiol. 46:666-672.

Mabey, W., J.H. Smith, R.T. Podoll, H.L. Johnson, T. Mill, T.W. Chou, J. Gate, I. Waight-Partridge, H. Jaber and D. Vandenberg. 1982. Aquatic Fate Process for Organic Priority Pollutants. EPA 440/4-81-014, U.S. Environmental Protection Agency, Washingt

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Oloffs, P.C., L.J. Albright and S.Y. Szeto. 1972. Fate and behaviour of five chlorinated hydrocarbons in three natural waters. Can. J. Microbiol. 18:1393.

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Wong, P.T.S. and K.L.E. Kaiser. 1975. Bacterial degradation of polychlorinated biphenyls. II. Rate studies. Bull. Environ. Contam. Toxicol. 3:249.


**Secondary sources for literature cited above**


Mackay, D., W.Y. Shiu and K.C. Ma. 1992. Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals. Volume I. Monoaromatic Hydrocarbons, Chlorobenzenes, and PCBs. Lewis Publishers, Chelsea, MI. 697 pp.

Environmental Fate Data Base. Managed by Syracuse Research Corporation with suppport from the U.S. Environmental Protection Agency, DuPont and Procter & Gamble. Internet address: http://esc.syrres.com/efdb.htm

## Table 4
## Fugacity-Based PCB Transport Coefficients Used in the PRAM

| | Compartment | Process | Notation | Solution |
|---|---|---|---|---|
| 1 | Air | diffusion from air to upper water column | $D_V$ | $D_V = 1/\{[1/(A_{12}*U_{12}*Z_A)]+[1/(A_{12}*U_{21}*Z_W)]\}$ |
| | | rain deposition | $D_{QW}$ | $D_{QW} = A_{12}*U_Q*Z_W$ |
| | | wet particle deposition into upper water column | $D_{DW}$ | $D_{DW} = A_{12}*\phi_{1AE}*U_Q*Z_{1AE}$ |
| | | dry particle deposition into upper water column | $D_{PW}$ | $D_{PW} = A_{12}*\phi_{1AE}*U_P*Z_{1AE}$ |
| | | advection of bulk air out of system | $D_{A1}$ | $D_{A1} = G_A*Z_1$ |
| 2 | Upper Water Column | diffusion from water to air | $D_V$ | $D_V = 1/\{[1/(A_{12}*U_{12}*Z_A)+[(1/(A_{12}*U_{21}*Z_W)]\}$ |
| | | diffusion from upper water column to lower water column | $D_W$ | $D_W = 1/\{[1/(A_{23}*1.728*Z_W)]+[1/(A_{23}*1.728*Z_W)]\}$ |
| | | advection of bulk water out of the system | $D_{A2}$ | $D_{A2} = G_{W2}*Z_2$ |
| | | degradation in bulk water | $D_{R2}$ | $D_{R2} = K_w *V_{2W}*\phi_{2W}*Z_W$ |
| 3 | Lower Water Column | diffusion from lower water column to upper water column | $D_W$ | $D_W = 1/\{[1/(A_{23}*1.728*Z_W)]+[1/(A_{23}*1.728*Z_W)]\}$ |
| | | diffusion from lower water column to sediment bed | $D_Y$ | $D_Y = 1/\{[(1/A_{43}*U_{34}*Z_W)+[(1/(A_{34}*U_{43}*Z_W)]\}$ |
| | | deposition of suspended solids onto sediment bed | $D_{DX}$ | $D_{DX} = A_{34}*U_{DX}*\phi_{3SS}*Z_{SS}$ |
| | | advection of bulk water out of the system | $D_{A3}$ | $D_{A3} = G_{W3}*Z_3$ |
| | | degradation in bulk water | $D_{R3}$ | $D_{R3} = K_w *V_{3W}*\phi_{3W}*Z_W$ |
| 4 | Sediment Bed | diffusion from sediment bed into lower water column | $D_Y$ | $D_Y = 1/\{[(1/A_{43}*U_{34}*Z_W)+[(1/(A_{34}*U_{43}*Z_W)]\}$ |
| | | re-suspension of sediment into lower water column | $D_{RX}$ | $D_{RX} = A_{34}*U_{RX}*\phi_{3SD}*Z_{SD}$ |
| | | degradation in bulk sediment | $D_{R4}$ | $D_{R4} = K_w *V_{4W}*\phi_{4W}*Z_W$ |
| | | sediment burial (advection) out of system | $D_B$ | $D_B = A_4*U_B*\phi_{3SD}*Z_{SD}$ |
| 5 | Vessel Interior | advection of bulk water into lower water column | $D_{A5}$ | $D_{A5} = G_{W5}*Z_5$ |
| | Inter-compartment Transport Coefficients | Air to water | $D_{12} = D_V + D_{QW} + D_{DW} + D_{PW}$ | |
| | | Upper water column to air | $D_{21} = D_V$ | |
| | | Upper water column to lower water column | $D_{23} = D_W$ | |
| | | Lower water column to upper water column | $D_{32} = D_W$ | |
| | | Lower water column to sediment bed including suspended solids | $D_{34} = D_Y + D_{DX}$ | |
| | | Sediment bed to lower water column including resuspension of sediment | $D_{43} = D_Y + D_{RX}$ | |
| | | Sunken vessel to lower water column | $D_{53} = D_{A5}$ | |

ΣD-air = $D_{12} + D_{A1} = DT_1$

ΣD-upper water column = $D_{21} + D_{23} + D_{A2} + D_{R2} = DT_2$

ΣD-lower water column = $D_{32} + D_{34} + D_{A3} + D_{R3} = DT_3$

ΣD-sediment bed = $D_{43} + D_{R4} + D_B = DT_4$

Note: See Figures 4 and 6 for additional information on process/compartment interaction.

# Table 5

## Food Web Diet Compositions Assumed for the PRAM and the ex-ORISKANY Memorial Reef

| | Suspended Solids (Epilimnion) | Suspended Solids (Hypolimnion) | Sediment[7] | Phytoplankton | Zooplankton | Pelagic Planktivore | Attached Algae | Reef Sessile Filter Feeder | Invertebrate Omnivore[3] | Reef Invertebrate Forager | Reef Vertebrate Forager | Infaunal Benthos | Epifaunal Benthos | Benthic Forager | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic (open water associated organisms)** | | | | | | | | | | | | | | | 0% |
| Zooplankton (TL-II) | 15%[1] | 15%[1] | | 70% | | | | | | | | | | | 100% |
| Planktivore (TL-III) | 0% | 0% | | 0% | 100% | | | 0% | | | | | 0% | | 100% |
| Piscivore (TL-IV) | | | | 0% | 10% | 90% | | 0% | 0% | 0% | 0% | | 0% | 0% | 100% |
| **Benthic (sediment associated organisms)** | | | | | | | | | | | | | | | |
| Infaunal Macroinvertebrate (TL-II) | | | 50%[2] | 30%[2] | 20%[2] | | 0% | | | | | | | | 0% |
| Epifaunal Invertebrate (TL-II) | | 0% | 25%[2] | 30%[2] | 20%[2] | | 0% | | | | | 25%[2] | | | 100% |
| Benthic Forager (TL-III) | | 0% | 5% | 0% | 0% | 0% | 0% | | | | | 50% | 45% | | 100% |
| Benthic Predator (TL-IV) | | 0% | 2% | 0% | 0% | 0% | | | | | | 20% | 20% | 58% | 100% |
| **Reef (reef associated organisms)** | | | | | | | | | | | | | | | |
| Sessile filter feeder (TL-II) | 0% | 10% | | 80% | 10% | | 0% | | | | | | | | 100% |
| Invertebrate Omnivore (TL-II)[3] | 0% | 0% | | 0% | 0% | | 80% | 20% | | | | | 0% | | 100% |
| Invertebrate Forager (TL-III) | | 5% | | 0% | 5% | 5% | 0%[4] | 35%[4] | 50%[4] | | | 0% | 0% | | 100% |
| Vertebrate Forager (TL-III) | | 0% | | 0% | 0%[5] | 19%[6] | 0%[5] | 19%[6] | 15%[6] | 22%[6] | | 12.5%[6] | 12.5%[6] | 0% | 100% |
| Reef Predator (TL-IV) | | 0% | | 0% | 0% | 0% | 0% | 0% | 0% | 15%[6] | 60%[6] | 8%[6] | 8%[6] | 8%[6] | 99% |

Notes:

[1] In recognition of the splitting time spent below the pycnocline, the dietary fractions have been adjusted to account for feeding below the pycnocline.

[2] In recognition of comments made and in consideration that a higher sediment ingestion rate would result in a more conservative exposure level, the compromised dietary fractions are presented.

[3] Based on a deductive evaluation of the potential PCB transfer pathways within the reef community, an invertebrate omnivore (e.g., echinoderm), was considered more significant than mobile reef planktivores.

[4] Based on comments made by J. Dodrill.

[5] Based on addition of invertebrate omnivore (TL-II) to the reef food web.

[6] Based on comments made by Robert Turpin indicating that vertebrate reef foragers and predators obtain a significant portion of their energy budget from the benthos.

[7] The term "sediment" refers to any material within the sediment bed that supplies the biological energy input, including detritus/Particulate Organic Matter.

# Table 6

## Food Web Water Exposure Values Assumed for the PRAM and the ex-ORISKANY Memorial Reef (Modified with Comments from Biology Technical Working Group; Revised, 12/31/04)

| | Upper Water Column | Lower Water Column | Vessel Interior | Sediment Pore Water | Total |
|---|---|---|---|---|---|
| **Pelagic Community** | | | | | |
| Phytoplankton (TL-I) | 100% | | | | 100% |
| Zooplankton (TL-II) | 50% | 50%[3] | | | 100% |
| Planktivore (TL-III) | 80% | 20% | | | 100% |
| Piscivore (TL-IV) | 80% | 20% | | | 100% |
| **Reef / Vessel Community** | | | | | |
| Attached algae (TL-I) | | 100% | | | 100% |
| Sessile filter feeder (TL-II) | 0% | 100% | 0%[1] | | 100% |
| Invertebrate Omnivore (TL-II)[2] | 0% | 80% | 20% | | 100% |
| Invertebrate forager (TL-III) | 0% | 70% | 30% | | 100% |
| Vertebrate forager (TL-III) | 0% | 70% | 30% | | 100% |
| Predator (TL-IV) | 0% | 80% | 20% | | 100% |
| **Benthic Community** | | | | | |
| Infaunal macro-invertebrate (TL-II) | 0% | 20% | | 80% | 100% |
| Epifaunal invertebrate (TL-II) | 0% | 50% | | 50% | 100% |
| Forager (TL-III) | 0% | 75% | | 25% | 100% |
| Predator (TL-IV) | 0% | 90% | | 10% | 100% |

Notes:

TL stands for Trophic Level

[1] This value is set to zero, per response to comments, which reflects our position that a vessel interior community is unlikely, and if existent, would represent a negligible portion of the overall reef community biomass.

[2] Based on a deductive evaluation of the potential PCB transfer pathways within the reef community, an invertebrate omnivore (e.g., echinoderm), was considered more significant than mobile reef planktivores.

[3] In recognition of the splitting time spent below the pycnocline, the dietary fractions have been adjusted to account for feeding below the pycnocline.

# Table 7

## Biological Parameters for Food Web Components Within the PRAM

| | Representative Species | Body Weight (kg)[a] | Lipid (%-dw) | Moisture (%)[b] | Caloric Density (kcal/g-dw)[b] | Fraction Metabolizable Energy from Gross[b] | Production[e] (% of total) | Respiration[e] (% of total) | Excretion[e] (% of total) |
|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | |
| Phytoplankton (TL-I) | algae | --- | 10.3%[c] | 84% | 2.36 | 0.60 | --- | --- | --- |
| Zooplankton (TL-II) | copepods | 0.000005 | 22.0%[c] | 76% | 3.6 | 0.65 | 18%[c] | 24% | 58% |
| Planktivore (TL-III) | herring | 0.05 | 28.1%[d1] | 75% | 4.9 | 0.70 | 20% | 60% | 20% |
| Piscivore (TL-IV) | jack | 0.5 | 28.1%[d1] | 75% | 4.9 | 0.70 | 20% | 60% | 20% |
| **Reef / Vessel Community** | | | | | | | | | |
| Attached algae (TL-I) | algae | --- | 10.3%[c] | 84% | 2.36 | 0.60 | --- | --- | --- |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.05 | 4.96%[d2] | 82% | 4.6 | 0.65 | 28% | 31% | 41% |
| Grazing / foraging omnivore (TL-II) | urchin | 0.05 | 29.0%[d6] | 82%[f] | 4.6[f] | 0.65 | 7%[g] | 25%[g] | 68%[g] |
| Invertebrate forager (TL-III) | crab | 1 | 9.18%[d3] | 74% | 2.7 | 0.65 | 28% | 59% | 13% |
| Vertebrate forager (TL-III) | triggerfish | 1 | 28.1%[d1] | 75% | 4.9 | 0.70 | 20% | 60% | 20% |
| Predator (TL-IV) | grouper | 1.5 | 28.1%[d1] | 75% | 4.9 | 0.70 | 20% | 60% | 20% |
| **Benthic Community** | | | | | | | | | |
| Infaunal invertebrate (TL-II) | polychaete | 0.01 | 5.98%[d4] | 84% | 4.6 | 0.65 | 71%[g] | 26%[g] | 3%[g] |
| Epifaunal invertebrate (TL-II) | nematode | 0.01 | 5.98%[d4] | 84% | 4.6 | 0.65 | 31% | 19% | 50% |
| Forager (TL-III) | lobster | 2 | 9.18%[d3] | 74% | 2.7 | 0.65 | 28% | 59% | 13% |
| Predator (TL-IV) | flounder | 3 | 22.0%[d5] | 75% | 4.9 | 0.70 | 20% | 60% | 20% |

Notes:

a = based on professional judgment for typical member of trophic level

b = values obtained from USEPA 1993

c = obtained from Parsons et al. 1979 (average of algae values in Table 6; zooplankton from Table 14 in Parsons et al. 1979)

d = obtained from USACE 2004 (http://ered1.wes.army.mil/cgi-bin/LipidOrgMean.exe)

- 1 = midwater fish wet weight converted using % moisture presented here
- 2 = marine / estuarine mollusks
- 3 = marine crustecea
- 4 = marine / estuarine worms
- 5 = bottom fish
- 6 = echinoderms

e = derived from energy budgets reported by Welch (1968), Table reflects combined energy loss due to fecal (F) and urinary (U) excretion as total excretion (EX)

f = assumed to equal that of bivalves without the shell

g = obtained from Parsons et al. 1979 Table 38

TL = trophic level

dw = dry weight

# Table 8

## Temperature and Body Weight Dependent Oxygen Consumption Regressions for the Biological Components Within the PRAM

| | Biota Type | α | $\beta_1$ | $\beta_2$ | Reference |
|---|---|---|---|---|---|
| **Pelagic Community** | | | | | |
| Pelagic zooplankton | copepod | 0.00638 | 0 | 0.0399 | Derived from Altman and Dittmer (1971) |
| Pelagic planktivore | herring | 0.00330 | -0.227 | 0.0548 | Hewett and Johnson (1992) |
| Pelagic Predator | jack | 0.001118602 | -0.55 | 0.12 | Derived by Barber (2004)* |
| **Reef / Vessel Community** | | | | | |
| Reef/Vessel sessile filter feeder | clam | 0.012 | 0 | 0.036 | Connolly (1991)** |
| Reef/Vessel omnivorous invertebrate | urchin | 0.00068 | 0 | 0.0792 | Derived from Altman and Dittmer (1971) |
| Reef/Vessel invertebrate forager | crab | 0.00116 | 0 | 0.0712 | Derived from Altman and Dittmer (1971) |
| Reef/Vessel vertebrate forager | triggerfish | 0.01518 | -0.415 | 0.061 | Derived by Barber (2004)* |
| Reef/Vessel predator | grouper | 0.00279 | -0.355 | 0.0811 | Kline (2004) |
| **Benthic Community** | | | | | |
| Benthic infaunal invertebrate | polychaete | 0.00168 | 0 | 0.0710 | Derived from Altman and Dittmer (1971) |
| Benthic epifaunal invertebrate | nematode | 0.00168 | 0 | 0.0710 | Derived from Altman and Dittmer (1971) |
| Benthic forager | lobster | 0.0035 | -0.13 | 0.066 | Connolly (1991) |
| Benthic predator | flounder | 0.0046 | -0.24 | 0.067 | Connolly (1991) |

Respiration rate from the following equation has units of $day^{-1}$.

$$r\left[\frac{1}{day}\right] = \alpha W\,[g]^{\beta_1}\, e^{\beta_2\left(T\,[^{o}C]\right)}$$

where:

r = the oxygen consumption rate
W = organism body wet weight in grams
T = temperature in degrees Celsius
α = allometric intercept
e = the natural logarithm base
$\beta_1$, $\beta_2$ = allometric slopes for body weight and temperature, respectively
* = values provided by Barber were derived for an equation with different units and dimensions than the equation for r, therefore the values shown in the table have been adjusted by the methodology in the following footnote.
** = mussel parameters were considered most representative of a reef sessile filter feeder and were therefore selected for use in PRAM

## Table 8

## Temperature and Body Weight Dependent Oxygen Consumption Regressions for the Biological Components Within the PRAM

**Adjustment of allometric parameters provided by Barber**

The oxygen consumption rates used in PRAM are calculated in units of $day^{-1}$. Barber's allometric parameters are derived for an equation which calculates rates as milligrams of $O_2$ per hour. Since these two rates are not equivalent in either dimensions or units, an adjustment of Barber's parameters must be made before utilizing them in PRAM. The adjustment has been made as follows:

Given: $r\left[\frac{1}{day}\right]=\left(\alpha_{1PRAM}W[g]^{\beta_{1PRAM}}e^{\beta_{2PRAM}(T[^\circ C])}\right)$ and $r\left[\frac{mgO_2}{h}\right]=\left(\alpha_{1Barber}W[g]^{\beta_{1Barber}}e^{\beta_{2Barber}(T[^\circ C])}\right)$

(1) $$r\left[\frac{1}{day}\right]\times\left(\frac{2.67gO_2}{gC}\right)\times\left(\frac{0.45gC}{g_{dw}}\right)\times\left((1-f)\frac{g_{dw}}{g_{ww}}\right)=r\left[\frac{mgO_2}{h}\right]\times\left(\frac{1}{g_{ww}}\right)\times\left(\frac{gO_2}{1000mgO_2}\right)\times\left(\frac{24h}{day}\right)$$

Where f = fraction moisture value from Table 8

(2) $$r\left[\frac{1}{day}\right]=r\left[\frac{mgO_2}{h}\right]\times\left(\frac{1}{g_{ww}}\right)\times\left(\frac{24}{2.67\times0.45\times(1-f)\times1000}\right)$$

(3) $$\alpha_{PRAM}W[g]^{\beta_{1PRAM}}e^{\beta_{2PRAM}(T[^\circ C])}=\left(\alpha_{Barber}W[g]^{\beta_{1Barber}}e^{\beta_{2Barber}(T[^\circ C])}\right)\times\left(\frac{1}{g_{ww}}\right)\times\left(\frac{24}{2.67\times0.45\times(1-f)\times1000}\right)$$

(4) $$\alpha_{PRAM}W[g]^{\beta_{1PRAM}}e^{\beta_{2PRAM}(T[^\circ C])}=\left(\alpha_{Barber}W[g]^{\beta_{1Barber}-1}e^{\beta_{2Barber}(T[^\circ C])}\right)\times\left(\frac{24}{2.67\times0.45\times(1-f)\times1000}\right)$$

From equation 4, we can observe the following relationships between parameters

$$\alpha_{1PRAM}=\alpha_{1Barber}\left(\frac{24}{2.67\times0.45\times(1-f)\times1000}\right)\qquad\beta_{1PRAM}=\beta_{1Barber}-1\qquad\beta_{2PRAM}=\beta_{2Barber}$$

The parameters provided by Barber have been adjusted as follows:

| | | $\alpha_1$ | $\beta_1$ | $\beta_2$ |
|---|---|---|---|---|
| Snapper species (jack, f = 0.75) | Barber | 0.014 | 0.45 | 0.12 |
| | PRAM | 0.0011186 | -0.55 | 0.12 |
| Interspecies (triggerfish, f = 0.75) | Barber | 0.19 | 0.585 | 0.061 |
| | PRAM | 0.015181 | -0.415 | 0.061 |

## Table 9

## Physical Boundaries and Conditions for the ex-ORISKANY Memorial Reef Site

| | Value | Units | Value | Units |
|---|---|---|---|---|
| **Vessel** | | | | |
| Displacement [1] | 27100 | tons | 27533600 | kg |
| Length [1] | 888 | ft | 271 | m |
| Beam [1a] | 120 | ft | 36.6 | m |
| Water depth [5] | 212 | ft | 65 | m |
| **Surface Water (all depths)** | | | | |
| Depth to the pycnocline [0, 2] | | | 15 | m |
| Suspended solids density [2] | | | 1.5 | $g/cm^3$ |
| Aerosol density [3] | | | 1.19 | $g/cm^3$ |
| Dissolved organic carbon density [2] | | | 1 | $g/cm^3$ |
| Suspended solids fraction organic carbon [4] | | | 15% | percent |
| **Air** | | | | |
| Air temperature [5] | | | 22.3 | °C |
| Active air space height above water column [3] | | | 10 | m |
| Air current [6] | 8.5 | mph | 13677 | meters/hr |
| Aerosol concentration [3] | | | 2.38.E-14 | $g/cm^3$ |
| Rainfall [7] | | | 6.50E-04 | m/day |
| Particle deposition rate [3] | | | 10.8 | m/hr |
| **Water above the pycnocline** | | | | |
| Temperature [5] | | | 24.5 | °C |
| Dissolved oxygen [8] | | | 6.12 | mg/L |
| Total suspended solids [3] | | | 10 | mg/L |
| Dissolved organic carbon [4] | | | 0.6 | mg/L |
| Water current [0, 6] | 0.5 | knot | 926 | meters/hr |
| **Water below the pycnocline** | | | | |
| Temperature [4] | | | 19.5 | °C |
| Dissolved oxygen [8] | | | 6.12 | mg/L |
| Total suspended solids [2] | | | 10 | mg/L |
| Dissolved organic carbon [4] | | | 0.6 | mg/L |
| Water current [0, 6] | 0.5 | knot | 926 | meters/hr |

## Table 9

## Physical Boundaries and Conditions for the ex-ORISKANY Memorial Reef Site

| | Value | Units | Value | Units |
|---|---|---|---|---|
| **Water within the vessel interior** | | | | |
| Temperature [4] | | | 19.5 | °C |
| Dissolved oxygen [9] | | | 4.59 | mg/L |
| Total suspended solids [3] | | | 10 | mg/L |
| Dissolved organic carbon [4] | | | 0.6 | mg/L |
| Water current - inside the vessel to outside the vessel [10] | | | 9.26 | meters/hr |
| **Sediment bed** | | | | |
| Temperature [4] | | | 19.5 | °C |
| Dissolved oxygen [9] | | | 3.06 | mg/L |
| Dissolved organic carbon [11] | | | 2 | mg/L |
| Sediment fraction organic carbon [4] | | | 1% | percent |
| Sediment density [2] | | | 1.5 | g/cm3 |
| Sediment moisture [2] | | | 10% | percent |
| Bio-active sediment depth [12] | | | 0.1 | m |
| Sediment deposition rate [13] | | | 0 | $m^3/m^2$-day |
| Sediment resuspension rate [13] | | | 0 | $m^3/m^2$-day |
| Sediment burial rate [13] | | | 0 | $m^3/m^2$-day |

Notes: Source of Input Value

0 = Consensus of TWG

1 = Based on Dictionary of American Naval Fighting Ships (online at http://www.hazegary.org/danfs/carriers/cv34.htm).

1a = Average between hull beam (93 ft) and flight deck beam (147.5 ft)

2 = Based on professional judgment

3 = Based on value used by Mackay and Paterson (1991)

4 = Typical or low-end value for oceans obtained from Parsons et al. 1979

5 = Yearly average at NOAA buoy # 42040 (online at http://www.ndbc.noaa.gov/station_history.phtml?station=42040).

6 = FFWCC 2004

7 = Based on a yearly average rainfall of 60 inches

8 = Based on Temperature (°C) and 90% saturation level (Spotte 1970)

9 = Assumes 75% of DO in water below pycnocline

10 = Assumed to be 1/10 of current of water within water column below pycnocline

11 = Upper limit for open ocean surface water obtained from Parsons et al. 1979

12 = Based on evidence obtained from Bosworth and Thibodeaux 1990

13 = Set at zero - assumes deposition and resuspension balance

# Table 10

## Summary of Statistical Analysis of PCB Concentrations in Materials Onboard the ex-ORISKANY

| PCB-Containing Material (estimated and detected values are in mg/kg) | Statistical Method | Resultant Estimate | Statistical Method | Resultant Estimate | Number of Samples | Detection Frequency | Maximum Detection | Minimum Detection | Maximum Non-detection | Minimum Non-detection | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bulkhead Insulation | Jackknife Mean | 2.15E+02 | Jackknifed UCL | 5.37E+02 | 32 | 56% | 6100 | 5.5 | 5 | 5 | There is a sufficient number of values for statistical analysis - the data were found to be non-normal, however, the bootstrap methods failed to normalize the dataset - use the Jackknife mean and UCL |
| Aluminized Paint | Jackknife Mean | 1.26E+01 | Jackknifed UCL | 2.00E+01 | 7 | 57% | 28 | 5.8 | 5 | 5 | There is a sufficient number of values for statistical analysis - the data were found to be non-normally distributed and the number of samples is below 15 - use the Jackknife mean and UCL |
| Electrical Cable | Bootstrap Mean | 1.49E+03 | Standard Bootstrap UCL | 2.56E+03 | 59 | 97% | 29000 | 6.1 | 5 | 1 | There is a sufficient number of values for statistical analysis - the data were found to be non-normal with high skewness, however, the Hall's transformed t bootstrap failed to normalize the dataset - use the Standard Bootstrap mean and UCL |
| Rubber Products | Bootstrap Mean | 3.72E+01 | Hall Adjusted Bootstrap | 5.29E+01 | 30 | 83% | 130 | 6.5 | 5 | 5 | There is a sufficient number of values for statistical analysis - the data were found to be non-normally distributed with high skewness - use the Standard Bootstrap mean and Hall's Adjusted Bootstrap UCL |
| Vent Gaskets | Bootstrap Mean | 2.05E+01 | Standard Bootstrap UCL | 3.14E+01 | 34 | 56% | 210 | 5 | 1 | 1 | There is a sufficient number of values for statistical analysis - the data were found to be non-normal with high skewness, however, the Hall's transformed t bootstrap failed to normalize the dataset - use the Standard Bootstrap mean and UCL |

where:

UCL is 95% Upper Confidence Limit for the mean

# Table 11

## Mass Estimates of PCB-Containing Materials Onboard the ex-ORISKANY

| | | Original Mass[1] | | Adjustment Factors | | | Current Material Mass | | PCB Adj Factor | Current PCB Mass | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (CACI Final Weight Report Mass) | | A | B | C | (FWR Mass*A*B*C) | | PCB Fraction in Material | Current Material Mass * Fraction PCB | |
| PRAM Source Term | Corresponding CACI Source Term | (lbs) | (kg) | CACI Source Term to PRAM Source Term Conversion | 30 Year Growth | Mass Remaining After Preparation | (lbs) | (kg) | (%) | (lbs) | (kg) |
| Vent Gasket Material | Vent Gaskets | 2,680 | 1,216 | 1 | 1.2 | 100% | 3,216 | 1,459 | 0.00314 | 10.09824 | 4.58049006 |
| Lubricants | Lubricants | 208,140 | 94,411 | 1 | 1 | 0% | 0 | 0 | 0.01 | 0 | 0 |
| Foam Rubber Material | N/A | 0 | 0 | N/A | N/A | N/A | 0 | 0 | 0.76 | 0 | 0 |
| Black Rubber Material | Rubber Products | 11,898 | 5,397 | 1 | 1 | 100% | 11,898 | 5,397 | 0.0053 | 63.0594 | 28.6032967 |
| Electrical Cable (insulation + wires) | Cable Insulation (insulation only) | 403,600 | 183,070 | 1.384 | 1.3 | 90% | 653,490 | 296,419 | 0.185 | 120895.682 | 54837.4243 |
| Bulkhead Insulation Material | Bulkhead Insulation | 115,695 | 52,478 | 1 | 1 | 27.4% | 31,700 | 14,379 | 0.054 | 1711.82322 | 776.470875 |
| Aluminum Paint | Paints | 298,999 | 135,624 | 1 | 3 | 95% | 852,147 | 386,528 | 0.002 | 1704.2943 | 773.05581 |

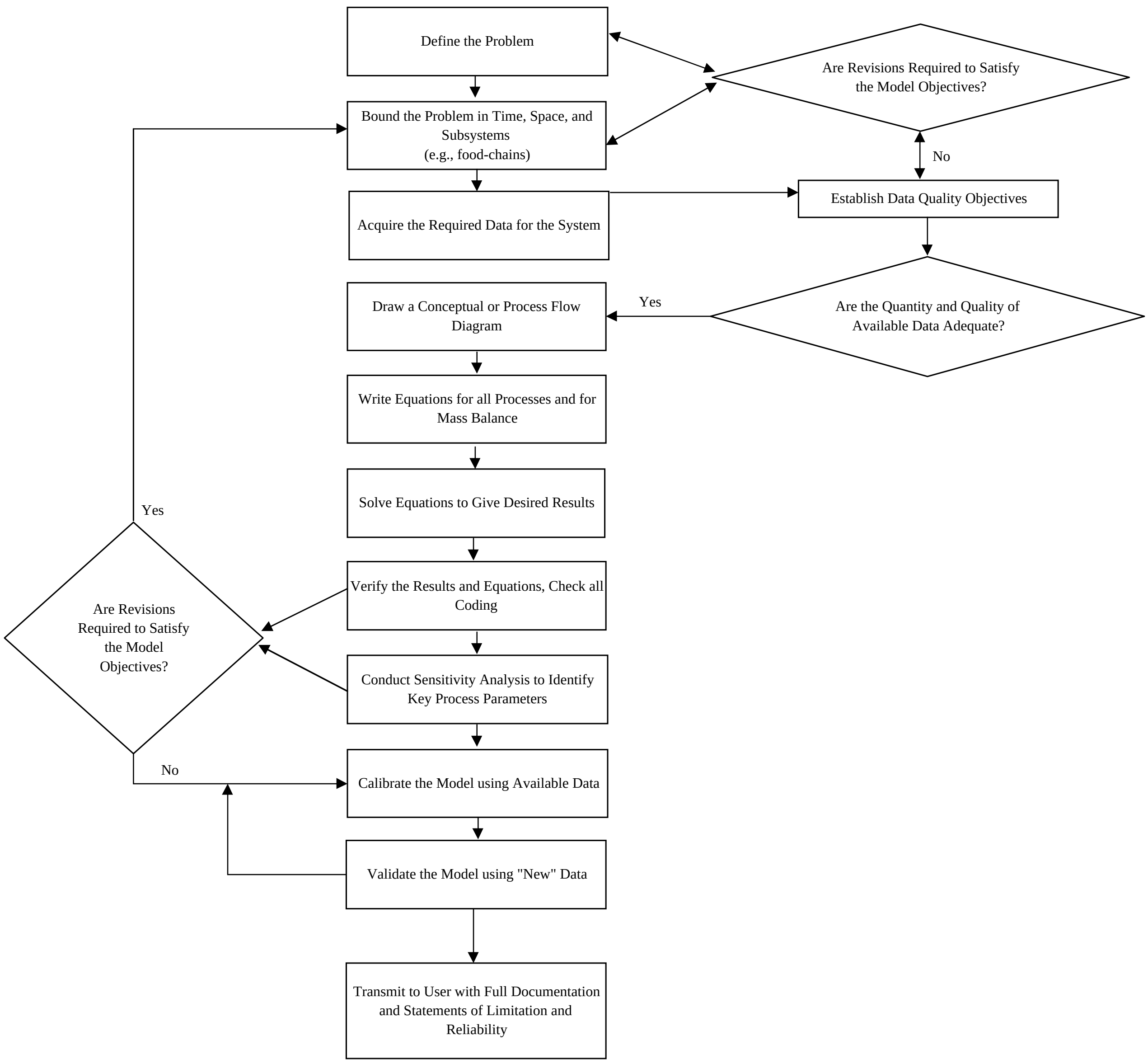
Notes:

Pape, L. Thomas. 2004. Final Report – Polychlorinated biphenyls (PCB) Source Term Estimates for ex-ORISKANY (CVA 34) Rev. 4. CACI International Inc.

**FIGURES**

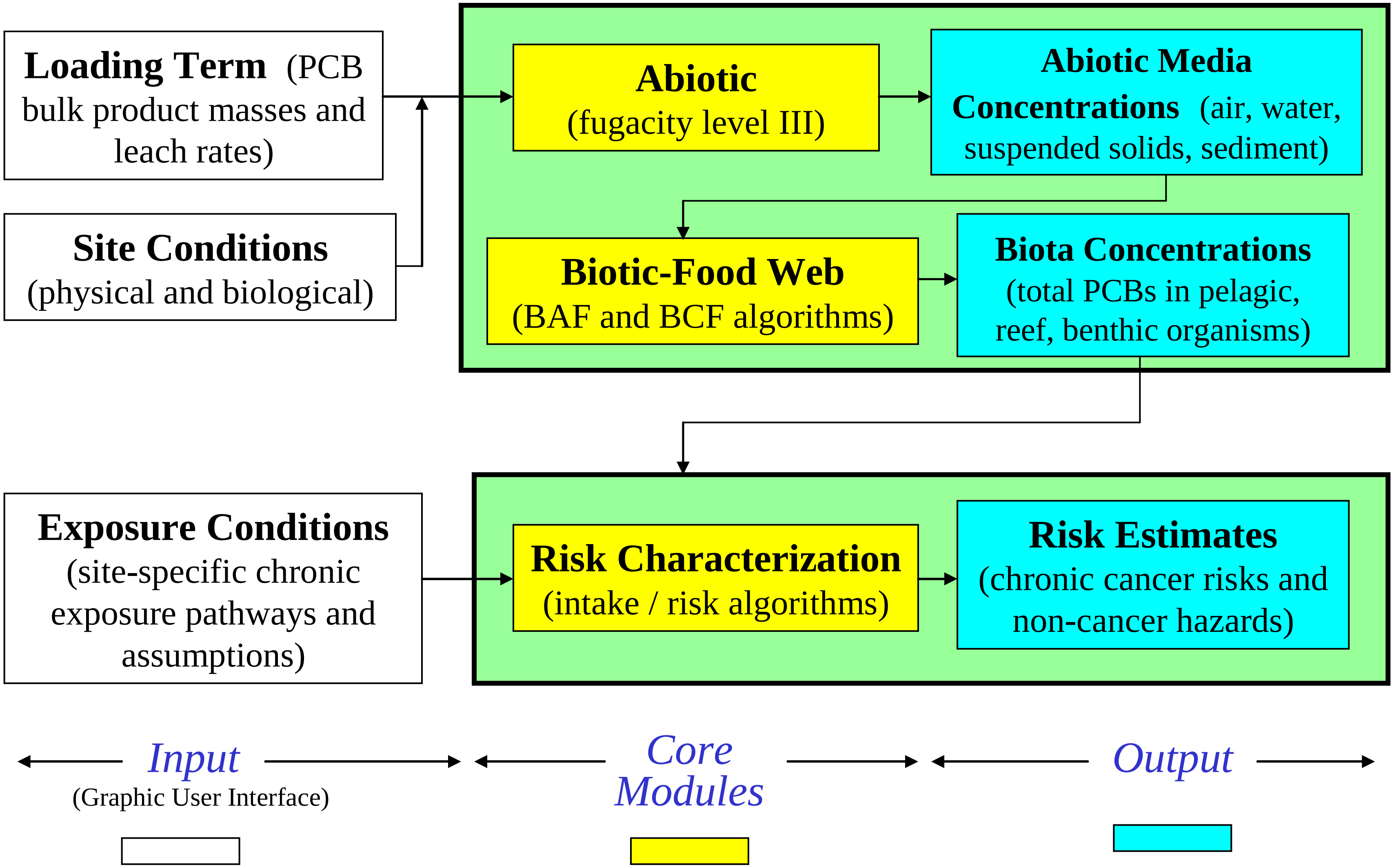
## Figure 1

## Flow Diagram for the Development of an Environmental Fate and Transport Model (adapted from Mackay et al., 1995)



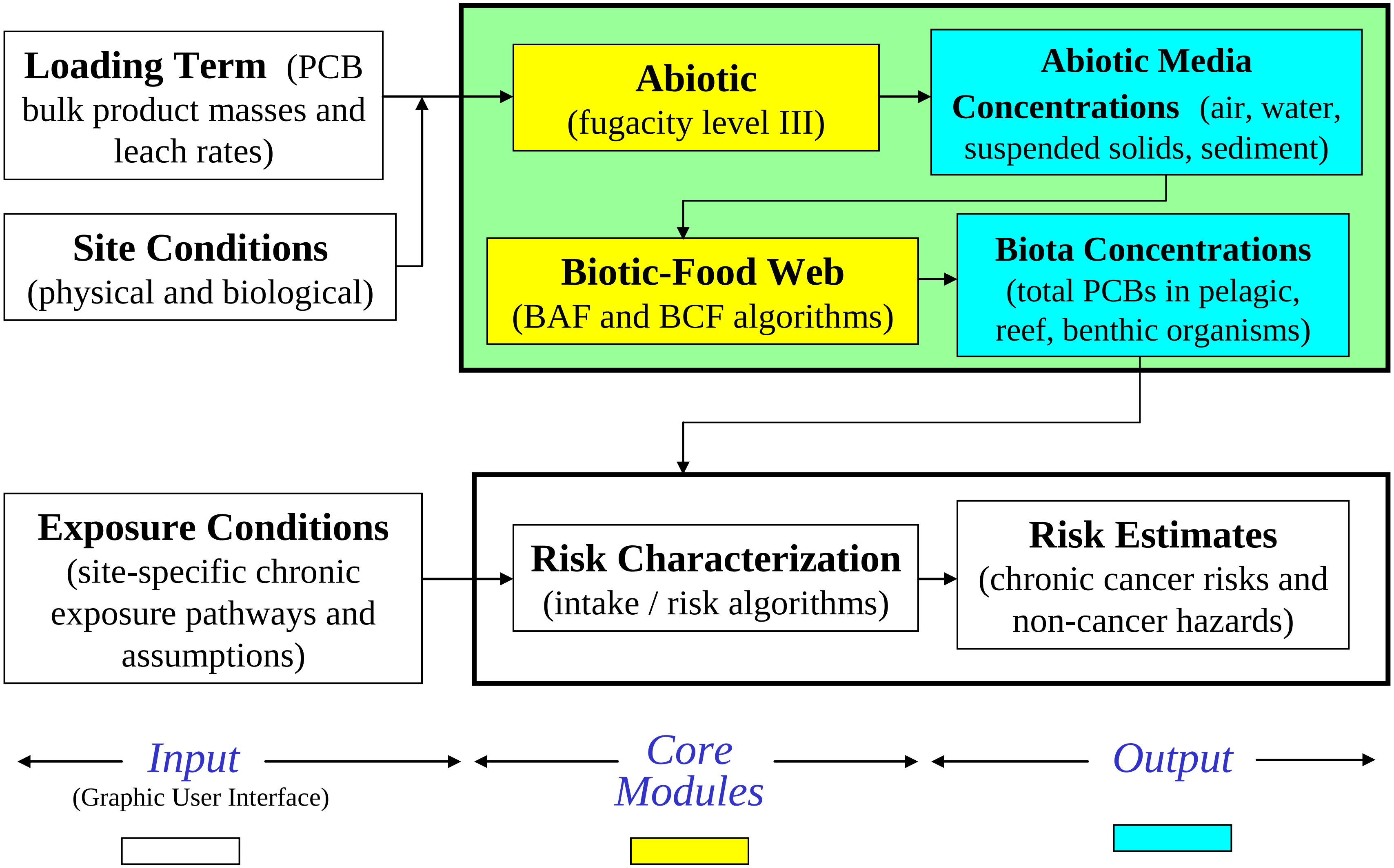
# Figure 2

## PRAM: Modules, Input, and Outputs



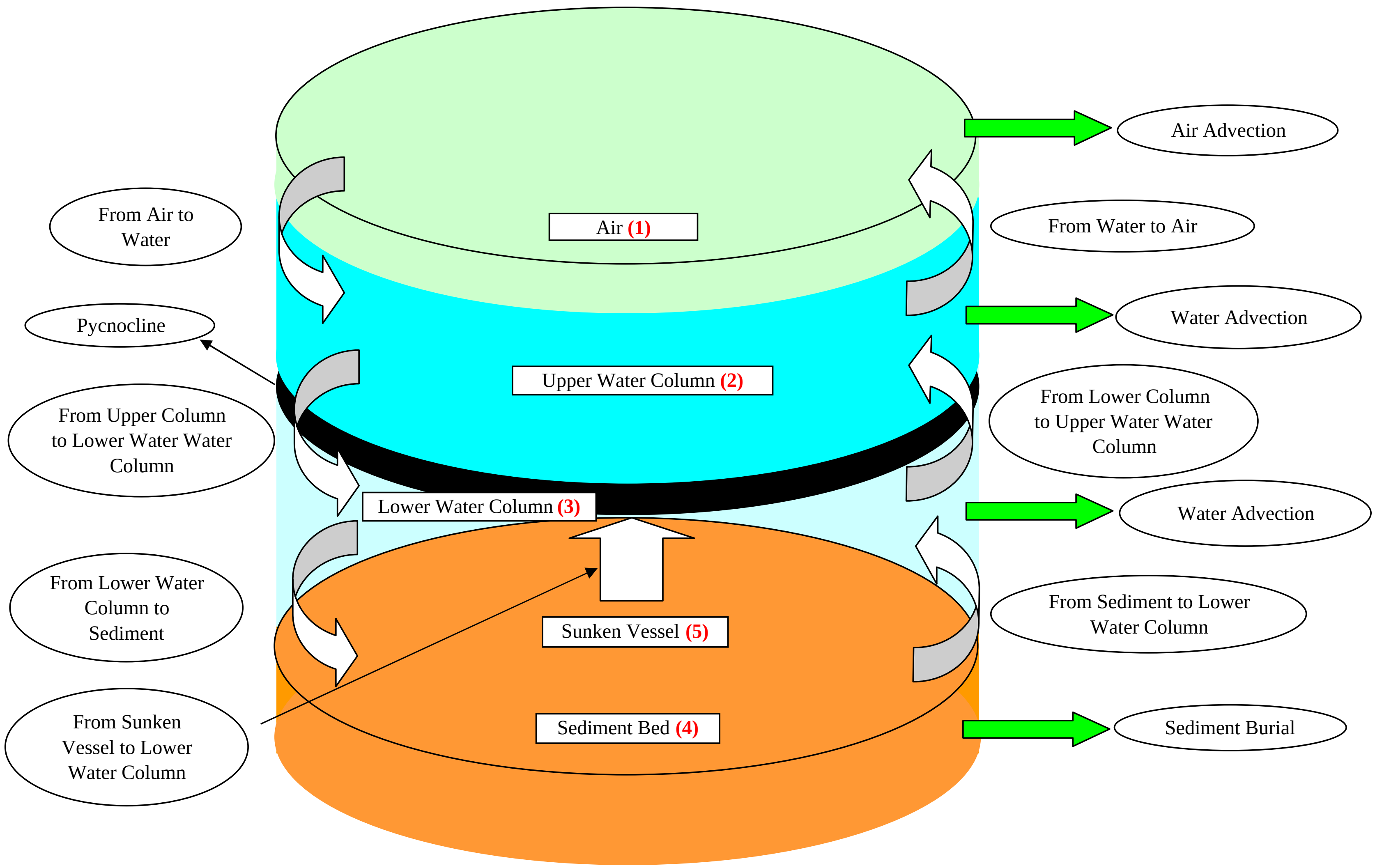
# Figure 3

## Abiotic and Biotic-Food Web Modules in PRAM



## Figure 4

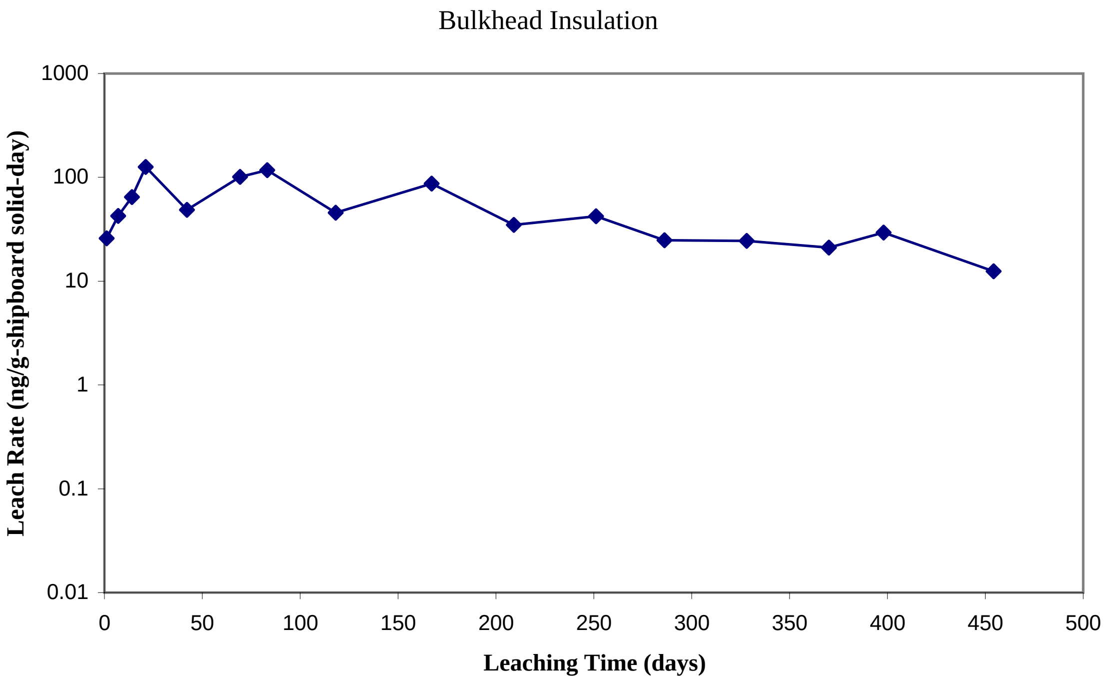
## Compartment Identification for PCB Transport in PRAM




*Reactive (Transformation) Processes are not presented*

**Figure 5**

**Example PCB Leach Rate Study Results:**
**Pentachlorobiphenyl (CL5) in Bulkhead Insulation and Ventilation Gaskets**
**(Adapted from R. George, SSC-SD, 2004)**



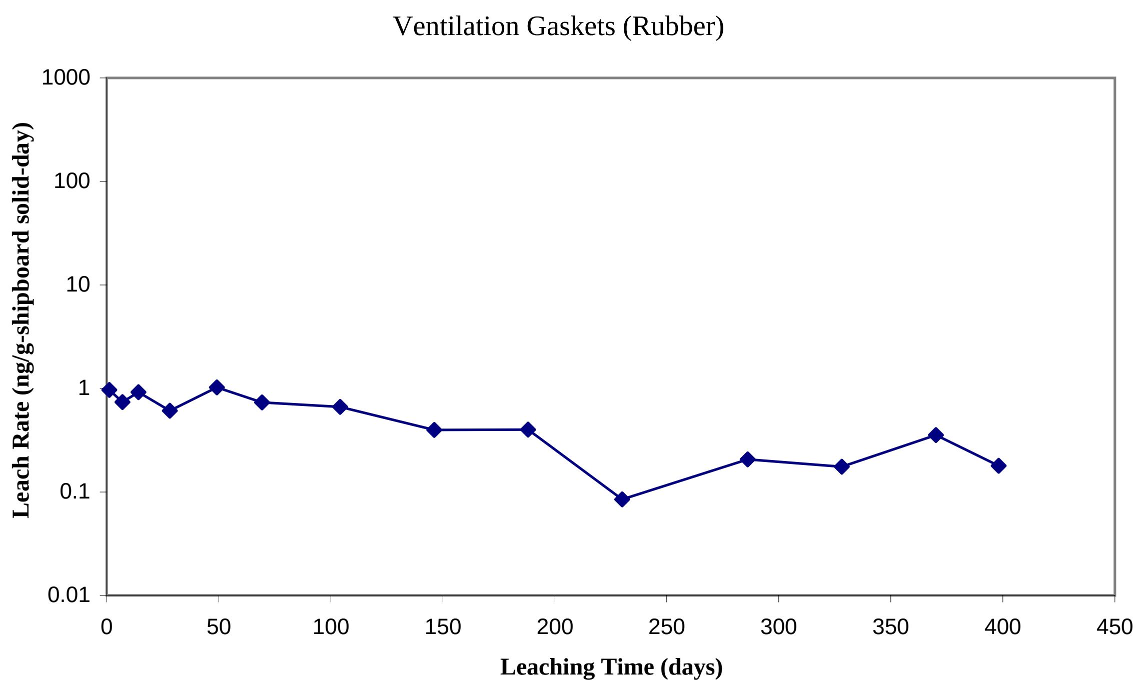
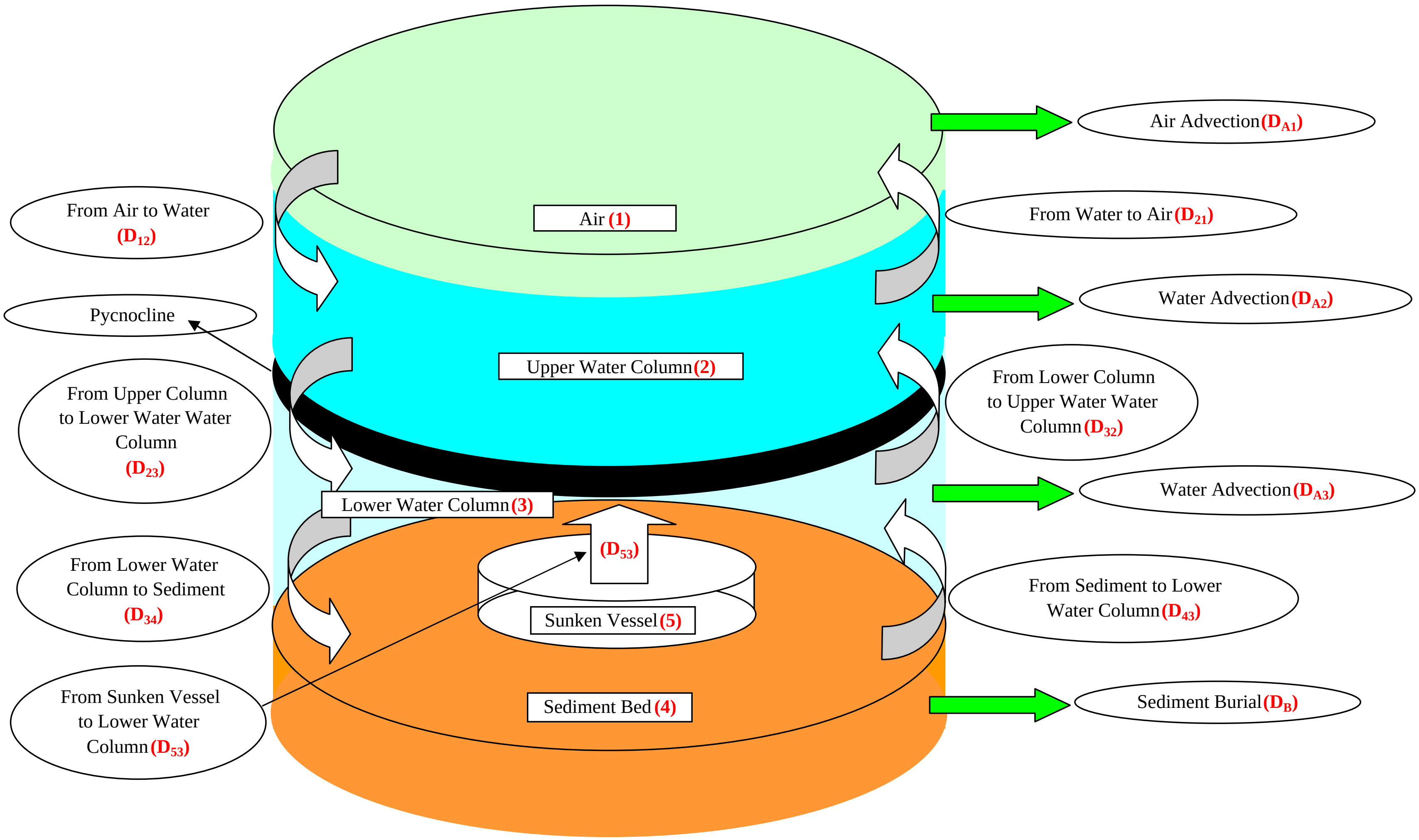



**Figure 6**

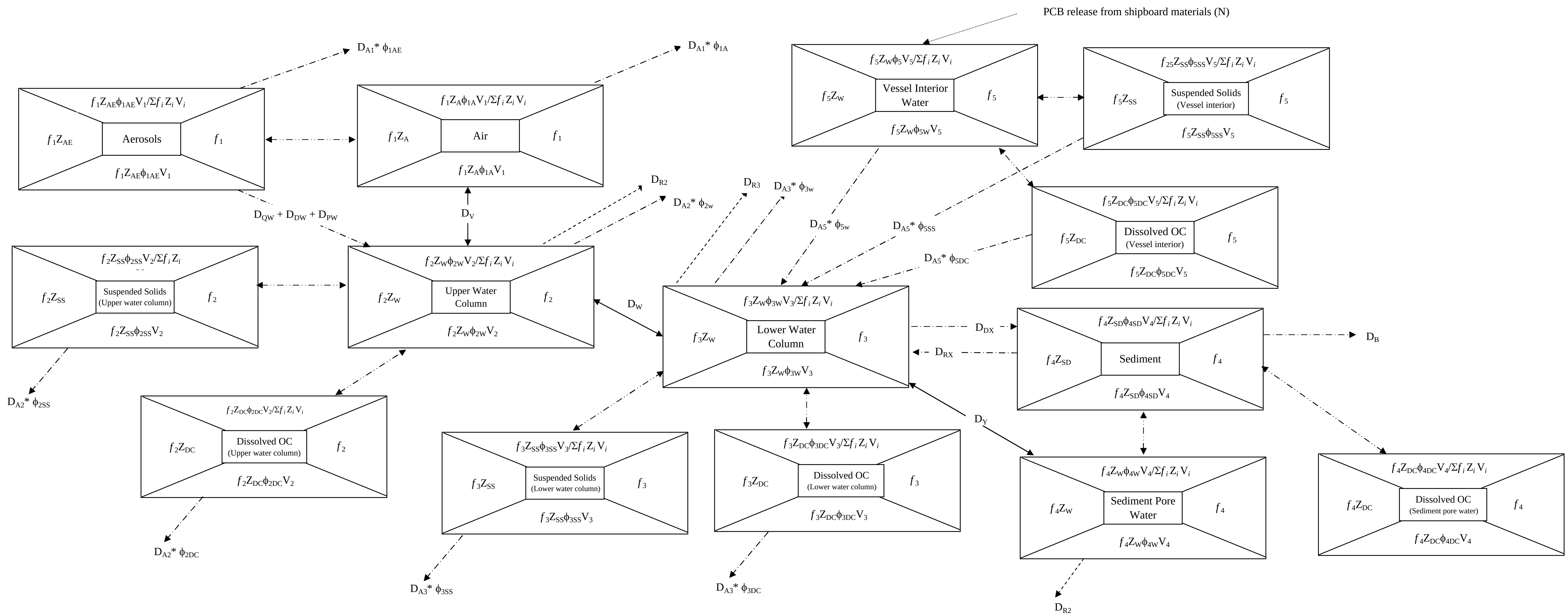
**Transport Coefficients and Conceptual Design for PCB Transport in PRAM**




*Reactive (Transformation) Processes are not presented*

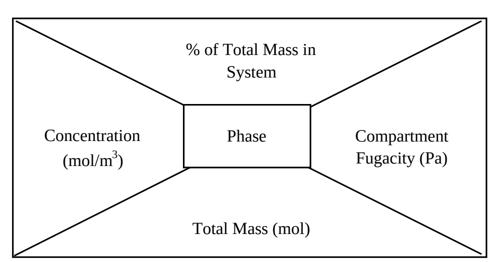
**Figure 7**

**Fugacity-Based Transport and Transfers of PCBs in PRAM**




**Legend**

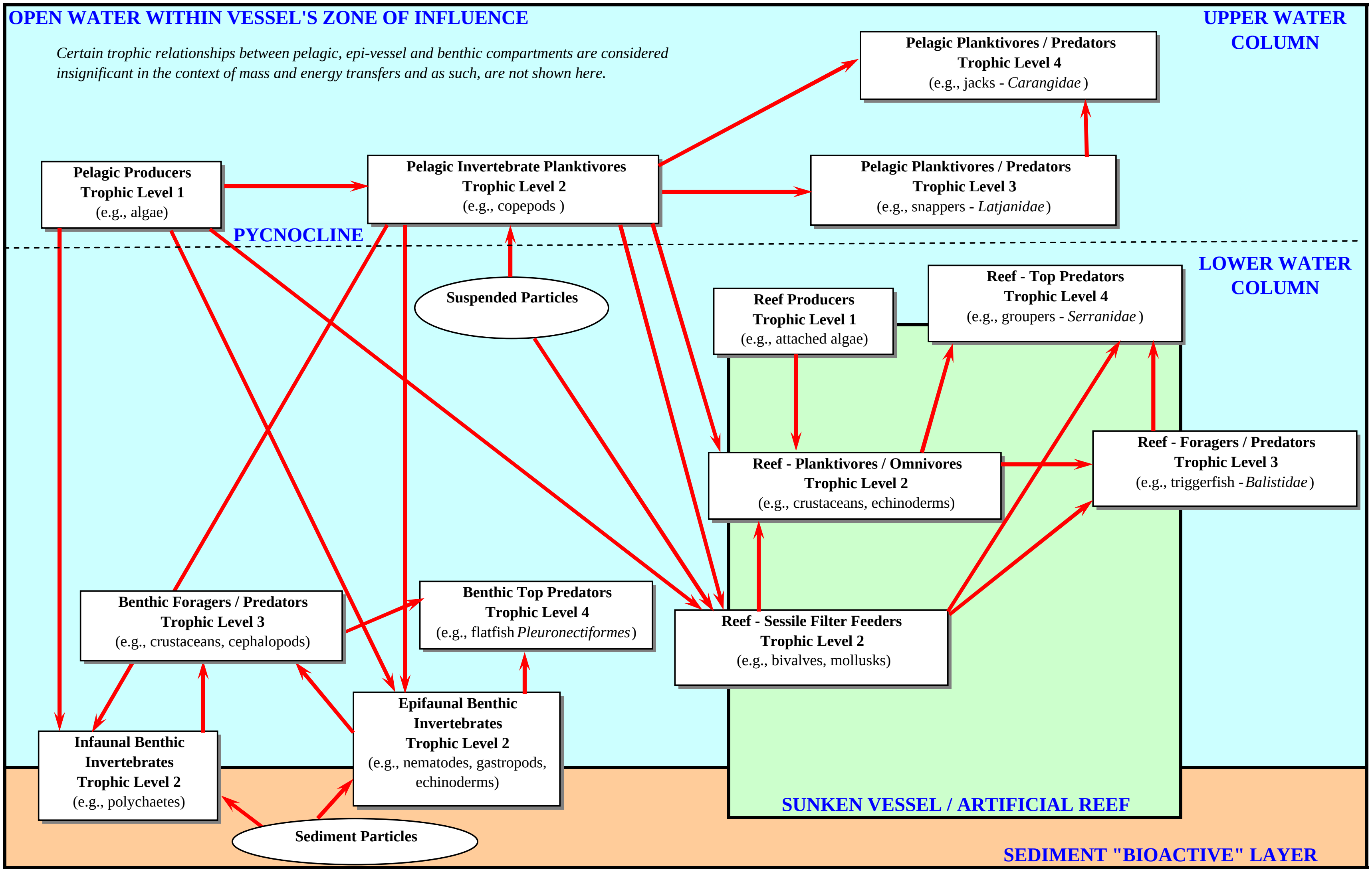
- Advection
- Mass Transfer (Diffusive Transport)
- Reaction
- Emission
- Simple partitioning




where:
$f$ = fugacity
$\phi$ = volume fraction of specific media within compartment
$Z$ = fugacity capacity of media (mol/m$^3$-Pa)
V = volume of compartment (m$^3$)
$D_{ij}$ = fugacity mass transfer coefficient (mol/Pa-day)

**Figure 8**

**Depiction of Food Web Used in PRAM**



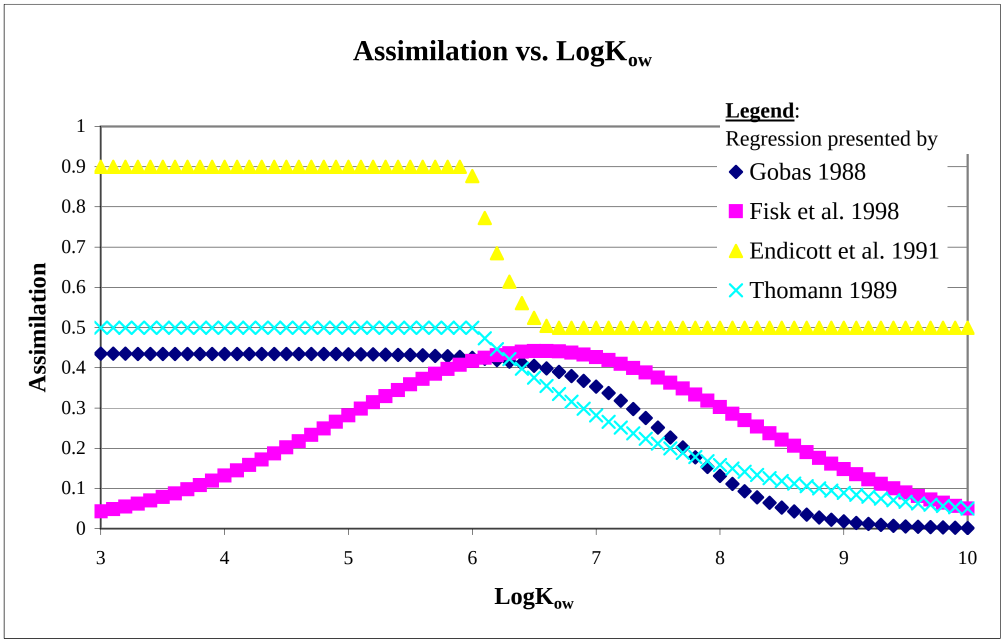

*Some organisms split their residence time between the Upper and Lower Water Columns.

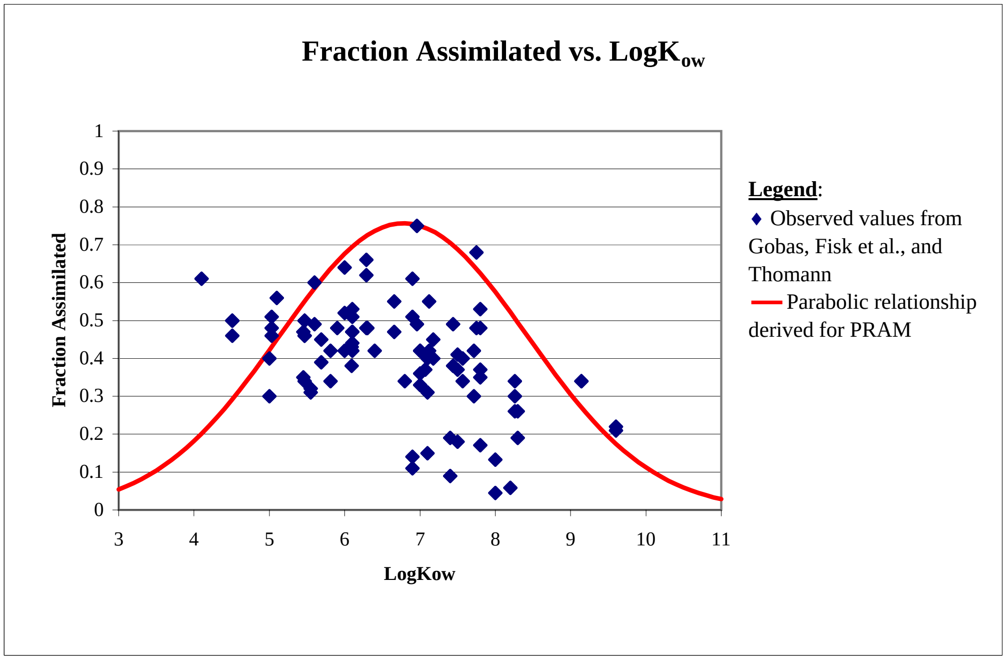


Arrows indicate the direction for the flow of energy and mass

**Figure 9**

**Assimilation Efficiencies Across Gastro-Intestinal Tracts as Function of Chemical-Specific $K_{ow}$ in the Food Web Module of PRAM**



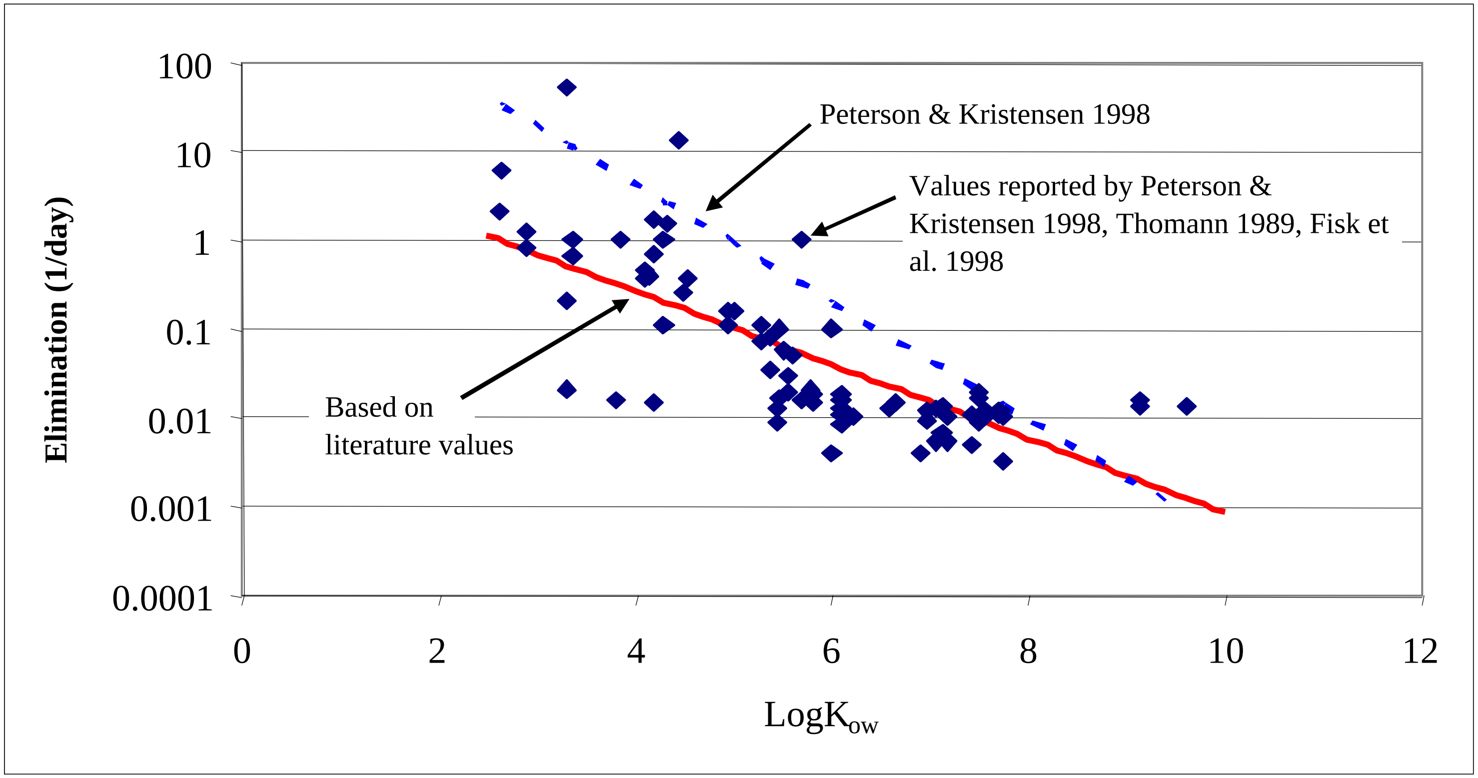




Review of the raw data suggested that the form of the relationship between $K_{ow}$ and $\alpha$ is perhaps best described as a parabolic function. A parabolic function was calibrated to assure a level of conservatism within the PRAM such virtually all of the reported assimilation efficiencies fell below the predicted values. The resultant algorithm is presented below and graphically compared to the observed values reported by Gobas et al. (1988), Thomann (1989), and Fisk et al. (1998).

$$\alpha = \frac{10^{-1.8+1.08\log Kow - 0.08\log Kow^2}}{100}$$

**Figure 10**

**Relationship Between $K_{ow}$ and Elimination Rates (Ke) of PCB in Aquatic Animals**




**Based on Peterson & Kristensen (1998) data only**

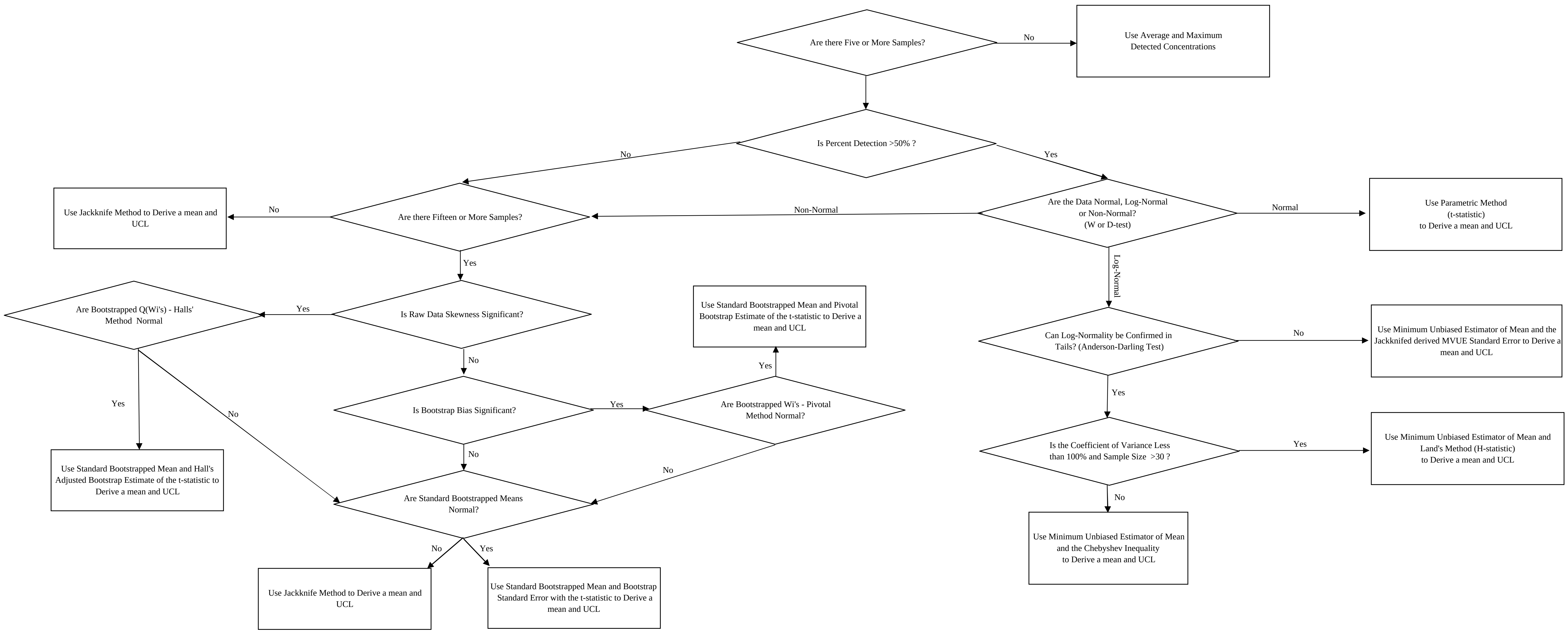
$$\log_{10} Ke\left[\frac{1}{day}\right] = 3.25 - 0.66 \times \log_{10} Kow$$

**Based on literature values (used in the PRAM)**

$$\log_{10} Ke\left[\frac{1}{day}\right] = 1.065 - 0.4131 \times \log_{10} Kow$$

**Figure 11**

**Logic Diagram for Statistical Estimation of Reasonable Maximum PCB Concentration and Central Tendency Concentration in Source Material Onboard the Ex-ORISKANY**






I:\Projects\PRAM\33756123 Navy PCB HHRA_WP\03000\REPORT\PRAM_ORISKANY-FIGS.xls\Fig 11

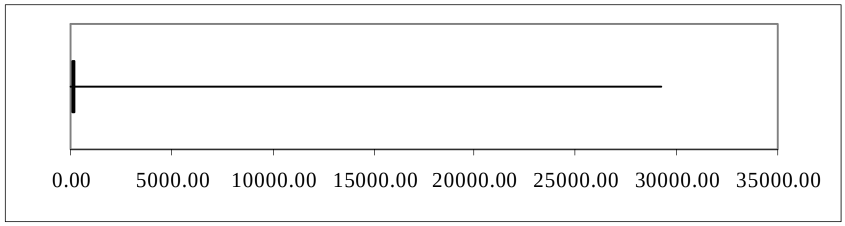
MVUE = minimum variance unbiased estimator
UCL = 95% upper confidence limit for the mean

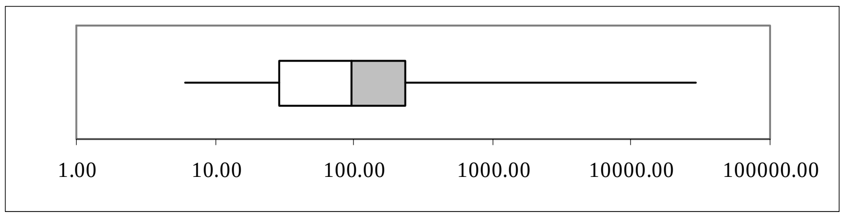
# Figure 12

## PCB Concentrations Presented as Box-Whisker Plots for Materials Found Onboard the Ex-ORSIKANY

### ELECTRICAL CABLE

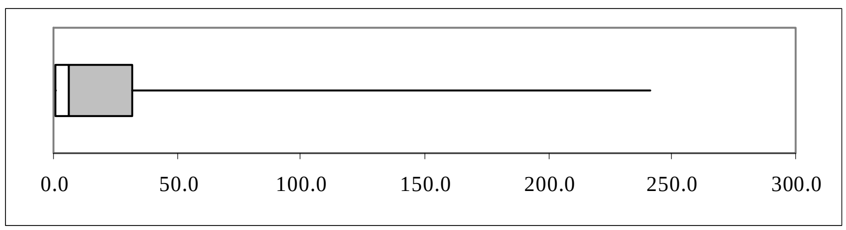
| Quantiles for the data set | |
|---|---|
| Minimum | 6.10 |
| Lower Quartile | 23.0 |
| Median | 67.0 |
| Upper Quartile | 140 |
| Maximum | 29000 |

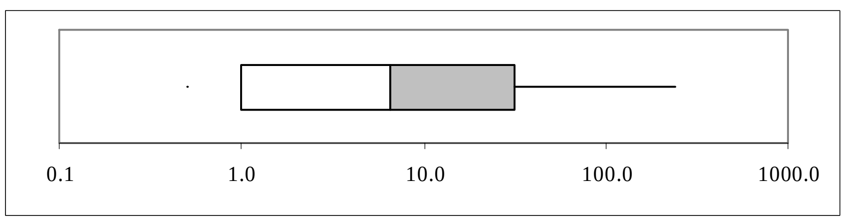



### VENTILATION GASKETS

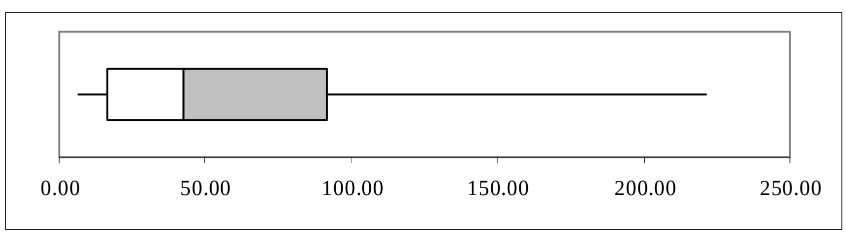
| Quantiles for the data set | |
|---|---|
| Minimum | 0.5 |
| Lower Quartile | 0.5 |
| Median | 5.5 |
| Upper Quartile | 25.0 |
| Maximum | 210 |

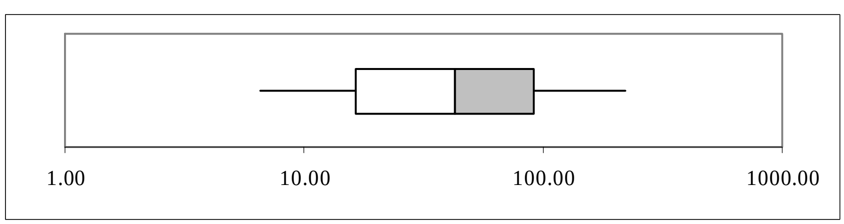



### RUBBER MATERIALS

| Quantiles for the data set | |
|---|---|
| Minimum | 6.50 |
| Lower Quartile | 10.0 |
| Median | 26.0 |
| Upper Quartile | 49.0 |
| Maximum | 130 |



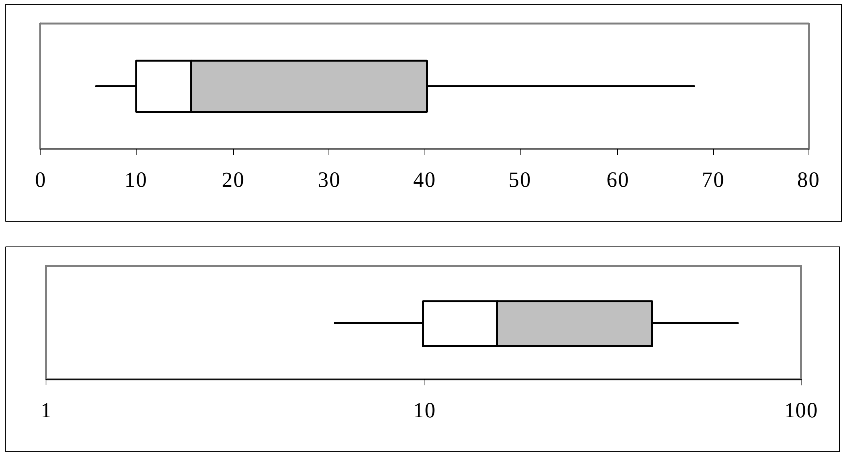

***The lines represent min and max, white box = 25th to 50th quantile, gray box = 50th to 75th quantile, 50th = the median value***

# Figure 12

## PCB Concentrations Presented as Box-Whisker Plots for Materials Found Onboard the Ex-ORSIKANY

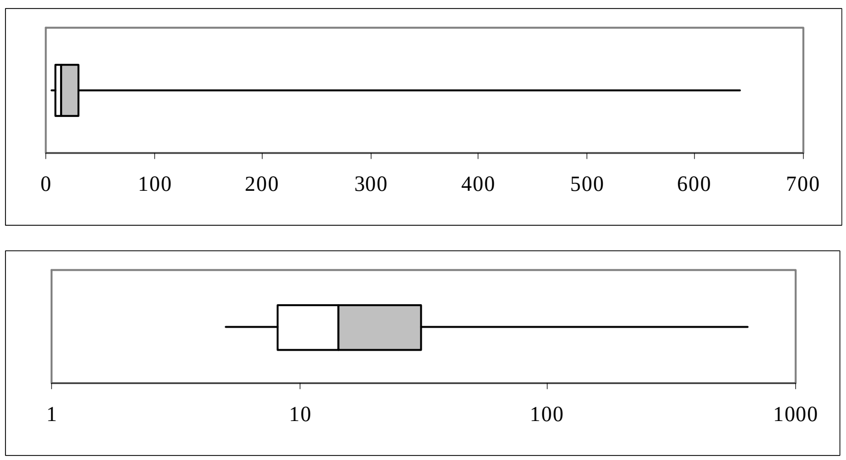
### PAINTS

| Quantiles for the data set | |
|---|---|
| Minimum | 5.8 |
| Lower Quartile | 4.12 |
| Median | 5.8 |
| Upper Quartile | 24.4 |
| Maximum | 28 |




### BULKHEAD INSULATION

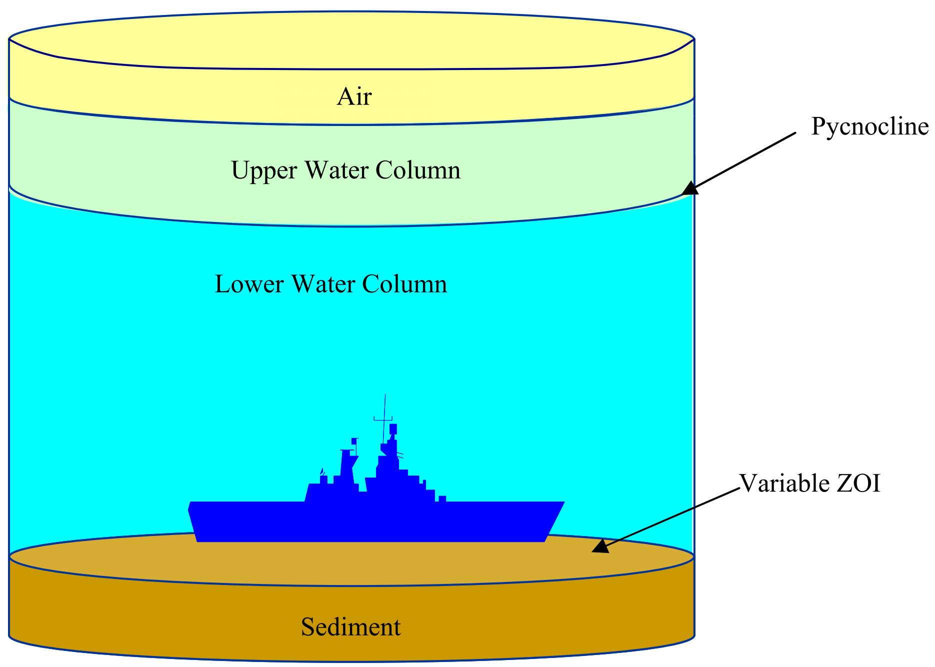
| Quantiles for the data set | |
|---|---|
| Minimum | 5 |
| Lower Quartile | 3.18 |
| Median | 6.15 |
| Upper Quartile | 16.5 |
| Maximum | 610 |




***The lines represent min and max, white box = 25$^{th}$ to 50$^{th}$ quantile, gray box = 50$^{th}$ to 75$^{th}$ quantile, 50$^{th}$ = the median value***

**Figure 13**

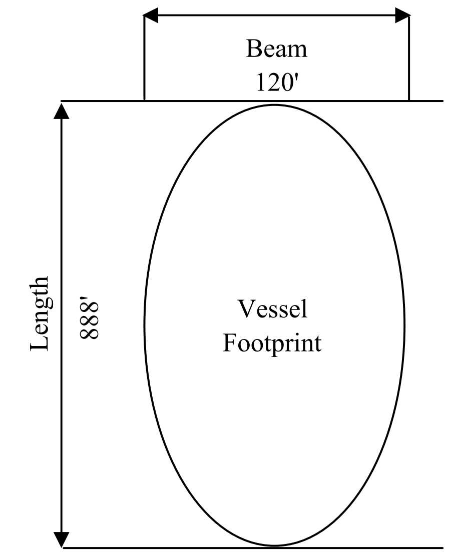
**Zone of Influence (ZOI) Ellipse Area Calculations**




## SIDE VIEW

Zone of Influence determines spatial footprint on ocean floor. PRAM models this elliptical footprint through upper and lower water columns as well as air space above vessel.

ZOI = 1 is equivalent to vessel footprint




## If ZOI = 1

Footprint = Vessel Footprint

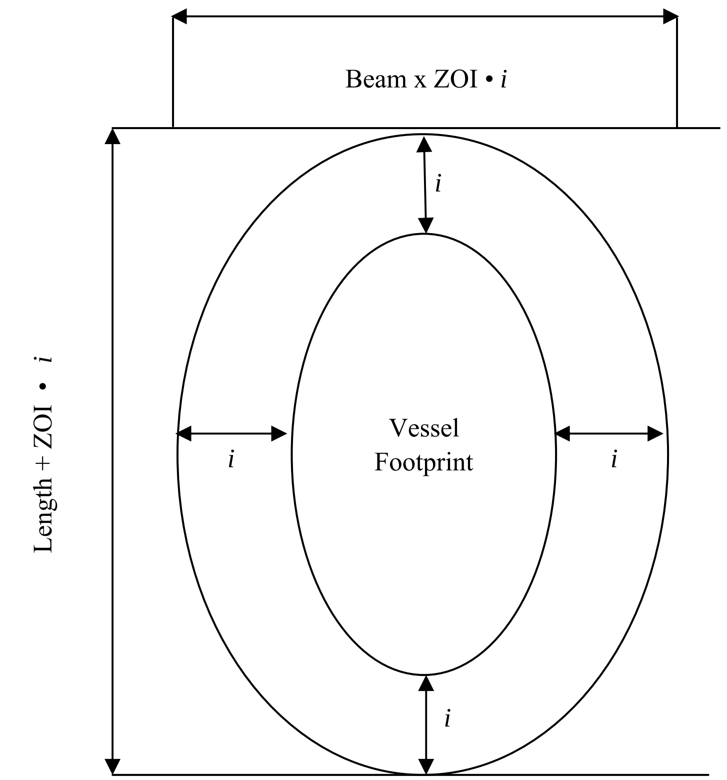
= Area of Ellipse

$$= \pi\left(\frac{\text{Length}}{2}\right)\left(\frac{\text{Beam}}{2}\right)$$

$$= \pi\left(\frac{888}{2}\right)\left(\frac{120}{2}\right)$$

$$= \pi(444)(60)$$

$$\approx 83{,}700 \text{ ft}^2$$




## For ZOI >1

Solve for increment, *i*

$$\text{Vessel footprint} \bullet \text{ZOI} = \frac{\pi}{4}(\text{L} + 2i)(\text{W} + 2i)$$

$$\frac{\pi}{4}\text{LW ZOI} = \frac{\pi}{4}\left(\text{LW} + 2i\text{W} + 2i\text{L} + 4i^2\right)$$

$$4i^2 + 2i(\text{W} + \text{L}) + (1 - \text{ZOI})\text{LW} = 0$$

$$i^2 + \frac{i}{2}(\text{W} + \text{L}) - \frac{(\text{ZOI} - 1)\text{LW}}{4} = 0$$

Solve quadratic equation for *i*

# Figure 14

## Risk Characterization Module in PRAM

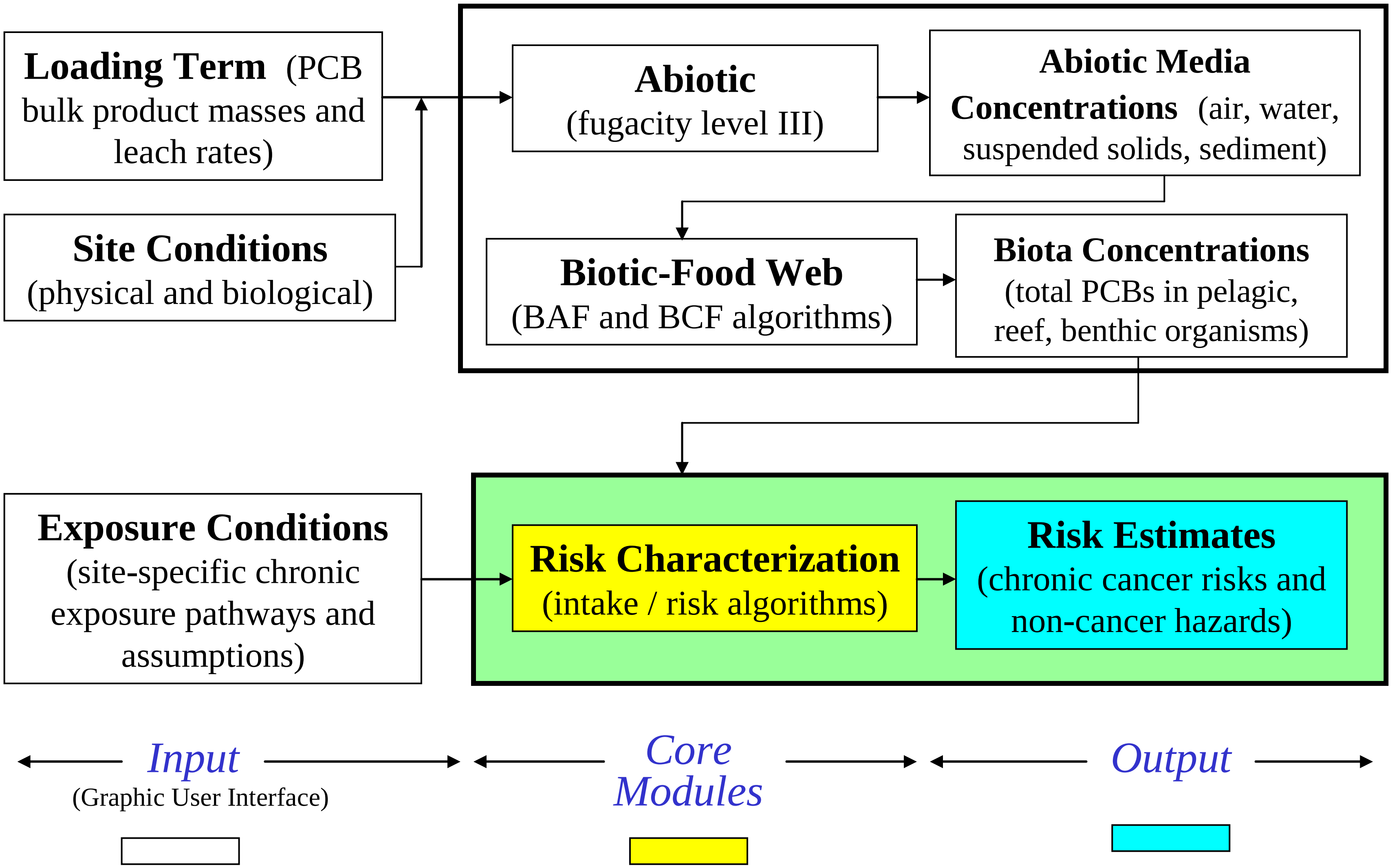
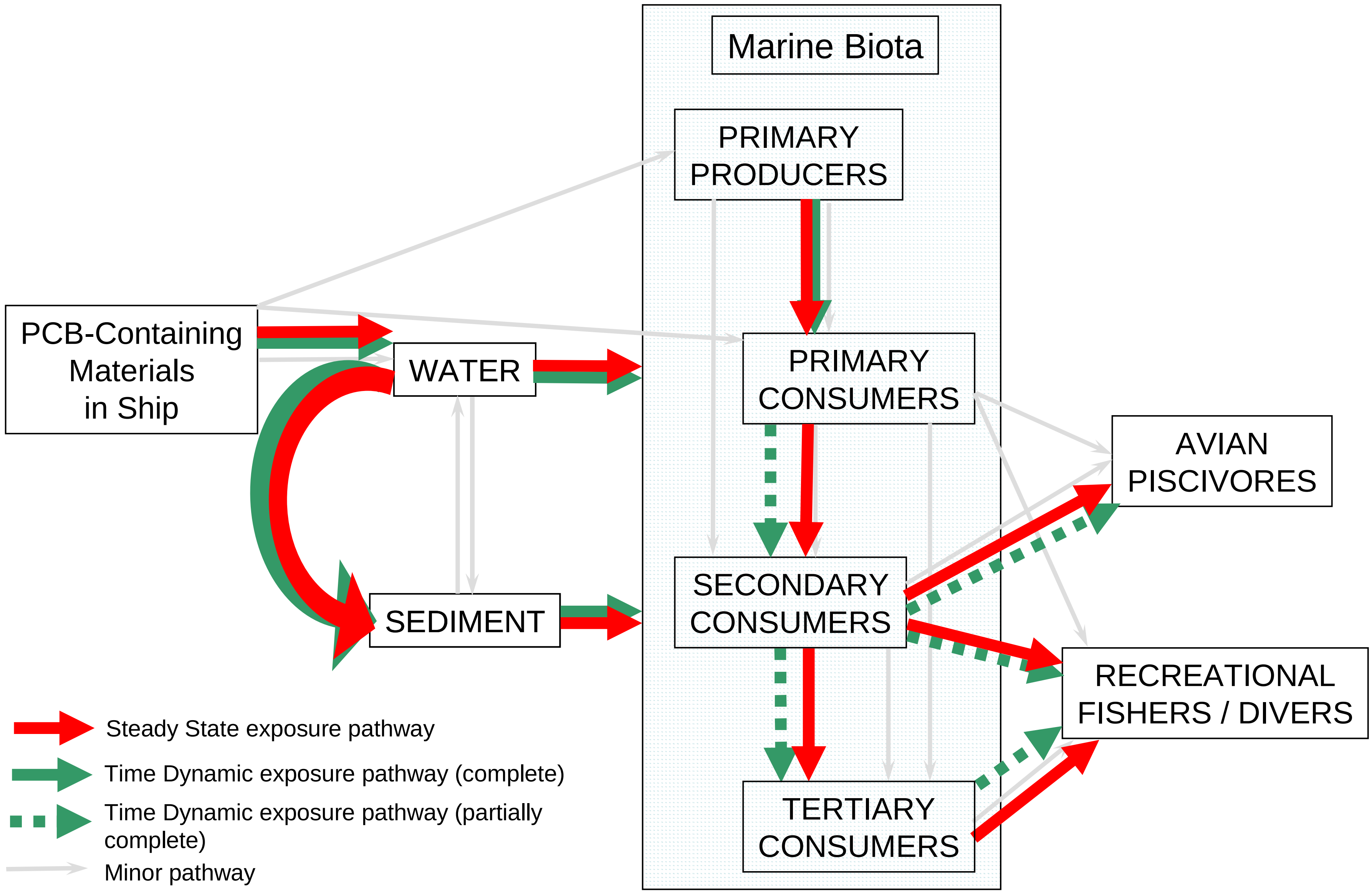


**Figure 15**

**SCEM - Site Conceptual Exposure Model**



# APPENDIX A

## REGRESSION ANALYSES: PCB LEACH RATES AND MATERIAL FRACTIONS

**LEACH RATES**

# ALUMINIZED PAINT

**Aluminized Paint**

| **Leaching Time (days)** ng/g material-d | Cl1 | Cl2 | Cl3 | Cl4 | Cl5 | Cl6 | Cl7 | Cl8 | Cl9 | Cl10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Homologue Leach Rates (ng PCB/g shipboard solid-day)** | | | | | | | | | |
| 0.008 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 1.101 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 3.1E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 7.022 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 5.0E-01 | 0.0E+00 | 0.0E+00 | 5.7E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 21.076 | 0.0E+00 | 0.0E+00 | 1.1E-01 | 4.4E-01 | 9.6E-01 | 4.8E-01 | 4.0E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 42.044 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.3E-01 | 8.3E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 71.241 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.2E-01 | 7.5E-01 | 5.7E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 105.081 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.4E-01 | 4.9E-01 | 3.6E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 147.088 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 2.4E-01 | 7.8E-01 | 5.1E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 189.030 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 2.0E-01 | 5.9E-01 | 3.4E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 231.006 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.2E-01 | 5.2E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 273.125 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 4.2E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 315.042 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 4.4E-02 | 2.9E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 357.008 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.6E-01 | 6.7E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 399.022 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 4.9E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 469.032 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 6.2E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Max | 0.0E+00 | 0.0E+00 | 1.1E-01 | 5.0E-01 | 9.6E-01 | 5.7E-01 | 3.1E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Min | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |

0.00043 g PCB / g paint (leachate study concentration)

| **Leaching Time (days)** ng/ g-PCB - d | Cl1 | Cl2 | Cl3 | Cl4 | Cl5 | Cl6 | Cl7 | Cl8 | Cl9 | Cl10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Homologue Leach Rates (ng PCB/g PCB-day)** | | | | | | | | | |
| 0.008 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.101 | 0 | 0 | 0 | 0 | 0 | 0 | 7191 | 0 | 0 | 0 |
| 7.022 | 0 | 0 | 0 | 1165 | 0 | 0 | 1314 | 0 | 0 | 0 |
| 21.076 | 0 | 0 | 261 | 1021 | 2240 | 1108 | 921 | 0 | 0 | 0 |
| 42.044 | 0 | 0 | 0 | 300 | 1919 | 0 | 0 | 0 | 0 | 0 |
| 71.241 | 0 | 0 | 0 | 272 | 1739 | 1333 | 0 | 0 | 0 | 0 |
| 105.081 | 0 | 0 | 0 | 324 | 1150 | 836 | 0 | 0 | 0 | 0 |
| 147.088 | 0 | 0 | 0 | 547 | 1810 | 1179 | 0 | 0 | 0 | 0 |
| 189.030 | 0 | 0 | 0 | 459 | 1376 | 793 | 0 | 0 | 0 | 0 |
| 231.006 | 0 | 0 | 0 | 283 | 1209 | 0 | 0 | 0 | 0 | 0 |
| 273.125 | 0 | 0 | 0 | 97 | 0 | 0 | 0 | 0 | 0 | 0 |
| 315.042 | 0 | 0 | 0 | 101 | 68 | 0 | 0 | 0 | 0 | 0 |
| 357.008 | 0 | 0 | 0 | 383 | 1559 | 0 | 0 | 0 | 0 | 0 |
| 399.022 | 0 | 0 | 0 | 114 | 0 | 0 | 0 | 0 | 0 | 0 |
| 469.032 | 0 | 0 | 0 | 144 | 0 | 0 | 0 | 0 | 0 | 0 |
| Max | 0 | 0 | 261 | 1165 | 2240 | 1333 | 7191 | 0 | 0 | 0 |
| Min | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Median | 0 | 0 | 0 | 283 | 1150 | 0 | 0 | 0 | 0 | 0 |
| Simple Average | 0 | 0 | 17.4 | 347 | 871 | 350 | 628 | 0 | 0 | 0 |
| Detects | 0 | 0 | 1 | 13 | 10 | 5 | 3 | 0 | 0 | 0 |
| Non-detects | 15 | 15 | 14 | 2 | 5 | 10 | 12 | 15 | 15 | 15 |
| Intercept | --- | --- | --- | 8.09E+00 | 9.74E+00 | 8.69E+00 | 8.85E+00 | --- | --- | --- |
| Slope | --- | --- | --- | -4.96E-01 | -5.70E-01 | -3.69E-01 | -7.19E-01 | --- | --- | --- |
| alpha | --- | --- | --- | 1.92E-03 | 1.67E-01 | 3.88E-01 | 1.37E-01 | --- | --- | --- |

## Tetrachlorobiphenyl in Aluminized Paint

| ng/ g-PCB - d | C14 |
|---|---|
| 7.64E-03 | 0 |
| 1.10E+00 | 0 |
| 7.02E+00 | 1165 |
| 2.11E+01 | 1021 |
| 4.20E+01 | 300 |
| 7.12E+01 | 272 |
| 1.05E+02 | 324 |
| 1.47E+02 | 547 |
| 1.89E+02 | 459 |
| 2.31E+02 | 283 |
| 2.73E+02 | 97 |
| 3.15E+02 | 101 |
| 3.57E+02 | 383 |
| 3.99E+02 | 114 |
| 4.69E+02 | 144 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 1.95E+00 | 7.02E+00 | 1165 | 7.06E+00 |
| 3.05E+00 | 2.11E+01 | 1021 | 6.93E+00 |
| 3.74E+00 | 4.20E+01 | 300 | 5.70E+00 |
| 4.27E+00 | 7.12E+01 | 272 | 5.61E+00 |
| 4.65E+00 | 1.05E+02 | 324 | 5.78E+00 |
| 4.99E+00 | 1.47E+02 | 547 | 6.30E+00 |
| 5.24E+00 | 1.89E+02 | 459 | 6.13E+00 |
| 5.44E+00 | 2.31E+02 | 283 | 5.65E+00 |
| 5.61E+00 | 2.73E+02 | 97 | 4.57E+00 |
| 5.75E+00 | 3.15E+02 | 101 | 4.62E+00 |
| 5.88E+00 | 3.57E+02 | 383 | 5.95E+00 |
| 5.99E+00 | 3.99E+02 | 114 | 4.73E+00 |
| 6.15E+00 | 4.69E+02 | 144 | 4.97E+00 |

**Maximum Release Rate at 7 day**
**1165 ng/gPCB-d**

**Release rate at 2 years**
**123.3 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.7736 |
| R Square | 0.5985 |
| Standard Error | 0.5371 |
| Observations | 13 |

ANOVA

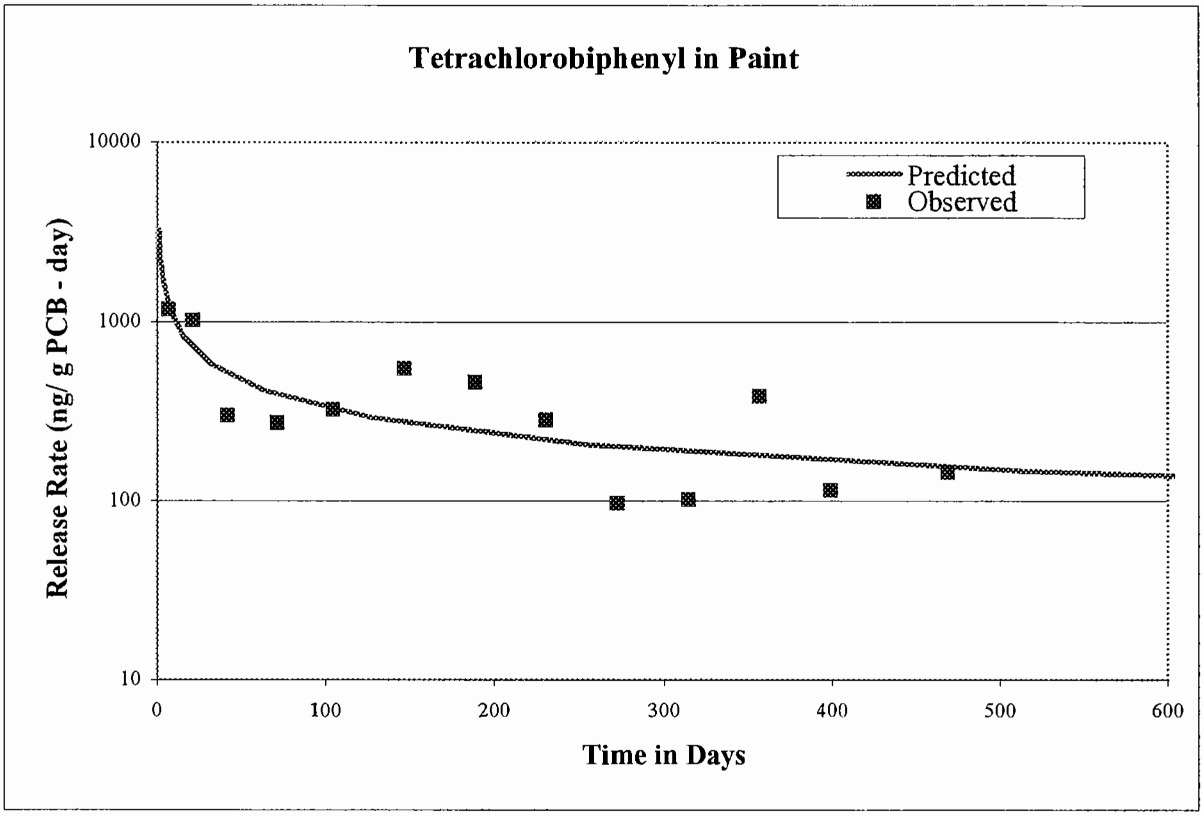
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 4.73E+00 | 4.73E+00 | 1.64E+01 | 1.92E-03 |
| Residual | 11 | 3.17E+00 | 2.88E-01 | | |
| Total | 12 | 7.90E+00 | | | |

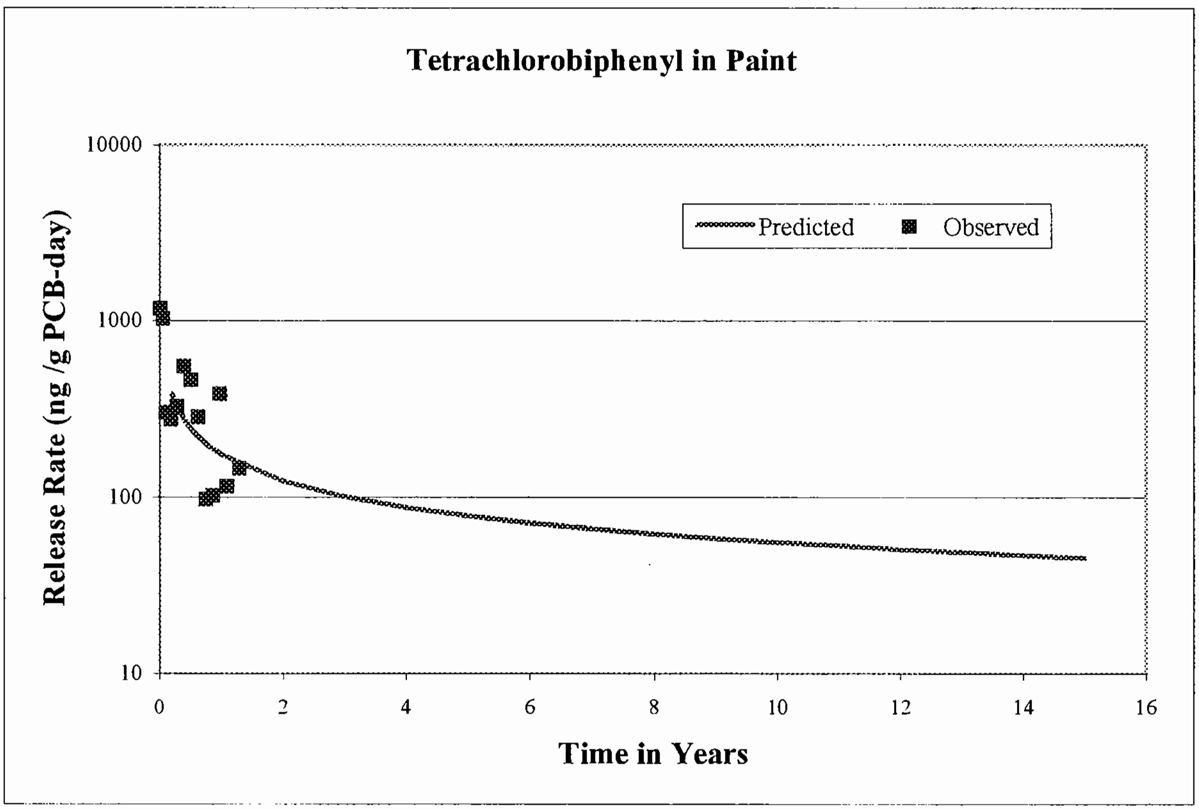
| | *Coefficients* | *andard Errc* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 8.09E+00 | 6.09E-01 | 1.33E+01 | 4.11E-08 | 6.74E+00 | 9.43E+00 |
| ln(day) | -4.96E-01 | 1.22E-01 | -4.05E+00 | 1.92E-03 | -7.66E-01 | -2.26E-01 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 7.12E+00 | -5.81E-02 |
| 2 | 6.57E+00 | 3.55E-01 |
| 3 | 6.23E+00 | -5.26E-01 |
| 4 | 5.97E+00 | -3.62E-01 |
| 5 | 5.78E+00 | 4.31E-03 |
| 6 | 5.61E+00 | 6.95E-01 |
| 7 | 5.49E+00 | 6.43E-01 |
| 8 | 5.39E+00 | 2.61E-01 |
| 9 | 5.30E+00 | -7.32E-01 |
| 10 | 5.23E+00 | -6.14E-01 |
| 11 | 5.17E+00 | 7.79E-01 |
| 12 | 5.11E+00 | -3.82E-01 |

| | | |
|---|---|---|
| 13 | 5.03E+00 | -6.48E-02 |



**Pentachlorobiphenyl in Aluminized Paint**

| ng/ g-PCB - d | Cl5 |
|---|---|
| 7.64E-03 | 0 |
| 1.10E+00 | 0 |
| 7.02E+00 | 0 |
| 2.11E+01 | 2240 |
| 4.20E+01 | 1919 |
| 7.12E+01 | 1739 |
| 1.05E+02 | 1150 |
| 1.47E+02 | 1810 |
| 1.89E+02 | 1376 |
| 2.31E+02 | 1209 |
| 2.73E+02 | 0 |
| 3.15E+02 | 68 |
| 3.57E+02 | 1559 |
| 3.99E+02 | 0 |
| 4.69E+02 | 0 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 3.05E+00 | 2.11E+01 | 2240 | 7.71E+00 |
| 3.74E+00 | 4.20E+01 | 1919 | 7.56E+00 |
| 4.27E+00 | 7.12E+01 | 1739 | 7.46E+00 |
| 4.65E+00 | 1.05E+02 | 1150 | 7.05E+00 |
| 4.99E+00 | 1.47E+02 | 1810 | 7.50E+00 |
| 5.24E+00 | 1.89E+02 | 1376 | 7.23E+00 |
| 5.44E+00 | 2.31E+02 | 1209 | 7.10E+00 |
| 5.75E+00 | 3.15E+02 | 68 | 4.21E+00 |
| 5.88E+00 | 3.57E+02 | 1559 | 7.35E+00 |

**Maximum Release Rate at 21 day**
**2240 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.5038 |
| R Square | 0.2538 |
| Standard Error | 0.9926 |
| Observations | 9 |

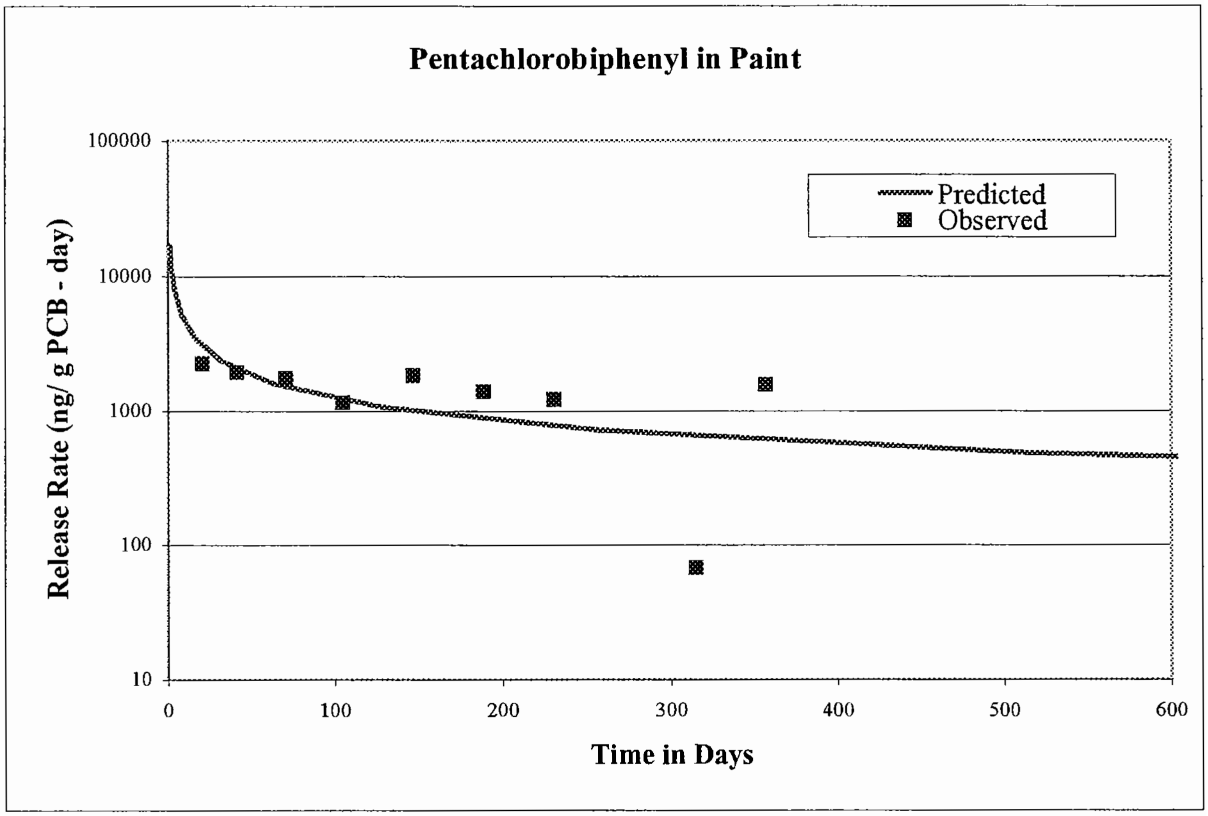
ANOVA

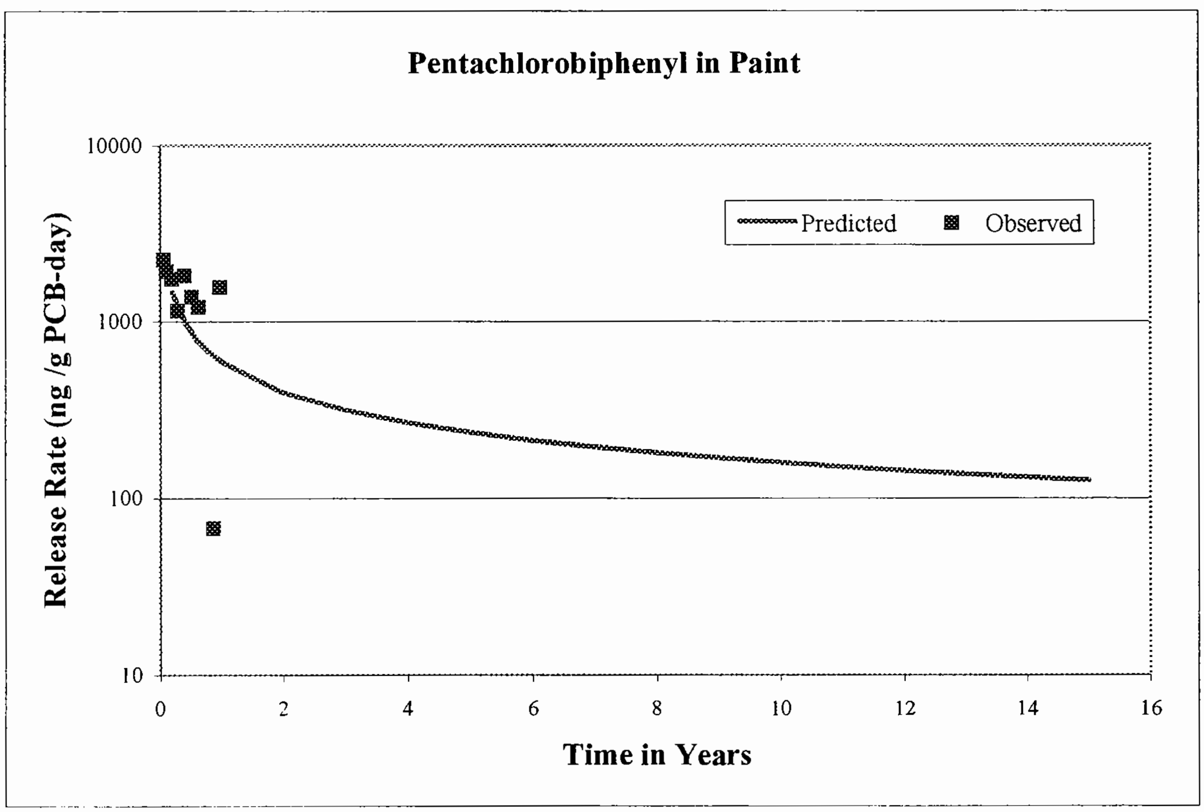
| | *df* | *SS* | *MS* | *F* | *Significance F* | |
|---|---|---|---|---|---|---|
| Regression | 1 | 2.35E+00 | 2.35E+00 | 2.38E+00 | 1.67E-01 | ***Not Significant*** |
| Residual | 7 | 6.90E+00 | 9.85E-01 | | | |
| Total | 8 | 9.24E+00 | | | | |

| | *Coefficients* | *andard Errc* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 9.74E+00 | 1.80E+00 | 5.42E+00 | 9.85E-04 | 5.49E+00 | 1.40E+01 |
| ln(day) | -5.70E-01 | 3.70E-01 | -1.54E+00 | 1.67E-01 | -1.44E+00 | 3.04E-01 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 8.01E+00 | -2.92E-01 |
| 2 | 7.61E+00 | -5.31E-02 |
| 3 | 7.31E+00 | 1.49E-01 |
| 4 | 7.09E+00 | -4.29E-02 |
| 5 | 6.90E+00 | 6.03E-01 |
| 6 | 6.76E+00 | 4.72E-01 |
| 7 | 6.64E+00 | 4.56E-01 |
| 8 | 6.46E+00 | -2.25E+00 |
| 9 | 6.39E+00 | 9.59E-01 |


Pentachlorobiphenyl in Paint
Release Rate (ng/ g PCB - day)
100000
10000
1000
100
10
0
100
200
300
400
500
600
Time in Days
Predicted
Observed


Pentachlorobiphenyl in Paint
Release Rate (ng /g PCB-day)
10000
1000
100
10
0
2
4
6
8
10
12
14
16
Time in Years
Predicted
Observed

## Hexachlorobiphenyl in Aluminized Paint

| ng/ g-PCB - d | Cl6 |
|---|---|
| 7.64E-03 | 0 |
| 1.10E+00 | 0 |
| 7.02E+00 | 0 |
| 2.11E+01 | 1108 |
| 4.20E+01 | 0 |
| 7.12E+01 | 1333 |
| 1.05E+02 | 836 |
| 1.47E+02 | 1179 |
| 1.89E+02 | 793 |
| 2.31E+02 | 0 |
| 2.73E+02 | 0 |
| 3.15E+02 | 0 |
| 3.57E+02 | 0 |
| 3.99E+02 | 0 |
| 4.69E+02 | 0 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 4.27E+00 | 7.12E+01 | 1333 | 7.20E+00 |
| 4.65E+00 | 1.05E+02 | 836 | 6.73E+00 |
| 4.99E+00 | 1.47E+02 | 1179 | 7.07E+00 |
| 5.24E+00 | 1.89E+02 | 793 | 6.68E+00 |

**Maximum Release Rate at 71 days**
**1333 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.6123 |
| R Square | 0.3749 |
| Standard Error | 0.2472 |
| Observations | 4 |

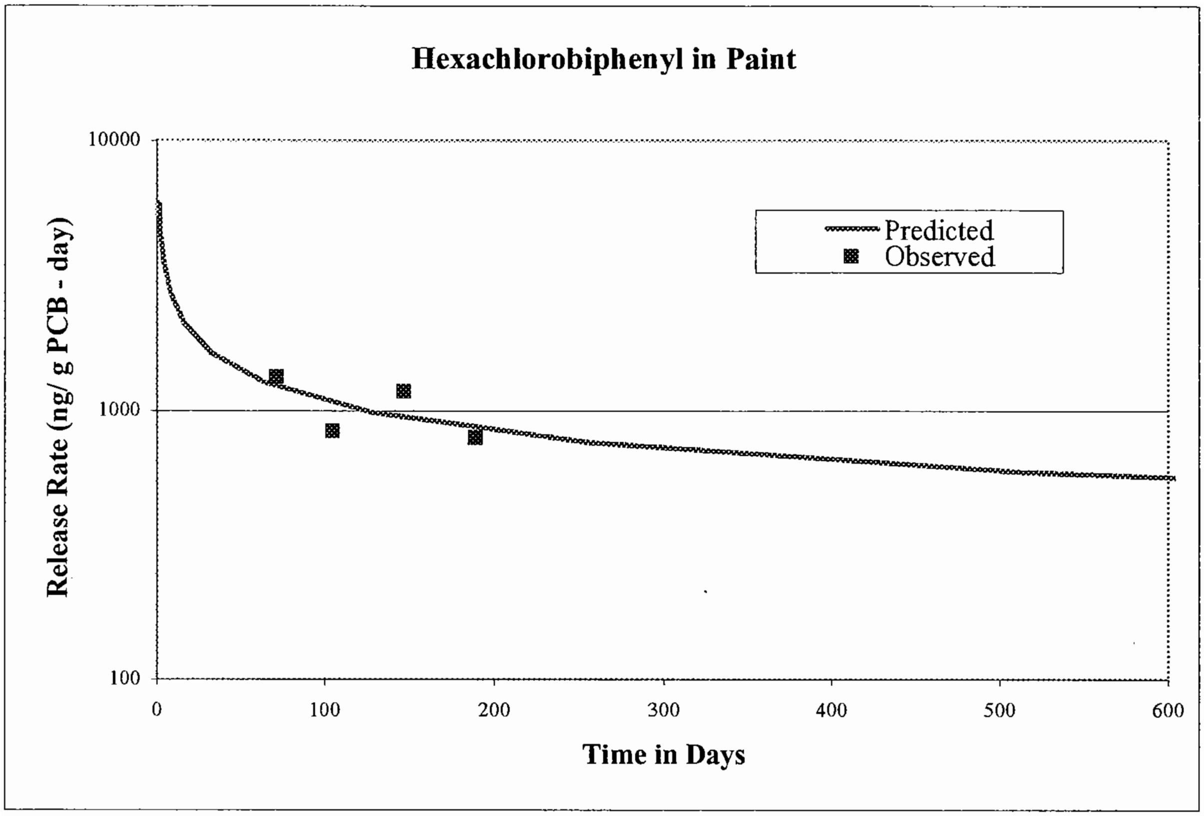
ANOVA

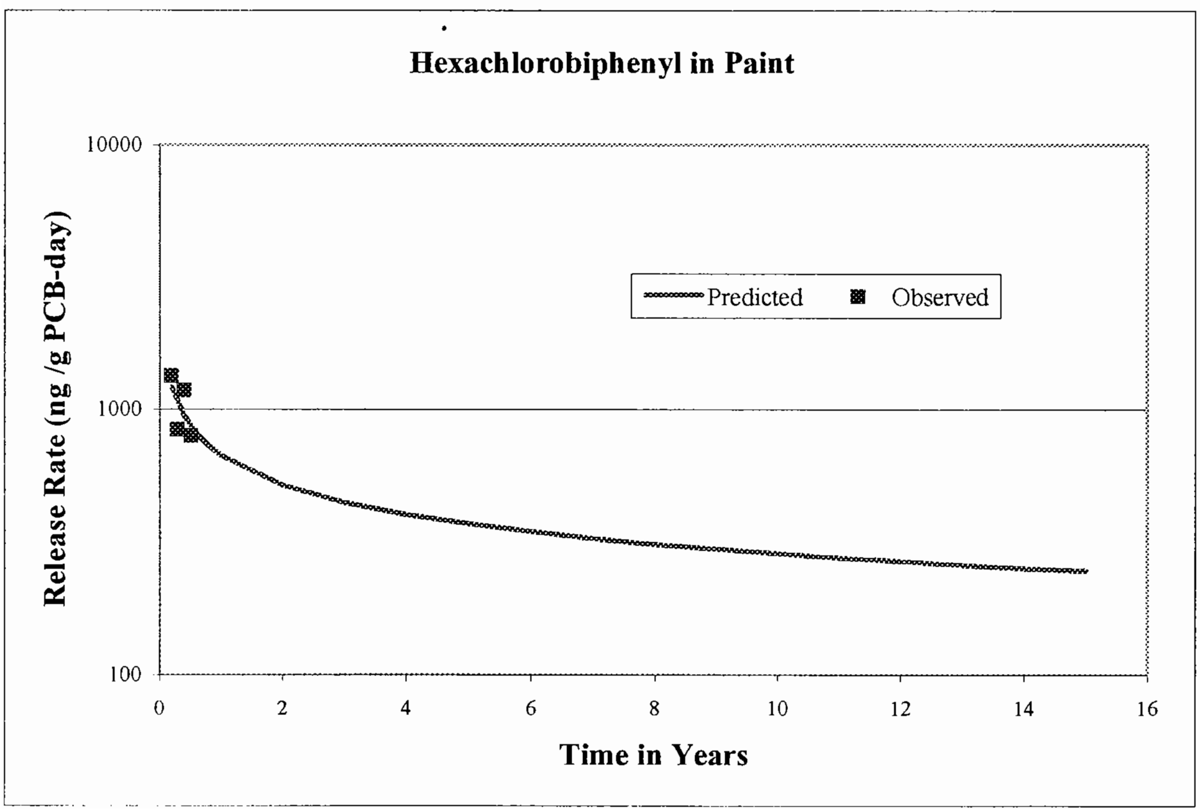
| | *df* | *SS* | *MS* | *F* | *Significance F* | |
|---|---|---|---|---|---|---|
| Regression | 1 | 7.33E-02 | 7.33E-02 | 1.20E+00 | 3.88E-01 | ***Not Significant*** |
| Residual | 2 | 1.22E-01 | 6.11E-02 | | | |
| Total | 3 | 1.95E-01 | | | | |

| | *Coefficients* | *andard Erro* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 8.69E+00 | 1.62E+00 | 5.36E+00 | 3.30E-02 | 1.72E+00 | 1.57E+01 |
| ln(day) | -3.69E-01 | 3.37E-01 | -1.10E+00 | 3.88E-01 | -1.82E+00 | 1.08E+00 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 7.11E+00 | 8.46E-02 |
| 2 | 6.97E+00 | -2.38E-01 |
| 3 | 6.84E+00 | 2.29E-01 |
| 4 | 6.75E+00 | -7.53E-02 |


Hexachlorobiphenyl in Paint
10000
1000
100
Release Rate (ng/ g PCB - day)
Predicted
Observed
0
100
200
300
400
500
600
Time in Days


Hexachlorobiphenyl in Paint
10000
1000
100
Release Rate (ng /g PCB-day)
Predicted
Observed
0
2
4
6
8
10
12
14
16
Time in Years

## Heptachlorobiphenyl in Aluminized Paint

| ng/ g-PCB - d | C17 |
|---|---|
| 7.64E-03 | 0 |
| 1.10E+00 | 7191 |
| 7.02E+00 | 1314 |
| 2.11E+01 | 921 |
| 4.20E+01 | 0 |
| 7.12E+01 | 0 |
| 1.05E+02 | 0 |
| 1.47E+02 | 0 |
| 1.89E+02 | 0 |
| 2.31E+02 | 0 |
| 2.73E+02 | 0 |
| 3.15E+02 | 0 |
| 3.57E+02 | 0 |
| 3.99E+02 | 0 |
| 4.69E+02 | 0 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 9.66E-02 | 1.10E+00 | 7191 | 8.88E+00 |
| 1.95E+00 | 7.02E+00 | 1314 | 7.18E+00 |
| 3.05E+00 | 2.11E+01 | 921 | 6.83E+00 |

**Maximum Release Rate at 1 day**
**7191 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.97703275 |
| R Square | 0.954592995 |
| Standard Error | 0.330974678 |
| Observations | 3 |

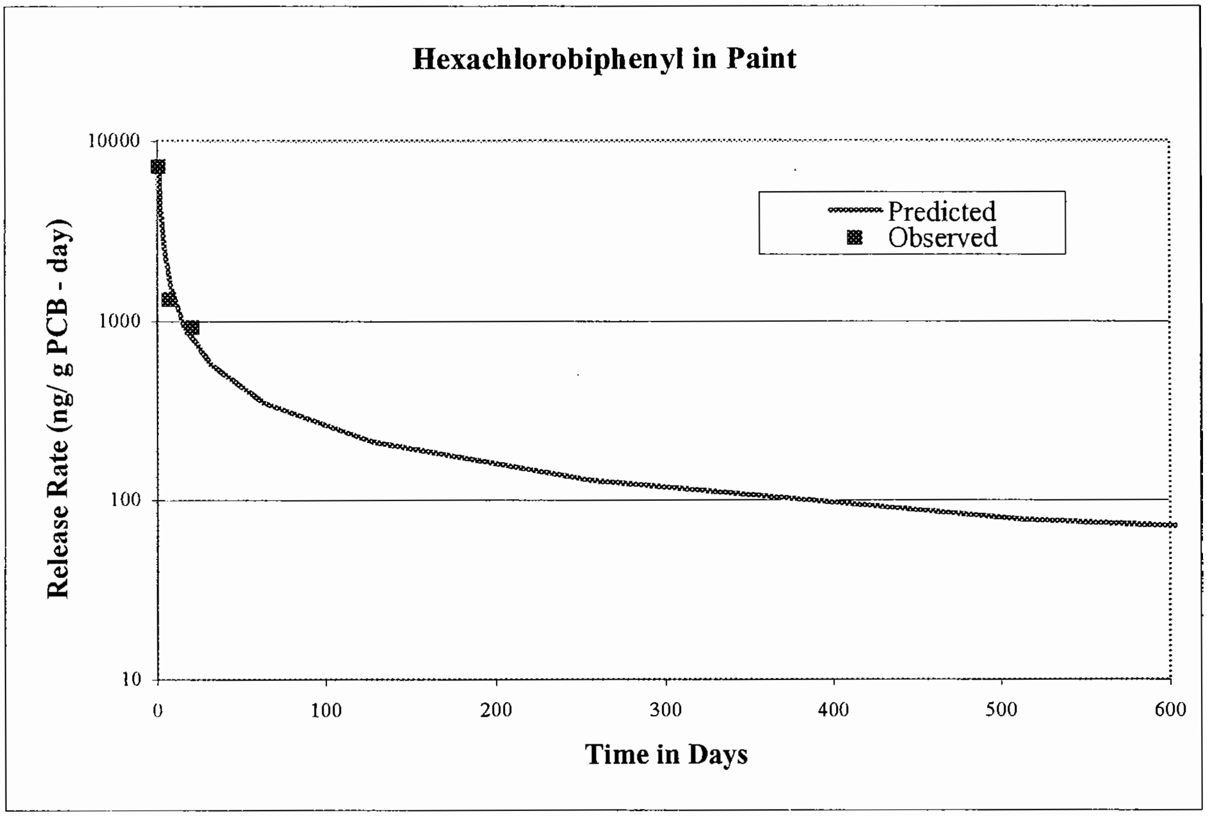
ANOVA

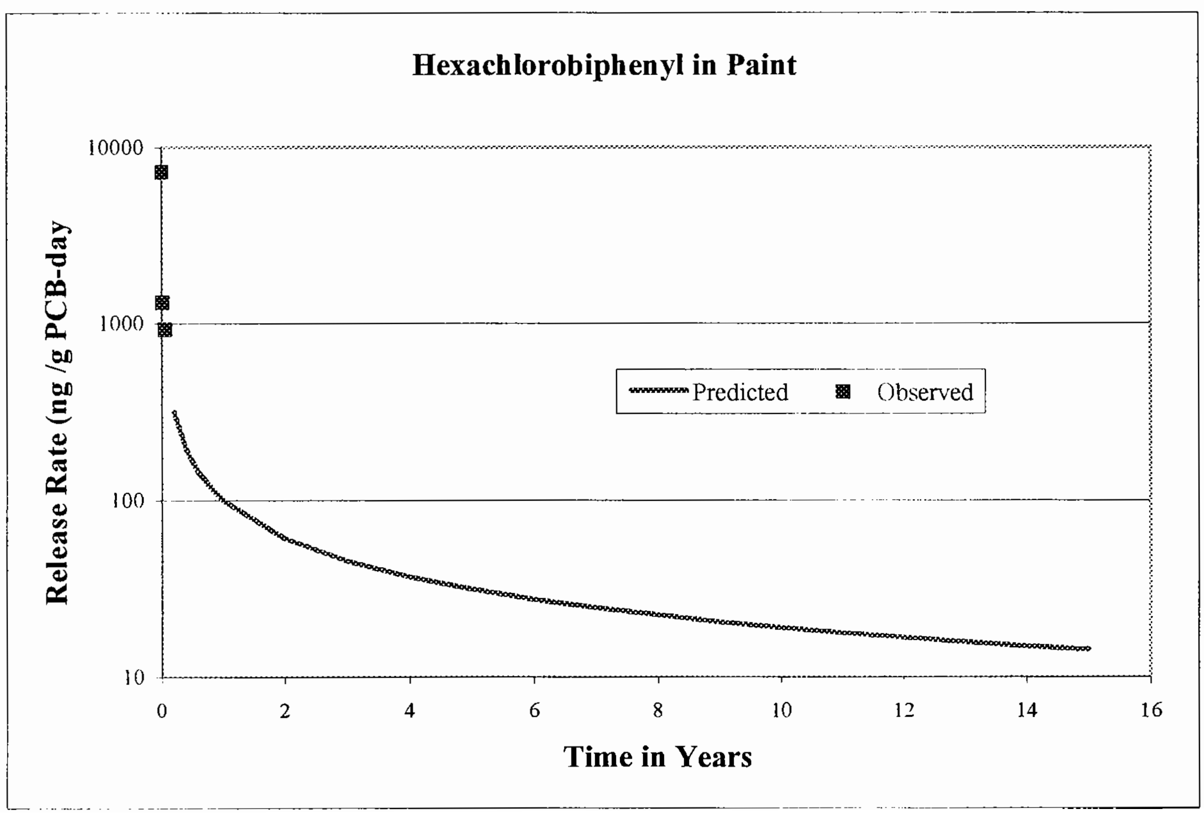
| | *df* | *SS* | *MS* | *F* | *Significance F* | |
|---|---|---|---|---|---|---|
| Regression | 1 | 2.30E+00 | 2.30E+00 | 2.10E+01 | 1.37E-01 | ***Not Significant*** |
| Residual | 1 | 1.10E-01 | 1.10E-01 | | | |
| Total | 2 | 2.41E+00 | | | | |

| | *Coefficients* | *andard Erro* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 8.85E+00 | 3.28E-01 | 2.70E+01 | 2.36E-02 | 4.68E+00 | 1.30E+01 |
| ln(day) | -7.19E-01 | 1.57E-01 | -4.59E+00 | 1.37E-01 | -2.71E+00 | 1.27E+00 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 8.78E+00 | 9.96E-02 |
| 2 | 7.45E+00 | -2.67E-01 |
| 3 | 6.66E+00 | 1.68E-01 |


Hexachlorobiphenyl in Paint
Predicted
Observed
Release Rate (ng/ g PCB - day)
10000
1000
100
10
0
100
200
300
400
500
600
Time in Days


Hexachlorobiphenyl in Paint
Predicted
Observed
Release Rate (ng /g PCB-day
10000
1000
100
10
0
2
4
6
8
10
12
14
16
Time in Years

**AROCLOR 1254**

Aroclor 1254

| Leaching Time (days) | Homologue Leach Rates (ng PCB/g shipboard solid-day) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cl1 | Cl2 | Cl3 | Cl4 | Cl5 | Cl6 | Cl7 | Cl8 | Cl9 | Cl10 |
| 2.08E-03 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 1.03E+00 | 5.5E+02 | 1.6E+03 | 5.1E+02 | 1.3E+03 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 6.06E+00 | 4.6E+02 | 1.2E+03 | 8.5E+02 | 5.4E+03 | 1.1E+03 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2.13E+01 | 2.9E+02 | 8.8E+02 | 7.0E+02 | 6.7E+03 | 2.8E+03 | 8.8E+01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 4.23E+01 | 2.0E+02 | 6.4E+02 | 5.6E+02 | 7.6E+03 | 5.0E+03 | 3.2E+02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 6.21E+01 | 2.1E+02 | 6.5E+02 | 6.2E+02 | 8.5E+03 | 6.9E+03 | 5.3E+02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 6.93E+01 | 2.1E+02 | 8.0E+02 | 1.1E+03 | 2.3E+04 | 2.6E+04 | 2.6E+03 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 1.11E+02 | 8.6E+01 | 3.4E+02 | 3.4E+02 | 5.7E+03 | 5.3E+03 | 6.8E+02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 1.46E+02 | 8.3E+01 | 3.4E+02 | 3.5E+02 | 6.0E+03 | 5.2E+03 | 5.5E+02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 1.88E+02 | 6.6E+01 | 2.6E+02 | 2.7E+02 | 3.4E+03 | 3.0E+03 | 4.0E+02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2.30E+02 | 5.4E+01 | 2.5E+02 | 3.0E+02 | 6.1E+03 | 8.6E+03 | 1.2E+03 | 7.2E+01 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2.86E+02 | 5.2E+01 | 2.0E+02 | 1.7E+02 | 2.5E+03 | 2.1E+03 | 3.7E+02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 3.31E+02 | 6.0E+01 | 2.8E+02 | 2.5E+02 | 3.2E+03 | 2.4E+03 | 3.5E+02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 3.70E+02 | 3.1E+01 | 1.9E+02 | 1.9E+02 | 2.6E+03 | 1.6E+03 | 1.6E+02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 4.33E+02 | 2.7E+01 | 1.4E+02 | 1.3E+02 | 1.9E+03 | 1.2E+03 | 1.4E+02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | | | | | | | | | | |
| Max | 5.5E+02 | 1.6E+03 | 1.1E+03 | 2.3E+04 | 2.6E+04 | 2.6E+03 | 7.2E+01 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Min | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Median | 8.3E+01 | 3.4E+02 | 3.4E+02 | 5.4E+03 | 2.8E+03 | 3.5E+02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Simple Average | 1.6E+02 | 5.2E+02 | 4.2E+02 | 5.6E+03 | 4.8E+03 | 5.0E+02 | 4.8E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | | | | | | | | | | |
| Number of detects | 14 | 14 | 14 | 14 | 13 | 12 | 1 | 0 | 0 | 0 |
| Number of nondetects | 1 | 1 | 1 | 1 | 2 | 3 | 14 | 15 | 15 | 15 |
| | | | | | | | | | | |
| intercept | 6.96E+00 | 7.80E+00 | 1.05E+01 | 1.44E+01 | 1.57E+01 | 1.31E+01 | --- | --- | --- | --- |
| slope | -5.17E-01 | -4.02E-01 | -9.18E-01 | -1.12E+00 | -1.40E+00 | -1.30E+00 | --- | --- | --- | --- |
| alpha | 1.97E-06 | 1.70E-06 | 5.02E-04 | 7.49E-04 | 1.57E-03 | 4.18E-03 | --- | --- | --- | --- |

## Monochlorobiphenyl in Aroclor 1254

| ng/ g-PCB - d | Cl1 |
|---|---|
| 2.08E-03 | 0 |
| 1.03E+00 | 554 |
| 6.06E+00 | 459 |
| 2.13E+01 | 292 |
| 4.23E+01 | 197 |
| 6.21E+01 | 207 |
| 6.93E+01 | 215 |
| 1.11E+02 | 85.5 |
| 1.46E+02 | 83.2 |
| 1.88E+02 | 66.1 |
| 2.30E+02 | 54.0 |
| 2.86E+02 | 51.9 |
| 3.31E+02 | 60.5 |
| 3.70E+02 | 31.2 |
| 4.33E+02 | 27.2 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 2.54E-02 | 1.03E+00 | 554 | 6.32E+00 |
| 1.80E+00 | 6.06E+00 | 459 | 6.13E+00 |
| 3.06E+00 | 2.13E+01 | 292 | 5.68E+00 |
| 3.74E+00 | 4.23E+01 | 197 | 5.28E+00 |
| 4.13E+00 | 6.21E+01 | 207 | 5.33E+00 |
| 4.24E+00 | 6.93E+01 | 215 | 5.37E+00 |
| 4.71E+00 | 1.11E+02 | 86 | 4.45E+00 |
| 4.98E+00 | 1.46E+02 | 83 | 4.42E+00 |
| 5.24E+00 | 1.88E+02 | 66 | 4.19E+00 |
| 5.44E+00 | 2.30E+02 | 54 | 3.99E+00 |
| 5.66E+00 | 2.86E+02 | 52 | 3.95E+00 |
| 5.80E+00 | 3.31E+02 | 60 | 4.10E+00 |
| 5.91E+00 | 3.70E+02 | 31 | 3.44E+00 |
| 6.07E+00 | 4.33E+02 | 27 | 3.30E+00 |

**Maximum Release Rate at 1 day**
**554 ng/gPCB-d**

**Release rate at 2 years**
**34.7 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.9263 |
| R Square | 0.8581 |
| Standard Error | 0.3793 |
| Observations | 14 |

ANOVA

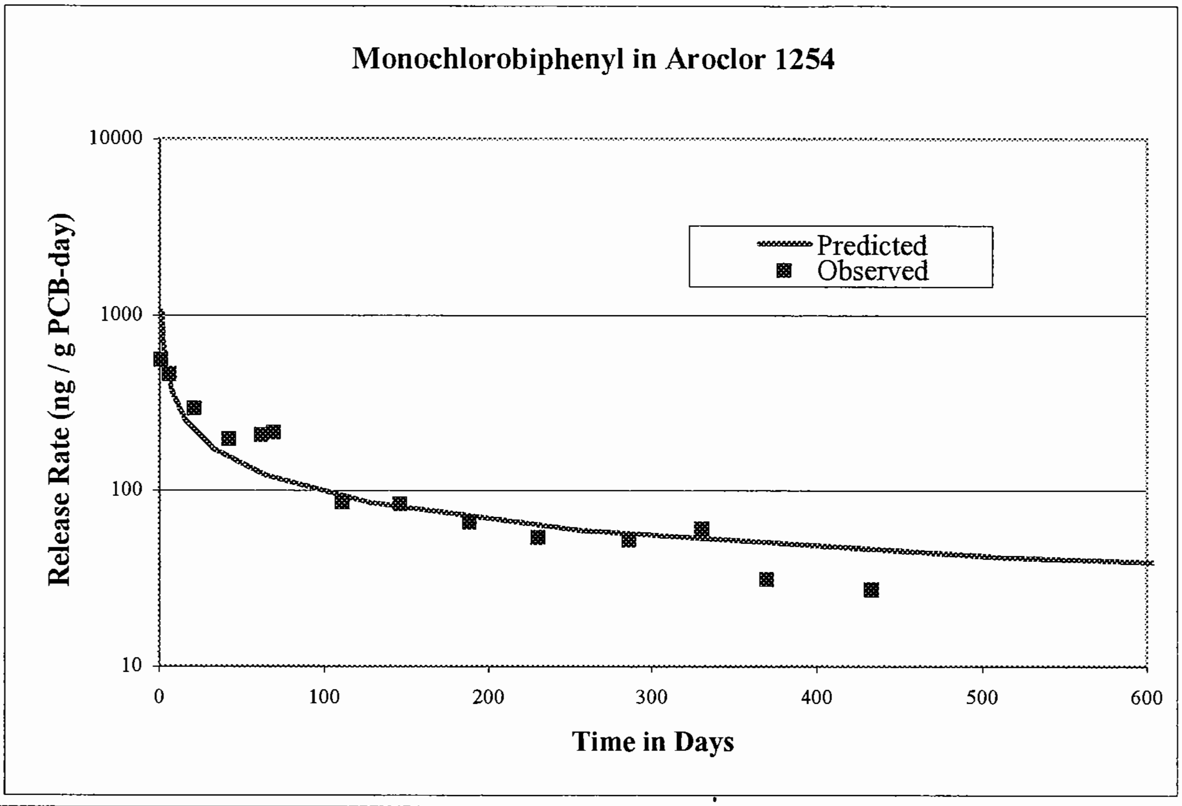
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 1.04E+01 | 1.04E+01 | 7.26E+01 | 1.97E-06 |
| Residual | 12 | 1.73E+00 | 1.44E-01 | | |
| Total | 13 | 1.22E+01 | | | |

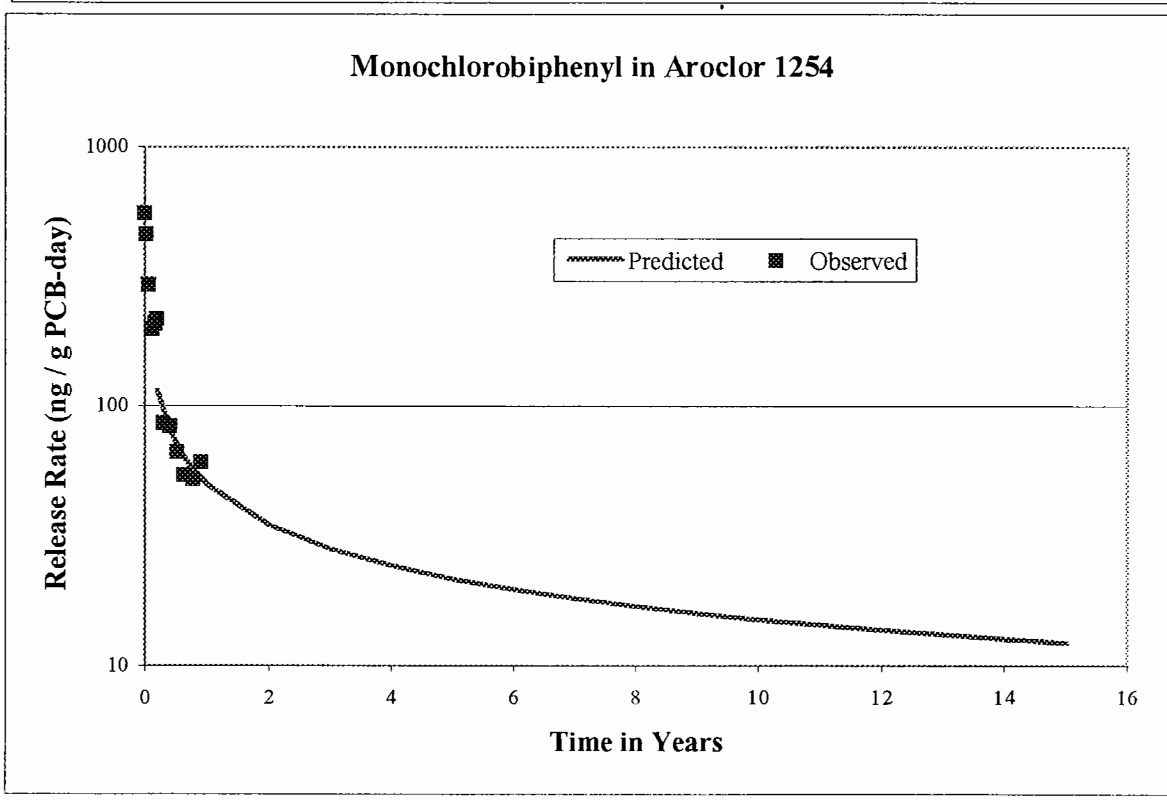
| | *Coefficients* | *andard Erro* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 6.96E+00 | 2.83E-01 | 2.46E+01 | 1.21E-11 | 6.34E+00 | 7.57E+00 |
| ln(day) | -5.17E-01 | 6.07E-02 | -8.52E+00 | 1.97E-06 | -6.49E-01 | -3.85E-01 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 6.94E+00 | -6.28E-01 |
| 2 | 6.03E+00 | 1.04E-01 |
| 3 | 5.38E+00 | 3.03E-01 |
| 4 | 5.02E+00 | 2.61E-01 |
| 5 | 4.82E+00 | 5.11E-01 |
| 6 | 4.77E+00 | 6.03E-01 |
| 7 | 4.52E+00 | -7.24E-02 |
| 8 | 4.38E+00 | 4.13E-02 |
| 9 | 4.25E+00 | -5.79E-02 |
| 10 | 4.14E+00 | -1.56E-01 |

| *Observatiordicted ln(ng/g-PCI* | | *Residuals* |
|---|---|---|
| 11 | 4.03E+00 | -8.23E-02 |
| 12 | 3.96E+00 | 1.45E-01 |
| 13 | 3.90E+00 | -4.58E-01 |
| 14 | 3.82E+00 | -5.15E-01 |


Monochlorobiphenyl in Aroclor 1254
Predicted
Observed
Release Rate (ng / g PCB-day)
10000
1000
100
10
0
100
200
300
400
500
600
Time in Days


Monochlorobiphenyl in Aroclor 1254
Predicted
Observed
Release Rate (ng / g PCB-day)
1000
100
10
0
2
4
6
8
10
12
14
16
Time in Years

**Dichlorobiphenyl in Aroclor 1254**

| ng/ g-PCB - d | Cl2 |
|---|---|
| 2.08E-03 | 0 |
| 1.03E+00 | 1576 |
| 6.06E+00 | 1213 |
| 2.13E+01 | 877 |
| 4.23E+01 | 643 |
| 6.21E+01 | 646 |
| 6.93E+01 | 797 |
| 1.11E+02 | 344 |
| 1.46E+02 | 340 |
| 1.88E+02 | 262 |
| 2.30E+02 | 249 |
| 2.86E+02 | 205 |
| 3.31E+02 | 278 |
| 3.70E+02 | 190 |
| 4.33E+02 | 139 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 2.54E-02 | 1.03E+00 | 1576 | 7.36E+00 |
| 1.80E+00 | 6.06E+00 | 1213 | 7.10E+00 |
| 3.06E+00 | 2.13E+01 | 877 | 6.78E+00 |
| 3.74E+00 | 4.23E+01 | 643 | 6.47E+00 |
| 4.13E+00 | 6.21E+01 | 646 | 6.47E+00 |
| 4.24E+00 | 6.93E+01 | 797 | 6.68E+00 |
| 4.71E+00 | 1.11E+02 | 344 | 5.84E+00 |
| 4.98E+00 | 1.46E+02 | 340 | 5.83E+00 |
| 5.24E+00 | 1.88E+02 | 262 | 5.57E+00 |
| 5.44E+00 | 2.30E+02 | 249 | 5.52E+00 |
| 5.66E+00 | 2.86E+02 | 205 | 5.32E+00 |
| 5.80E+00 | 3.31E+02 | 278 | 5.63E+00 |
| 5.91E+00 | 3.70E+02 | 190 | 5.24E+00 |
| 6.07E+00 | 4.33E+02 | 139 | 4.94E+00 |

**Maximum Release Rate at 1 day**
**1576 ng/gPCB-d**

**Release rate at 2 years**
**172 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.9281 |
| R Square | 0.8614 |
| Standard Error | 0.2904 |
| Observations | 14 |

ANOVA

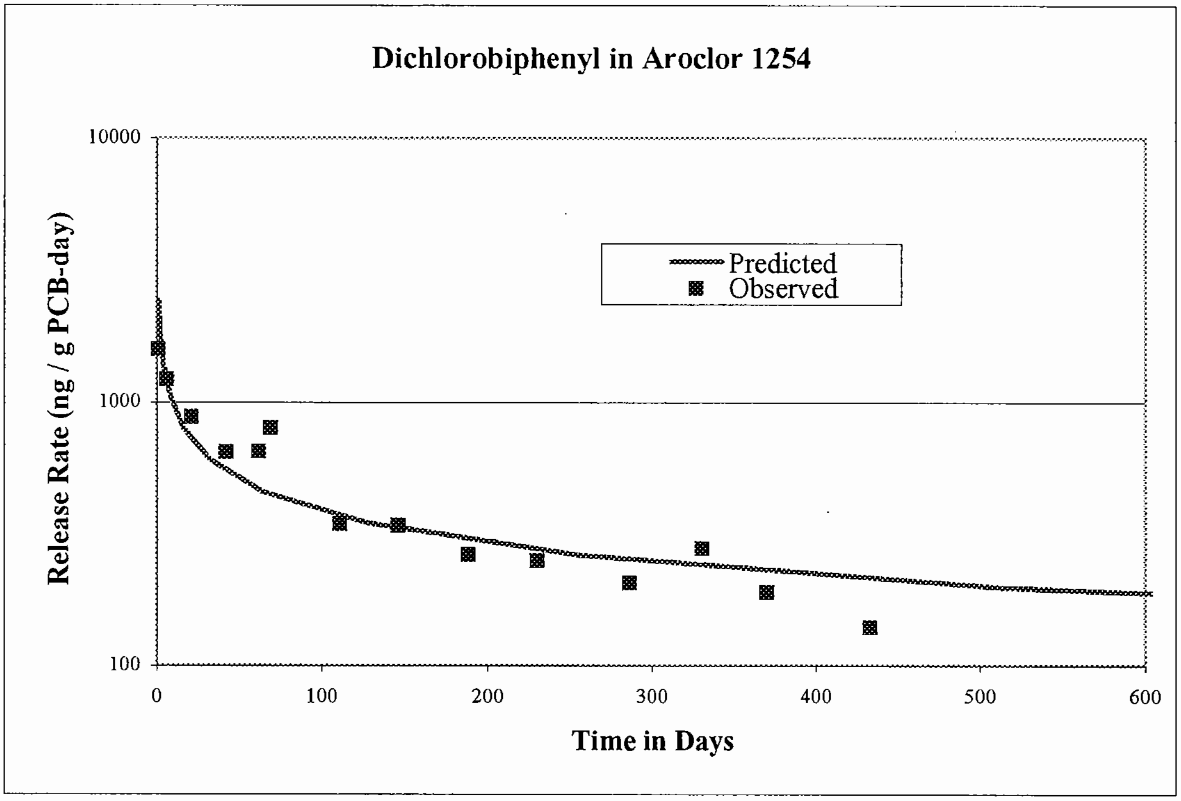
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 6.29E+00 | 6.29E+00 | 7.46E+01 | 1.70E-06 |
| Residual | 12 | 1.01E+00 | 8.44E-02 | | |
| Total | 13 | 7.31E+00 | | | |

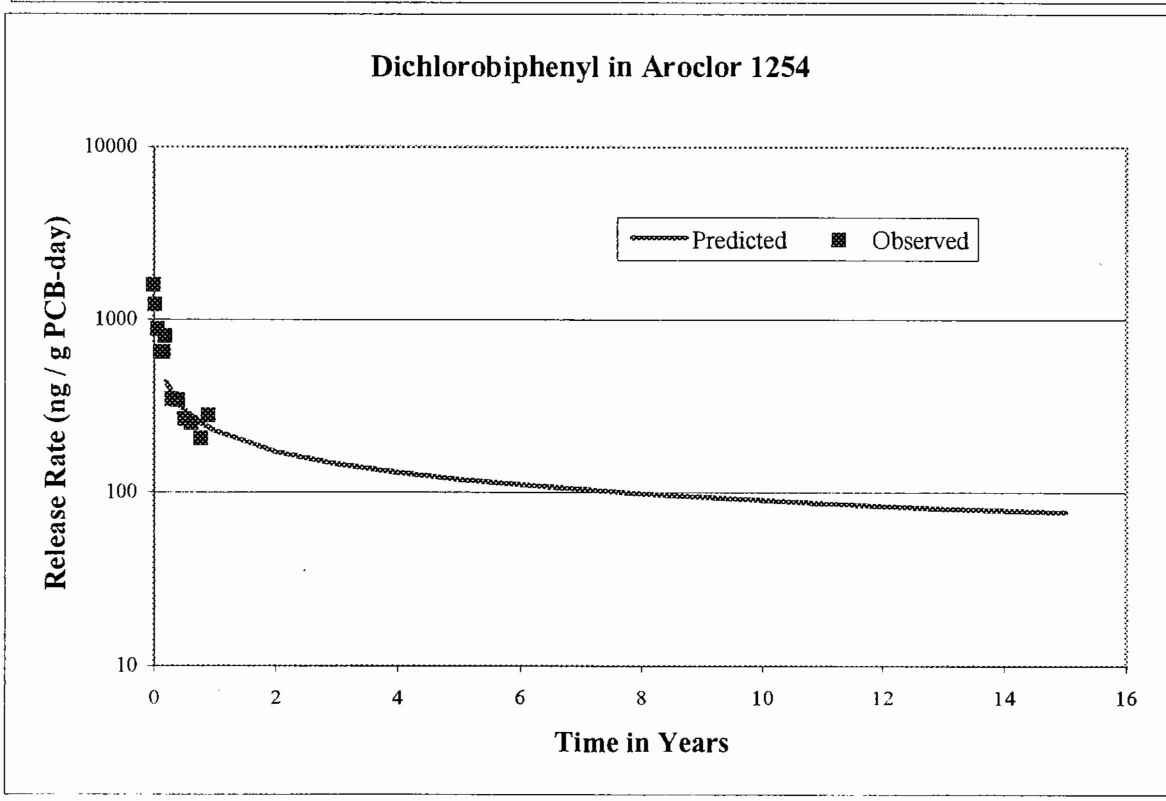
| | *Coefficients* | *andard Err* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 7.80E+00 | 2.16E-01 | 3.60E+01 | 1.33E-13 | 7.33E+00 | 8.27E+00 |
| ln(day) | -4.02E-01 | 4.65E-02 | -8.64E+00 | 1.70E-06 | -5.03E-01 | -3.00E-01 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 7.79E+00 | -4.25E-01 |
| 2 | 7.07E+00 | 2.68E-02 |
| 3 | 6.57E+00 | 2.07E-01 |
| 4 | 6.29E+00 | 1.72E-01 |
| 5 | 6.14E+00 | 3.31E-01 |
| 6 | 6.10E+00 | 5.85E-01 |
| 7 | 5.91E+00 | -6.46E-02 |
| 8 | 5.80E+00 | 3.38E-02 |
| 9 | 5.69E+00 | -1.25E-01 |
| 10 | 5.61E+00 | -9.50E-02 |

| *Observation* | *dicted ln(ng/g-PC1* | *Residuals* |
|---|---|---|
| 11 | 5.53E+00 | -2.05E-01 |
| 12 | 5.47E+00 | 1.58E-01 |
| 13 | 5.42E+00 | -1.78E-01 |
| 14 | 5.36E+00 | -4.22E-01 |


Dichlorobiphenyl in Aroclor 1254
Release Rate (ng / g PCB-day)
10000
1000
100
0
100
200
300
400
500
600
Time in Days
Predicted
Observed


Dichlorobiphenyl in Aroclor 1254
Release Rate (ng / g PCB-day)
10000
1000
100
10
0
2
4
6
8
10
12
14
16
Time in Years
Predicted
Observed

## Trichlorobiphenyl in Aroclor 1254

| ng/ g-PCB - d | Cl3 |
|---|---|
| 2.08E-03 | 0 |
| 1.03E+00 | 511 |
| 6.06E+00 | 849 |
| 2.13E+01 | 702 |
| 4.23E+01 | 562 |
| 6.21E+01 | 623 |
| 6.93E+01 | 1103 |
| 1.11E+02 | 344 |
| 1.46E+02 | 353 |
| 1.88E+02 | 273 |
| 2.30E+02 | 301 |
| 2.86E+02 | 173 |
| 3.31E+02 | 248 |
| 3.70E+02 | 190 |
| 4.33E+02 | 132 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 4.24E+00 | 6.93E+01 | 1103 | 7.01E+00 |
| 4.71E+00 | 1.11E+02 | 344 | 5.84E+00 |
| 4.98E+00 | 1.46E+02 | 353 | 5.87E+00 |
| 5.24E+00 | 1.88E+02 | 273 | 5.61E+00 |
| 5.44E+00 | 2.30E+02 | 301 | 5.71E+00 |
| 5.66E+00 | 2.86E+02 | 173 | 5.15E+00 |
| 5.80E+00 | 3.31E+02 | 248 | 5.51E+00 |
| 5.91E+00 | 3.70E+02 | 190 | 5.24E+00 |
| 6.07E+00 | 4.33E+02 | 132 | 4.89E+00 |

**Maximum Release Rate at 69 days**
**1103 ng/gPCB-d**

**Release rate at 2 years**
**89.7 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.9169 |
| R Square | 0.8407 |
| Standard Error | 0.2587 |
| Observations | 9 |

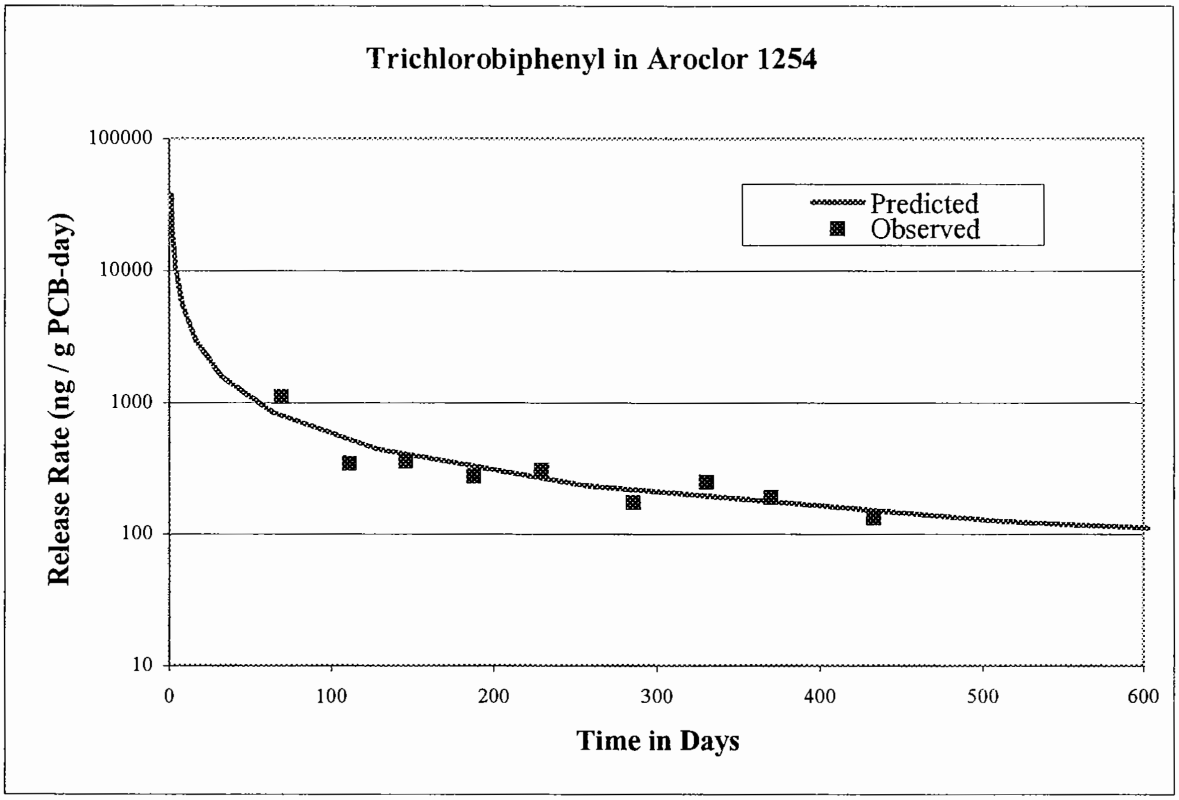
ANOVA

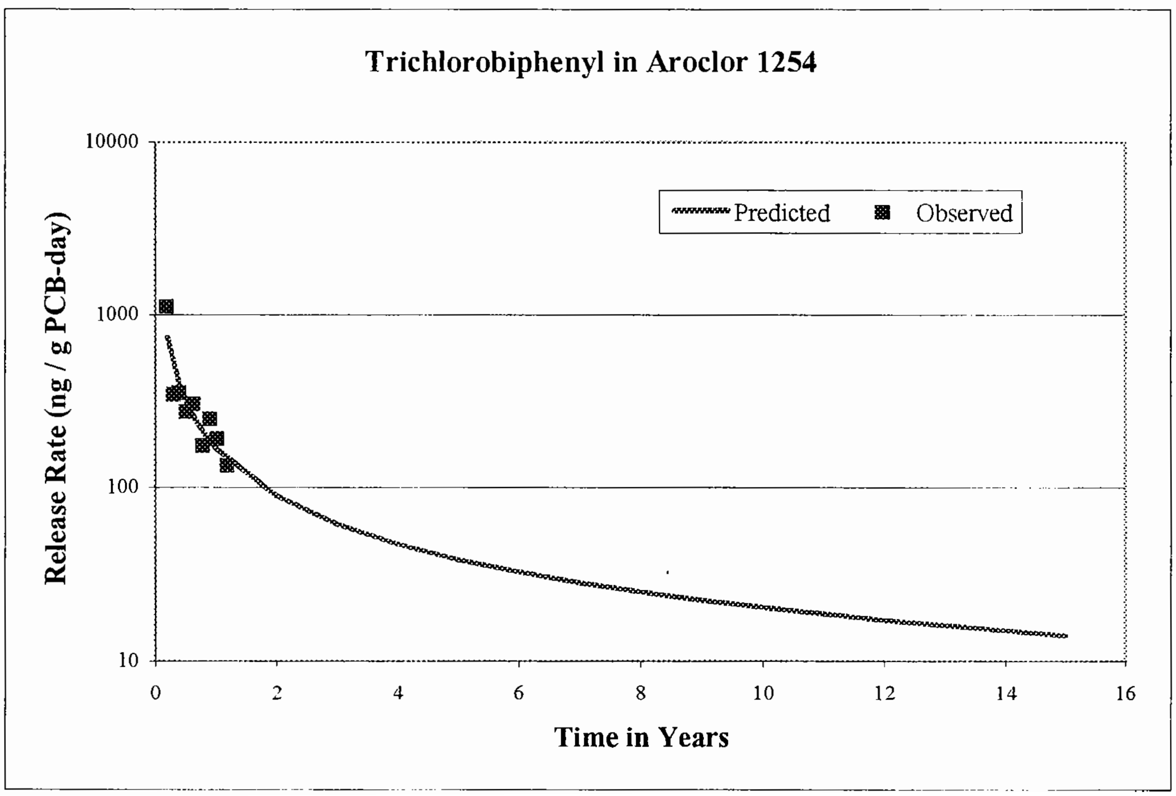
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 2.47E+00 | 2.47E+00 | 3.69E+01 | 5.02E-04 |
| Residual | 7 | 4.68E-01 | 6.69E-02 | | |
| Total | 8 | 2.94E+00 | | | |

| | *Coefficients* | *andard Erro* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 1.05E+01 | 8.11E-01 | 1.30E+01 | 3.69E-06 | 8.63E+00 | 1.25E+01 |
| ln(day) | -9.18E-01 | 1.51E-01 | -6.08E+00 | 5.02E-04 | -1.27E+00 | -5.61E-01 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 6.66E+00 | 3.48E-01 |
| 2 | 6.22E+00 | -3.83E-01 |
| 3 | 5.97E+00 | -1.07E-01 |
| 4 | 5.74E+00 | -1.32E-01 |
| 5 | 5.56E+00 | 1.52E-01 |
| 6 | 5.36E+00 | -2.02E-01 |
| 7 | 5.22E+00 | 2.89E-01 |
| 8 | 5.12E+00 | 1.25E-01 |
| 9 | 4.98E+00 | -8.90E-02 |


Trichlorobiphenyl in Aroclor 1254
Release Rate (ng / g PCB-day)
100000
10000
1000
100
10
0
100
200
300
400
500
600
Time in Days
Predicted
Observed


Trichlorobiphenyl in Aroclor 1254
Release Rate (ng / g PCB-day)
10000
1000
100
10
0
2
4
6
8
10
12
14
16
Time in Years
Predicted
Observed

## Tetrachlorobiphenyl in Aroclor 1254

| ng/ g-PCB - d | Cl4 |
|---|---|
| 2.08E-03 | 0 |
| 1.03E+00 | 1278 |
| 6.06E+00 | 5373 |
| 2.13E+01 | 6726 |
| 4.23E+01 | 7630 |
| 6.21E+01 | 8461 |
| 6.93E+01 | 22679 |
| 1.11E+02 | 5737 |
| 1.46E+02 | 6049 |
| 1.88E+02 | 3357 |
| 2.30E+02 | 6128 |
| 2.86E+02 | 2517 |
| 3.31E+02 | 3173 |
| 3.70E+02 | 2565 |
| 4.33E+02 | 1882 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 4.24E+00 | 6.93E+01 | 22679 | 1.00E+01 |
| 4.71E+00 | 1.11E+02 | 5737 | 8.65E+00 |
| 4.98E+00 | 1.46E+02 | 6049 | 8.71E+00 |
| 5.24E+00 | 1.88E+02 | 3357 | 8.12E+00 |
| 5.44E+00 | 2.30E+02 | 6128 | 8.72E+00 |
| 5.66E+00 | 2.86E+02 | 2517 | 7.83E+00 |
| 5.80E+00 | 3.31E+02 | 3173 | 8.06E+00 |
| 5.91E+00 | 3.70E+02 | 2565 | 7.85E+00 |
| 6.07E+00 | 4.33E+02 | 1882 | 7.54E+00 |

**Maximum Release Rate at 69 days**
**22679 ng/gPCB-d**

**Release rate at 2 years**
**1082 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.9065 |
| R Square | 0.8218 |
| Standard Error | 0.3375 |
| Observations | 9 |

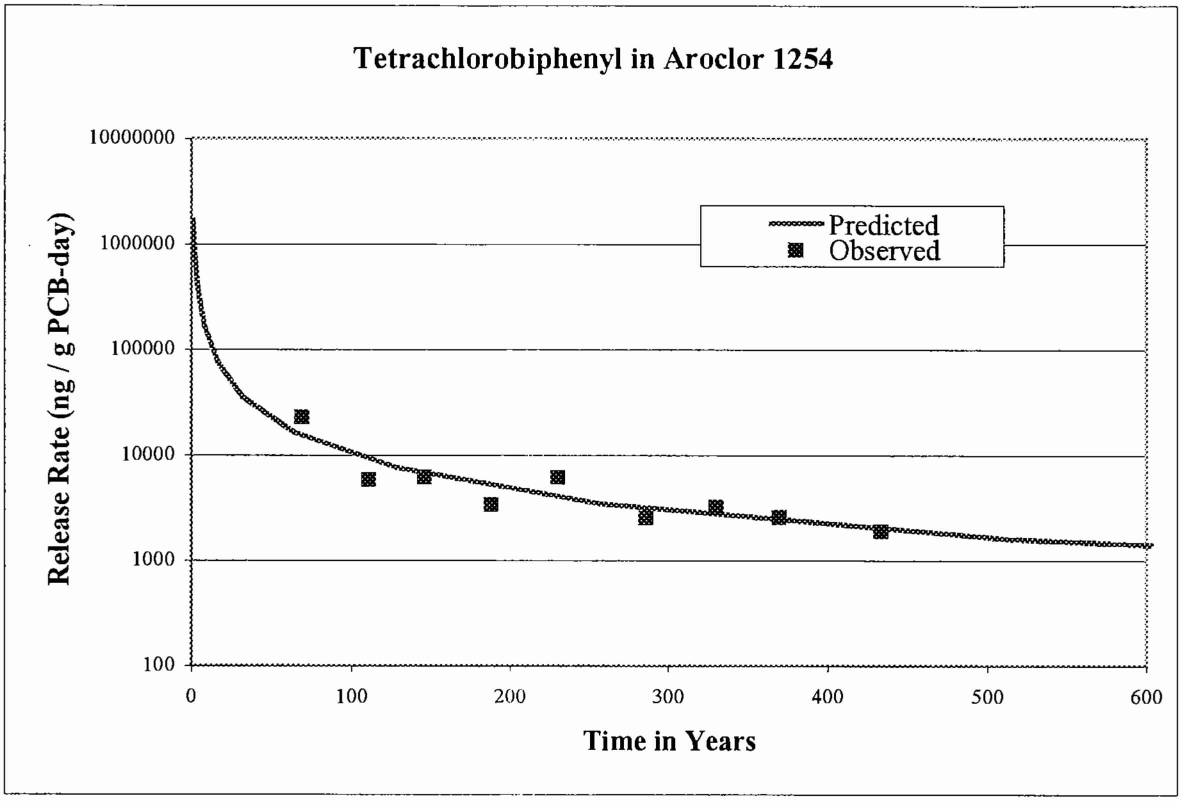
ANOVA

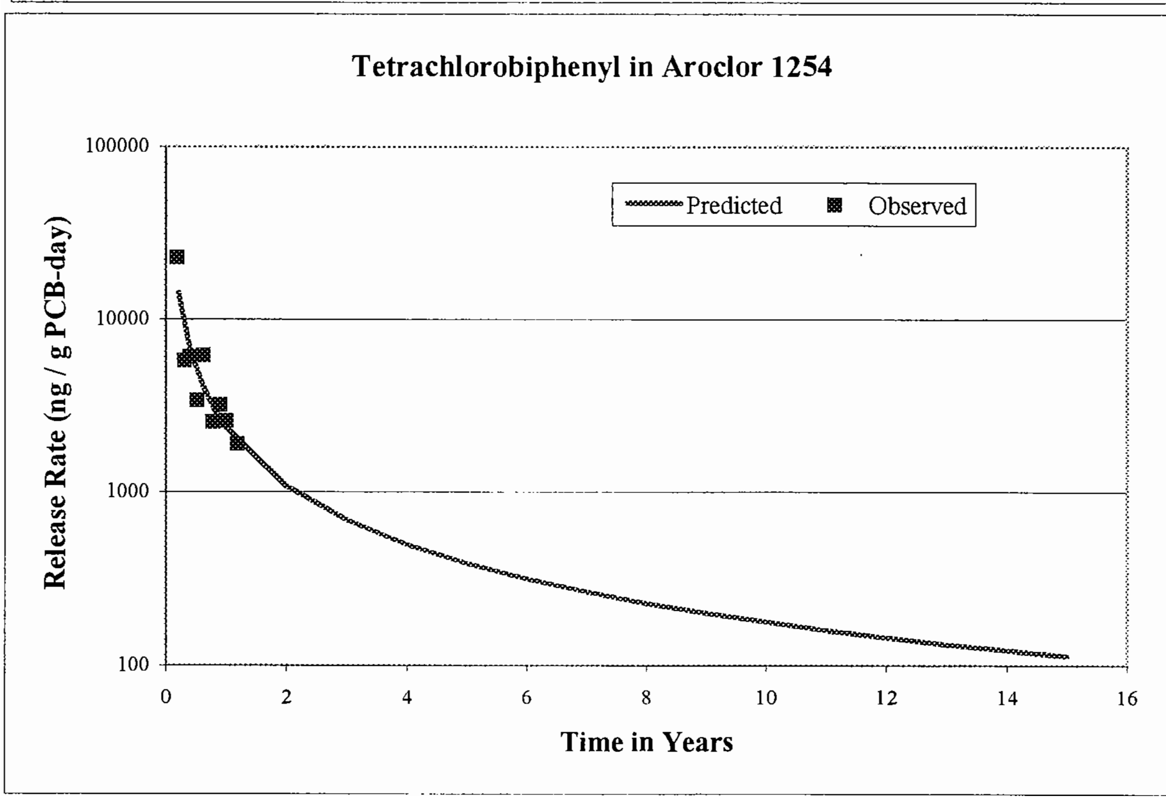
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 3.68E+00 | 3.68E+00 | 3.23E+01 | 7.49E-04 |
| Residual | 7 | 7.97E-01 | 1.14E-01 | | |
| Total | 8 | 4.47E+00 | | | |

| | *Coefficients* | *andard Erro* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 1.44E+01 | 1.06E+00 | 1.36E+01 | 2.76E-06 | 1.19E+01 | 1.69E+01 |
| ln(day) | -1.12E+00 | 1.97E-01 | -5.68E+00 | 7.49E-04 | -1.59E+00 | -6.54E-01 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 9.62E+00 | 4.06E-01 |
| 2 | 9.09E+00 | -4.39E-01 |
| 3 | 8.79E+00 | -8.00E-02 |
| 4 | 8.50E+00 | -3.86E-01 |
| 5 | 8.28E+00 | 4.41E-01 |
| 6 | 8.04E+00 | -2.04E-01 |
| 7 | 7.87E+00 | 1.89E-01 |
| 8 | 7.75E+00 | 1.03E-01 |
| 9 | 7.57E+00 | -3.02E-02 |


Tetrachlorobiphenyl in Aroclor 1254
Predicted
Observed
Release Rate (ng / g PCB-day)
10000000
1000000
100000
10000
1000
100
0
100
200
300
400
500
600
Time in Years


Tetrachlorobiphenyl in Aroclor 1254
Predicted
Observed
Release Rate (ng / g PCB-day)
100000
10000
1000
100
0
2
4
6
8
10
12
14
16
Time in Years

## Pentachlorobiphenyl in Aroclor 1254

| ng/ g-PCB - d | C15 |
|---|---|
| 2.08E-03 | 0 |
| 1.03E+00 | 0 |
| 6.06E+00 | 1127 |
| 2.13E+01 | 2778 |
| 4.23E+01 | 5020 |
| 6.21E+01 | 6902 |
| 6.93E+01 | 26356 |
| 1.11E+02 | 5320 |
| 1.46E+02 | 5167 |
| 1.88E+02 | 3043 |
| 2.30E+02 | 8620 |
| 2.86E+02 | 2124 |
| 3.31E+02 | 2380 |
| 3.70E+02 | 1561 |
| 4.33E+02 | 1185 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 4.24E+00 | 6.93E+01 | 26356 | 1.02E+01 |
| 4.71E+00 | 1.11E+02 | 5320 | 8.58E+00 |
| 4.98E+00 | 1.46E+02 | 5167 | 8.55E+00 |
| 5.24E+00 | 1.88E+02 | 3043 | 8.02E+00 |
| 5.44E+00 | 2.30E+02 | 8620 | 9.06E+00 |
| 5.66E+00 | 2.86E+02 | 2124 | 7.66E+00 |
| 5.80E+00 | 3.31E+02 | 2380 | 7.77E+00 |
| 5.91E+00 | 3.70E+02 | 1561 | 7.35E+00 |
| 6.07E+00 | 4.33E+02 | 1185 | 7.08E+00 |

**Maximum Release Rate at 69 days**
**26356 ng/gPCB-d**

**Release rate at 2 years**
**660 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.8838 |
| R Square | 0.7811 |
| Standard Error | 0.4806 |
| Observations | 9 |

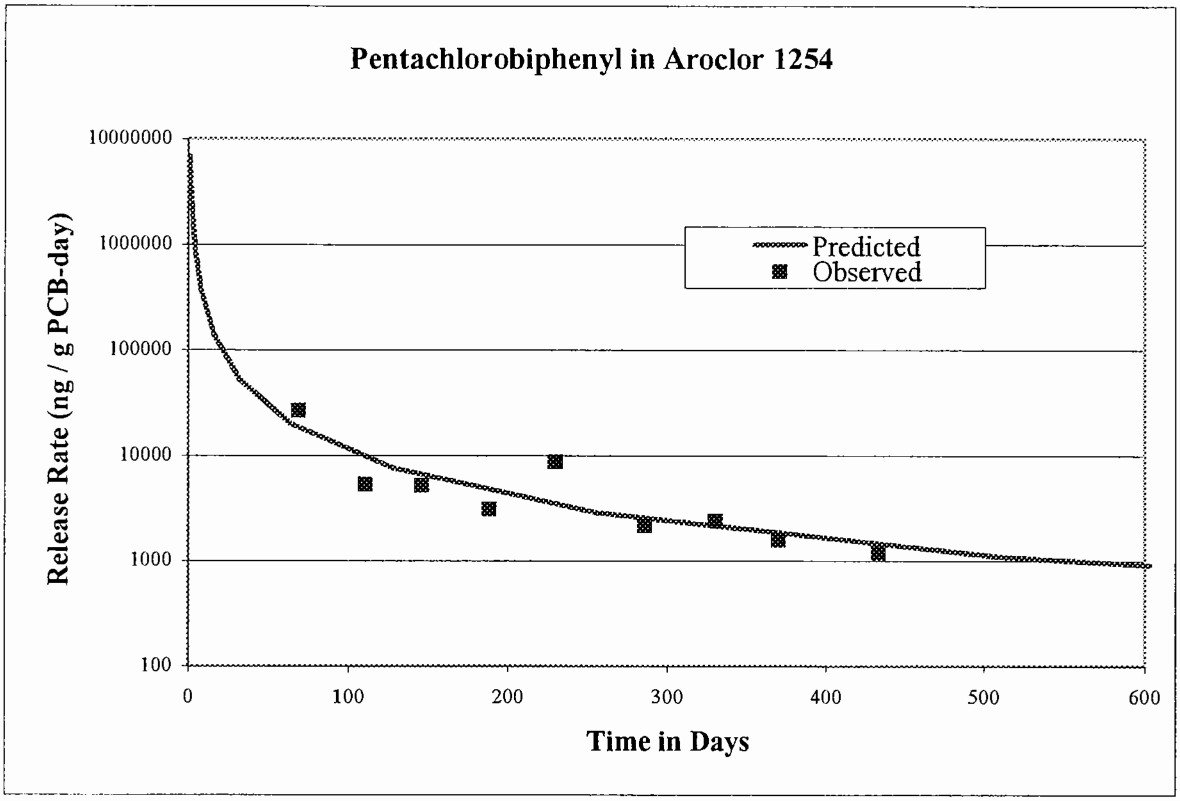
ANOVA

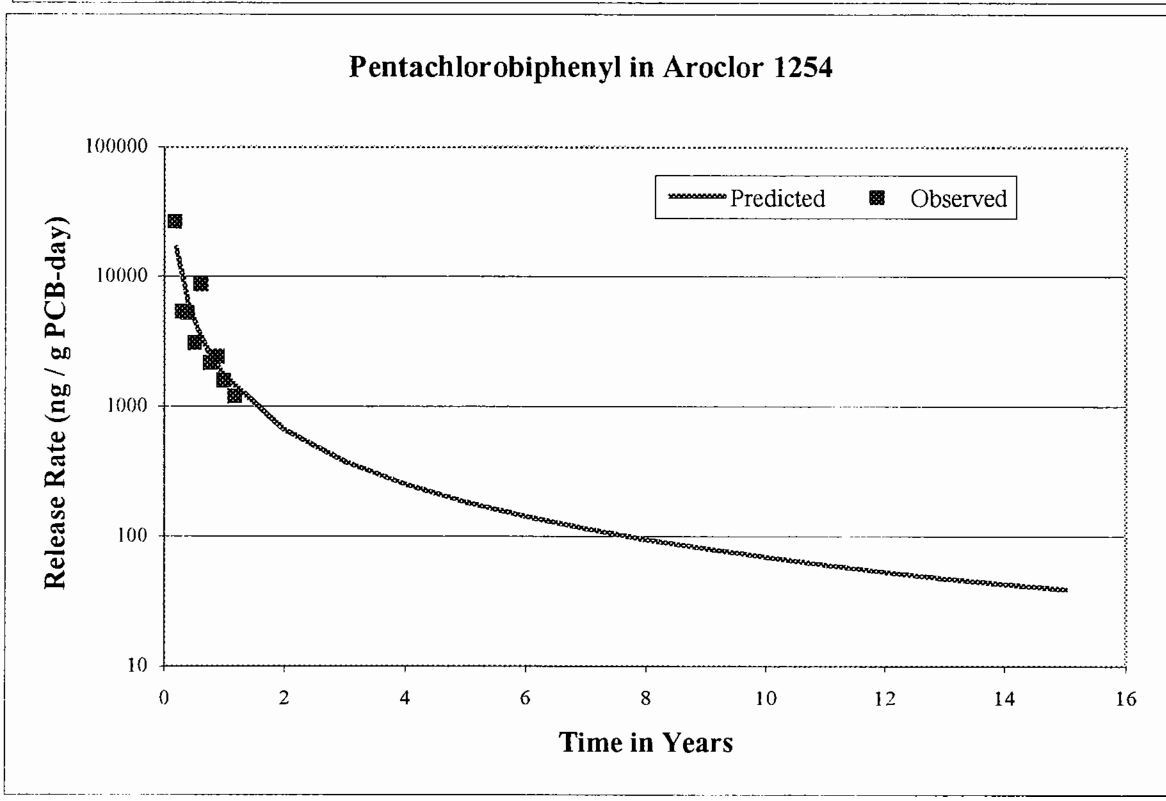
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 5.77E+00 | 5.77E+00 | 2.50E+01 | 1.57E-03 |
| Residual | 7 | 1.62E+00 | 2.31E-01 | | |
| Total | 8 | 7.38E+00 | | | |

| | *Coefficients* | *andard Err* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 1.57E+01 | 1.51E+00 | 1.04E+01 | 1.60E-05 | 1.22E+01 | 1.93E+01 |
| ln(day) | -1.40E+00 | 2.81E-01 | -5.00E+00 | 1.57E-03 | -2.07E+00 | -7.39E-01 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 9.79E+00 | 3.85E-01 |
| 2 | 9.13E+00 | -5.53E-01 |
| 3 | 8.75E+00 | -1.98E-01 |
| 4 | 8.39E+00 | -3.73E-01 |
| 5 | 8.11E+00 | 9.50E-01 |
| 6 | 7.81E+00 | -1.45E-01 |
| 7 | 7.60E+00 | 1.71E-01 |
| 8 | 7.44E+00 | -9.17E-02 |
| 9 | 7.22E+00 | -1.46E-01 |


Pentachlorobiphenyl in Aroclor 1254
10000000
1000000
100000
10000
1000
100
Release Rate (ng / g PCB-day)
Predicted
Observed
0
100
200
300
400
500
600
Time in Days


Pentachlorobiphenyl in Aroclor 1254
100000
10000
1000
100
10
Release Rate (ng / g PCB-day)
Predicted
Observed
0
2
4
6
8
10
12
14
16
Time in Years

## Hexachlorobiphenyl in Aroclor 1254

| ng/ g-PCB - d | Cl6 |
|---|---|
| 2.08E-03 | 0 |
| 1.03E+00 | 0 |
| 6.06E+00 | 0 |
| 2.13E+01 | 88 |
| 4.23E+01 | 321 |
| 6.21E+01 | 534 |
| 6.93E+01 | 2636 |
| 1.11E+02 | 678 |
| 1.46E+02 | 555 |
| 1.88E+02 | 399 |
| 2.30E+02 | 1246 |
| 2.86E+02 | 370 |
| 3.31E+02 | 347 |
| 3.70E+02 | 156 |
| 4.33E+02 | 139 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 4.24E+00 | 6.93E+01 | 2636 | 7.88E+00 |
| 4.71E+00 | 1.11E+02 | 678 | 6.52E+00 |
| 4.98E+00 | 1.46E+02 | 555 | 6.32E+00 |
| 5.24E+00 | 1.88E+02 | 399 | 5.99E+00 |
| 5.44E+00 | 2.30E+02 | 1246 | 7.13E+00 |
| 5.66E+00 | 2.86E+02 | 370 | 5.91E+00 |
| 5.80E+00 | 3.31E+02 | 347 | 5.85E+00 |
| 5.91E+00 | 3.70E+02 | 156 | 5.05E+00 |
| 6.07E+00 | 4.33E+02 | 139 | 4.94E+00 |

**Maximum Release Rate at 69 days**
**2636 ng/gPCB-d**

**Release rate at 2 years**
**94.2 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.8445 |
| R Square | 0.7131 |
| Standard Error | 0.5337 |
| Observations | 9 |

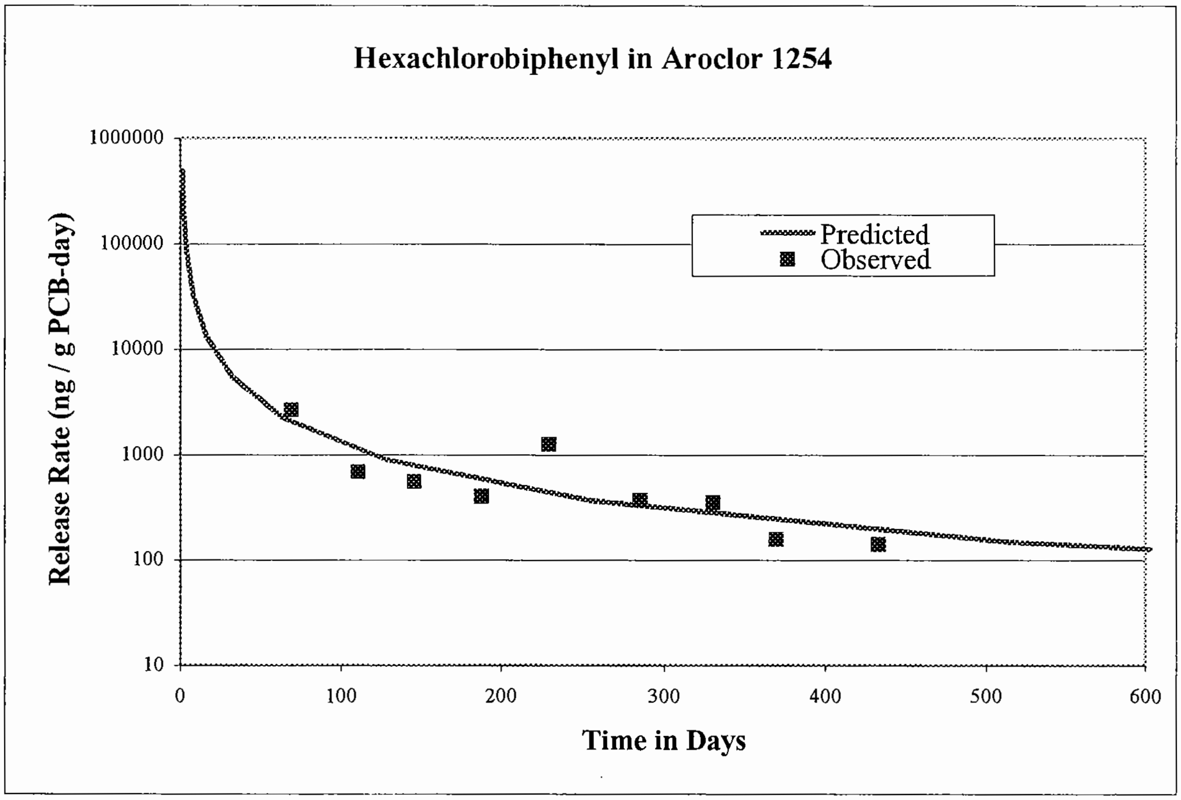
ANOVA

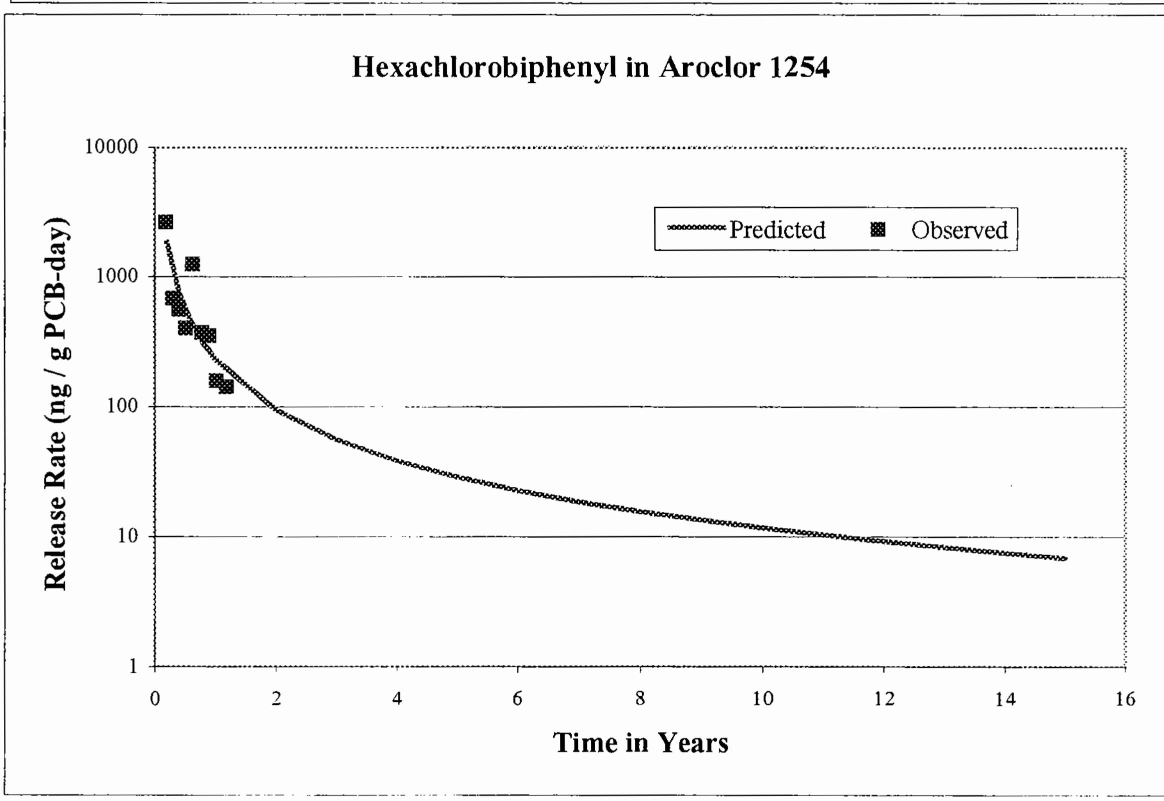
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 4.96E+00 | 4.96E+00 | 1.74E+01 | 4.18E-03 |
| Residual | 7 | 1.99E+00 | 2.85E-01 | | |
| Total | 8 | 6.95E+00 | | | |

| | *Coefficients* | *andard Err* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 1.31E+01 | 1.67E+00 | 7.84E+00 | 1.04E-04 | 9.16E+00 | 1.71E+01 |
| ln(day) | -1.30E+00 | 3.12E-01 | -4.17E+00 | 4.18E-03 | -2.04E+00 | -5.63E-01 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 7.61E+00 | 2.71E-01 |
| 2 | 6.99E+00 | -4.73E-01 |
| 3 | 6.64E+00 | -3.19E-01 |
| 4 | 6.31E+00 | -3.20E-01 |
| 5 | 6.05E+00 | 1.08E+00 |
| 6 | 5.76E+00 | 1.50E-01 |
| 7 | 5.58E+00 | 2.74E-01 |
| 8 | 5.43E+00 | -3.78E-01 |
| 9 | 5.22E+00 | -2.86E-01 |


Hexachlorobiphenyl in Aroclor 1254
Release Rate (ng / g PCB-day)
1000000
100000
10000
1000
100
10
0
100
200
300
400
500
600
Time in Days
Predicted
Observed


Hexachlorobiphenyl in Aroclor 1254
Release Rate (ng / g PCB-day)
10000
1000
100
10
1
0
2
4
6
8
10
12
14
16
Time in Years
Predicted
Observed

**BLACK RUBBER MATERIAL**

**Black Rubber Material**

| Leaching Time (days) | Homologue Leach Rates (ng PCB/g shipboard solid-day) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cl1 | Cl2 | Cl3 | Cl4 | Cl5 | Cl6 | Cl7 | Cl8 | Cl9 | Cl10 |
| 0.006 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 2.7E+02 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 1.169 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.3E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 7.074 | 2.9E-01 | 8.0E-01 | 3.4E-01 | 1.2E+00 | 9.6E-01 | 0.0E+00 | 5.0E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 14.081 | 0.0E+00 | 2.0E+00 | 3.8E-01 | 1.5E+00 | 7.4E-01 | 0.0E+00 | 3.5E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 28.153 | 1.9E-01 | 2.5E-01 | 2.3E-01 | 1.1E+00 | 9.2E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 49.204 | 1.5E-01 | 2.4E-02 | 1.2E-01 | 1.0E+00 | 6.1E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 69.272 | 0.0E+00 | 2.3E-02 | 1.8E-01 | 1.4E+00 | 1.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 104.181 | 1.3E-01 | 1.6E-01 | 1.3E-01 | 7.8E-01 | 7.3E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 146.122 | 1.1E-01 | 1.5E-01 | 1.6E-01 | 6.6E-01 | 6.6E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 188.072 | 9.1E-02 | 9.1E-02 | 9.9E-02 | 4.7E-01 | 4.0E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 230.109 | 8.3E-02 | 9.8E-03 | 3.5E-01 | 4.4E-01 | 4.0E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 286.142 | 1.0E-01 | 1.2E-02 | 2.6E-01 | 2.2E-01 | 8.5E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 328.083 | 9.1E-02 | 5.6E-02 | 5.3E-02 | 2.9E-01 | 2.1E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 370.110 | 9.1E-02 | 8.4E-02 | 7.3E-02 | 3.3E-01 | 1.7E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 398.072 | 8.1E-02 | 1.8E-01 | 1.4E-01 | 4.3E-01 | 3.5E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 475.124 | 7.0E-02 | 5.4E-02 | 9.1E-02 | 2.6E-01 | 1.8E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Max | 2.9E-01 | 2.0E+00 | 3.8E-01 | 1.5E+00 | 1.0E+00 | 0.0E+00 | 2.7E+02 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Min | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |

0.0016 g PCB / g rubber material (leachate study concentration)

| Leaching Time (days) | Homologue Leach Rates (ng PCB/g PCB-day) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ng/ g-PCB - d | Cl1 | Cl2 | Cl3 | Cl4 | Cl5 | Cl6 | Cl7 | Cl8 | Cl9 | Cl10 |
| 0.006 | 0 | 0 | 0 | 0 | 0 | 0 | 167503 | 0 | 0 | 0 |
| 1.169 | 0 | 0 | 0 | 0 | 0 | 0 | 833 | 0 | 0 | 0 |
| 7.074 | 184 | 502 | 211 | 736 | 602 | 0 | 311 | 0 | 0 | 0 |
| 14.081 | 0 | 1267 | 239 | 922 | 461 | 0 | 222 | 0 | 0 | 0 |
| 28.153 | 119 | 158 | 143 | 688 | 574 | 0 | 0 | 0 | 0 | 0 |
| 49.204 | 93 | 15 | 78 | 654 | 379 | 0 | 0 | 0 | 0 | 0 |
| 69.272 | 0 | 14 | 114 | 895 | 638 | 0 | 0 | 0 | 0 | 0 |
| 104.181 | 80 | 97 | 80 | 486 | 458 | 0 | 0 | 0 | 0 | 0 |
| 146.122 | 67 | 91 | 101 | 414 | 414 | 0 | 0 | 0 | 0 | 0 |
| 188.072 | 57 | 57 | 62 | 295 | 248 | 0 | 0 | 0 | 0 | 0 |
| 230.109 | 52 | 6 | 216 | 273 | 249 | 0 | 0 | 0 | 0 | 0 |
| 286.142 | 63 | 7 | 162 | 137 | 53 | 0 | 0 | 0 | 0 | 0 |
| 328.083 | 57 | 35 | 33 | 181 | 129 | 0 | 0 | 0 | 0 | 0 |
| 370.110 | 57 | 52 | 46 | 204 | 109 | 0 | 0 | 0 | 0 | 0 |
| 398.072 | 51 | 114 | 86 | 271 | 221 | 0 | 0 | 0 | 0 | 0 |
| 475.124 | 44 | 34 | 57 | 163 | 111 | 0 | 0 | 0 | 0 | 0 |
| Max | 184 | 1267 | 239 | 922 | 638 | 0 | 167503 | 0 | 0 | 0 |
| Min | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Median | 57.1 | 43.5 | 82.9 | 284 | 248 | 0 | 0 | 0 | 0 | 0 |
| Simple Average | 57.8 | 153 | 102 | 395 | 290 | 0 | 10554 | 0 | 0 | 0 |
| Number of detects | 12 | 14 | 14 | 14 | 14 | 0 | 4 | 0 | 0 | 0 |
| Number of nondetects | 4 | 2 | 2 | 2 | 2 | 16 | 12 | 16 | 16 | 16 |
| intercept | 5.81E+00 | 7.09E+00 | 5.99E+00 | 8.50E+00 | 1.07E+01 | --- | 7.40E+00 | --- | --- | --- |
| slope | -3.17E-01 | -6.55E-01 | -2.97E-01 | -5.36E-01 | -9.95E-01 | --- | -8.78E-01 | --- | --- | --- |
| alpha | 2.88E-08 | 7.83E-02 | 4.98E-02 | 2.22E-05 | 4.47E-03 | --- | 7.51E-03 | --- | --- | --- |

## Monochlorobiphenyl in Bulkhead Insulation

| ng/ g-PCB - d | Cl1 |
|---|---|
| 6.25E-03 | 0 |
| 1.17E+00 | 0 |
| 7.07E+00 | 184 |
| 1.41E+01 | 0 |
| 2.82E+01 | 119 |
| 4.92E+01 | 93.0 |
| 6.93E+01 | 0 |
| 1.04E+02 | 80.1 |
| 1.46E+02 | 67.4 |
| 1.88E+02 | 57.1 |
| 2.30E+02 | 51.7 |
| 2.86E+02 | 63.5 |
| 3.28E+02 | 57.1 |
| 3.70E+02 | 57.0 |
| 3.98E+02 | 50.7 |
| 4.75E+02 | 44.1 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 1.96E+00 | 7.07E+00 | 184 | 5.21E+00 |
| 3.34E+00 | 2.82E+01 | 119 | 4.78E+00 |
| 3.90E+00 | 4.92E+01 | 93 | 4.53E+00 |
| 4.65E+00 | 1.04E+02 | 80 | 4.38E+00 |
| 4.98E+00 | 1.46E+02 | 67 | 4.21E+00 |
| 5.24E+00 | 1.88E+02 | 57 | 4.05E+00 |
| 5.44E+00 | 2.30E+02 | 52 | 3.95E+00 |
| 5.66E+00 | 2.86E+02 | 63 | 4.15E+00 |
| 5.79E+00 | 3.28E+02 | 57 | 4.05E+00 |
| 5.91E+00 | 3.70E+02 | 57 | 4.04E+00 |
| 5.99E+00 | 3.98E+02 | 51 | 3.93E+00 |
| 6.16E+00 | 4.75E+02 | 44 | 3.79E+00 |

**Maximum Release Rate at 7 days**
**184 ng/gPCB-d**

**Release rate at 2 years**
**41.4 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.9793 |
| R Square | 0.9591 |
| Standard Error | 0.0873 |
| Observations | 12 |

ANOVA

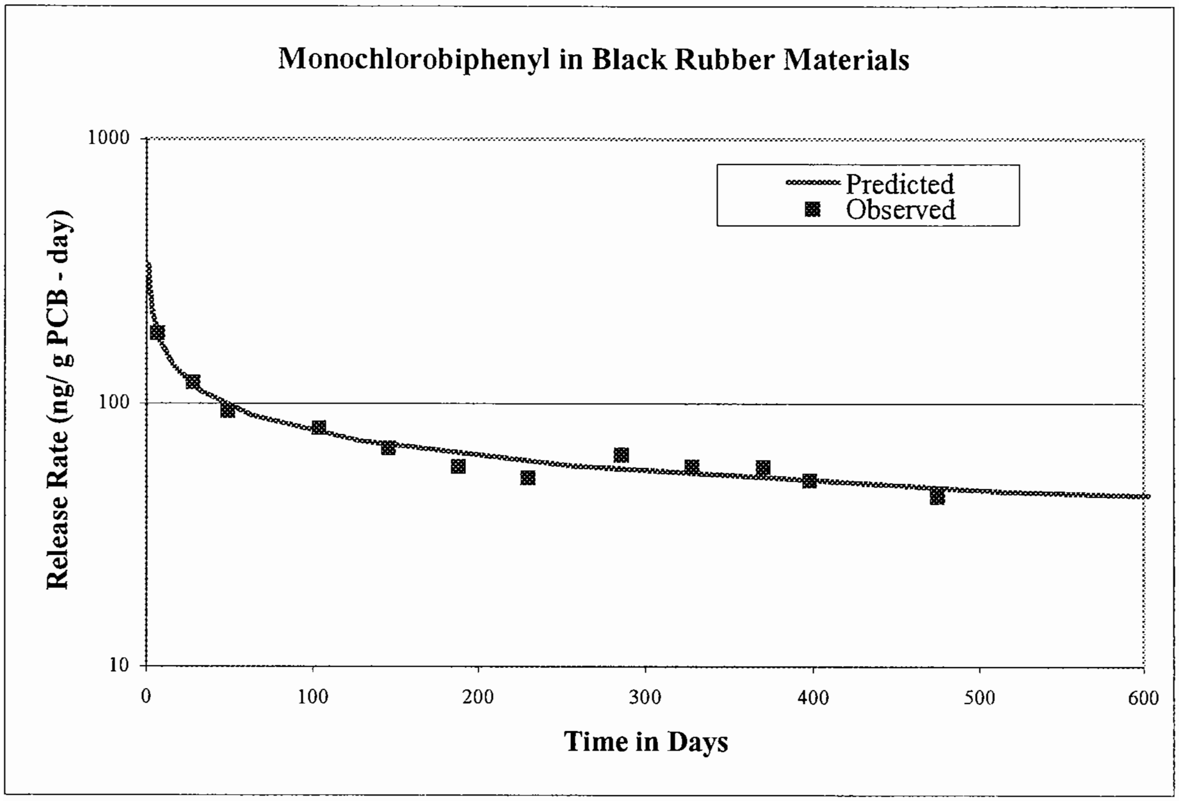
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 1.78E+00 | 1.78E+00 | 2.34E+02 | 2.88E-08 |
| Residual | 10 | 7.61E-02 | 7.61E-03 | | |
| Total | 11 | 1.86E+00 | | | |

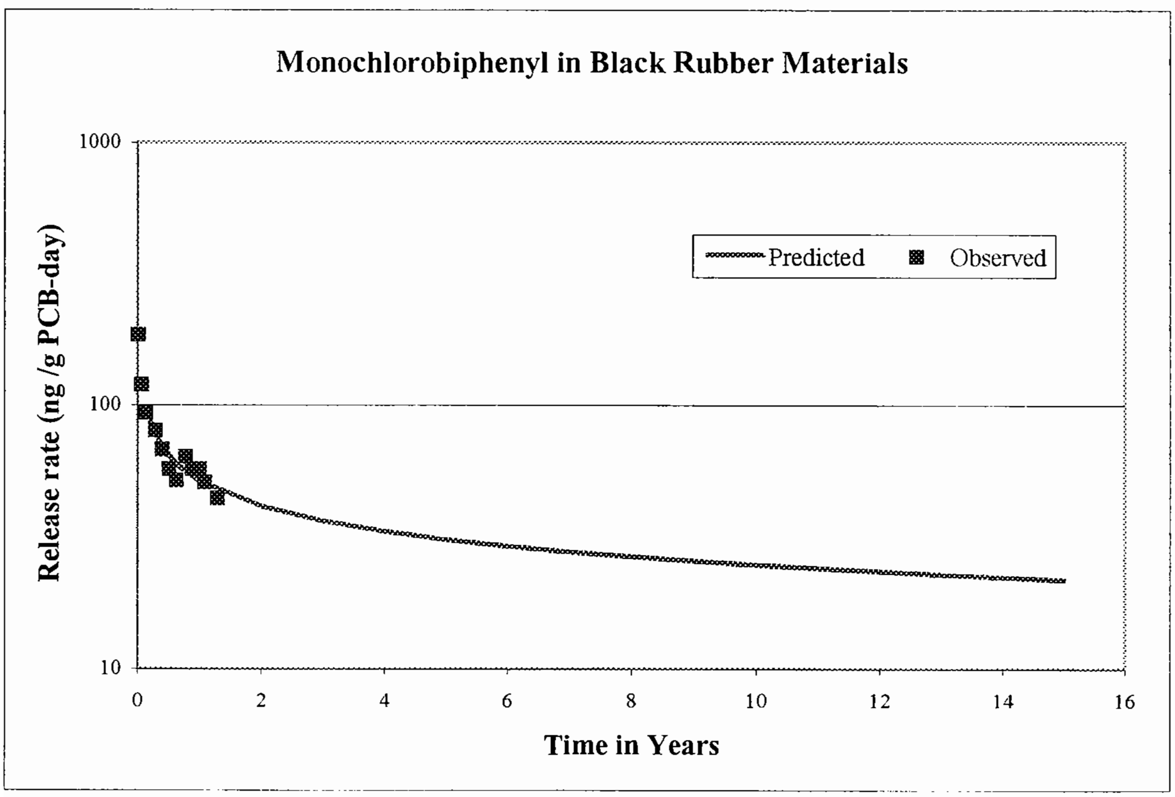
| | *Coefficients* | *andard Errc* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 5.81E+00 | 1.05E-01 | 5.54E+01 | 8.85E-14 | 5.58E+00 | 6.05E+00 |
| ln(day) | -3.17E-01 | 2.07E-02 | -1.53E+01 | 2.88E-08 | -3.63E-01 | -2.71E-01 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 5.19E+00 | 2.14E-02 |
| 2 | 4.76E+00 | 2.37E-02 |
| 3 | 4.58E+00 | -4.67E-02 |
| 4 | 4.34E+00 | 4.20E-02 |
| 5 | 4.23E+00 | -2.36E-02 |
| 6 | 4.15E+00 | -1.09E-01 |
| 7 | 4.09E+00 | -1.45E-01 |
| 8 | 4.02E+00 | 1.30E-01 |
| 9 | 3.98E+00 | 6.79E-02 |
| 10 | 3.94E+00 | 1.04E-01 |
| 11 | 3.92E+00 | 9.75E-03 |

| | | |
|---|---|---|
| 12 | 3.86E+00 | -7.47E-02 |



**Dichlorobiphenyl in Bulkhead Insulation**

| ng/ g-PCB - d | Cl2 |
|---|---|
| 6.25E-03 | 0 |
| 1.17E+00 | 0 |
| 7.07E+00 | 502 |
| 1.41E+01 | 1267 |
| 2.82E+01 | 158 |
| 4.92E+01 | 15.2 |
| 6.93E+01 | 14 |
| 1.04E+02 | 97.2 |
| 1.46E+02 | 91.4 |
| 1.88E+02 | 57.1 |
| 2.30E+02 | 6.1 |
| 2.86E+02 | 7.4 |
| 3.28E+02 | 34.8 |
| 3.70E+02 | 52.3 |
| 3.98E+02 | 114 |
| 4.75E+02 | 33.7 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 2.64E+00 | 1.41E+01 | 1267 | 7.14E+00 |
| 3.34E+00 | 2.82E+01 | 158 | 5.06E+00 |
| 3.90E+00 | 4.92E+01 | 15 | 2.72E+00 |
| 4.24E+00 | 6.93E+01 | 14 | 2.66E+00 |
| 4.65E+00 | 1.04E+02 | 97 | 4.58E+00 |
| 4.98E+00 | 1.46E+02 | 91 | 4.52E+00 |
| 5.24E+00 | 1.88E+02 | 57 | 4.05E+00 |
| 5.44E+00 | 2.30E+02 | 6 | 1.81E+00 |
| 5.66E+00 | 2.86E+02 | 7 | 2.00E+00 |
| 5.79E+00 | 3.28E+02 | 35 | 3.55E+00 |
| 5.91E+00 | 3.70E+02 | 52 | 3.96E+00 |
| 5.99E+00 | 3.98E+02 | 114 | 4.74E+00 |
| 6.16E+00 | 4.75E+02 | 34 | 3.52E+00 |

**Maximum Release Rate at 14 days**
**1267 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.5051 |
| R Square | 0.2552 |
| Standard Error | 1.2907 |
| Observations | 13 |

ANOVA

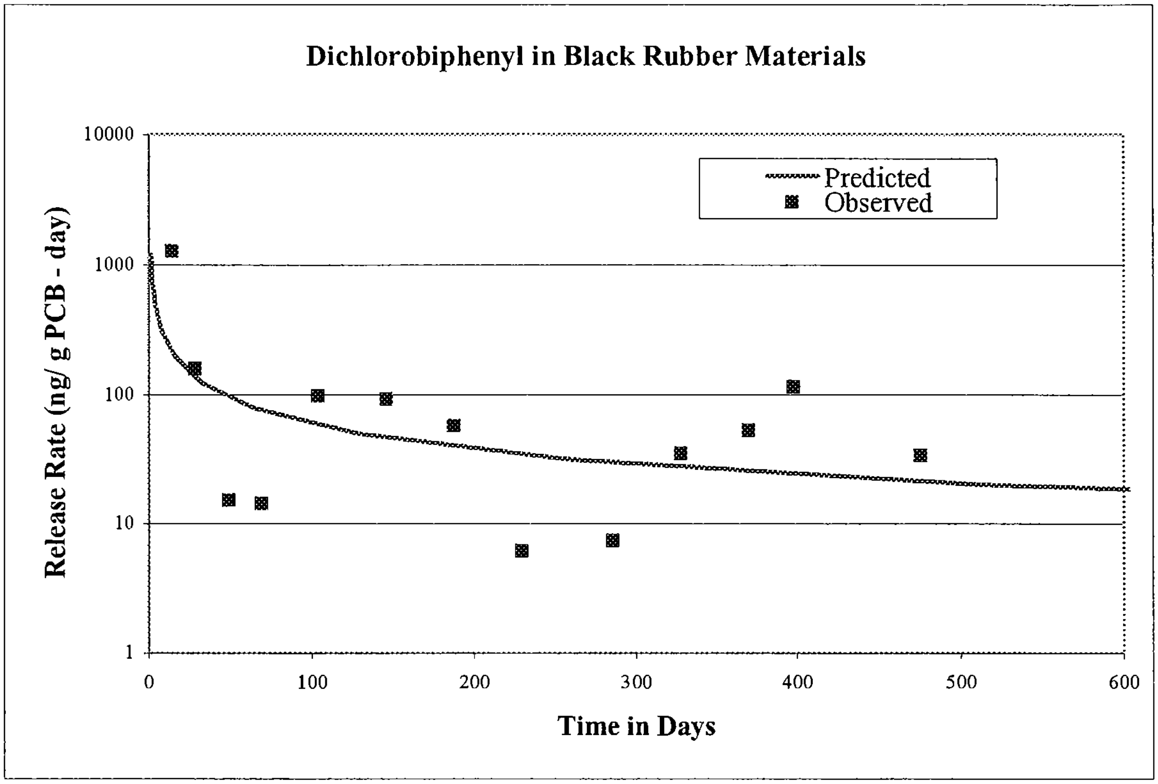
| | *df* | *SS* | *MS* | *F* | *Significance F* | |
|---|---|---|---|---|---|---|
| Regression | 1 | 6.28E+00 | 6.28E+00 | 3.77E+00 | 7.83E-02 | ***Not Significant*** |
| Residual | 11 | 1.83E+01 | 1.67E+00 | | | |
| Total | 12 | 2.46E+01 | | | | |

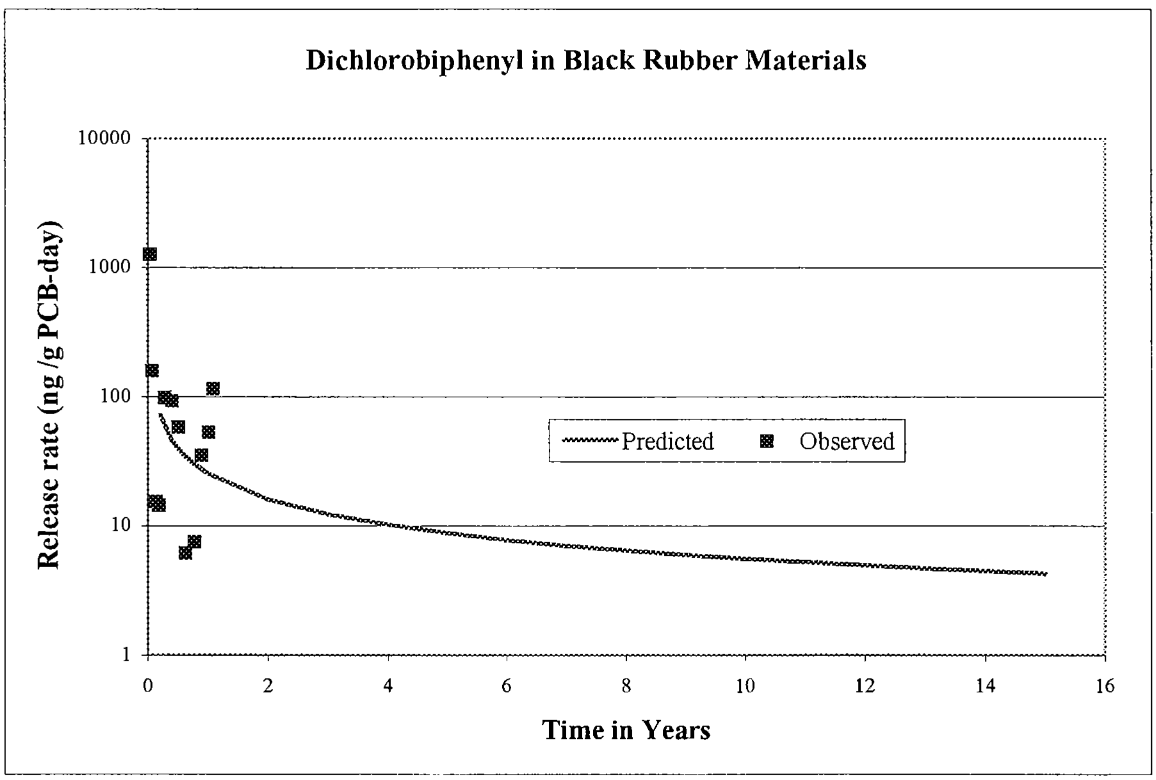
| | *Coefficients* | *andard Err* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 7.09E+00 | 1.70E+00 | 4.18E+00 | 1.55E-03 | 3.35E+00 | 1.08E+01 |
| ln(day) | -6.55E-01 | 3.38E-01 | -1.94E+00 | 7.83E-02 | -1.40E+00 | 8.77E-02 |

RESIDUAL OUTPUT

| *Observation* | *cted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 5.36E+00 | 1.79E+00 |
| 2 | 4.90E+00 | 1.57E-01 |
| 3 | 4.54E+00 | -1.82E+00 |
| 4 | 4.31E+00 | -1.66E+00 |
| 5 | 4.05E+00 | 5.30E-01 |
| 6 | 3.83E+00 | 6.90E-01 |
| 7 | 3.66E+00 | 3.85E-01 |
| 8 | 3.53E+00 | -1.72E+00 |
| 9 | 3.38E+00 | -1.38E+00 |
| 10 | 3.30E+00 | 2.53E-01 |

| *Observation* | *dicted ln(ng/g-PCI* | *Residuals* |
|---|---|---|
| 11 | 3.22E+00 | 7.40E-01 |
| 12 | 3.17E+00 | 1.57E+00 |
| 13 | 3.05E+00 | 4.65E-01 |


Dichlorobiphenyl in Black Rubber Materials
Release Rate (ng/ g PCB - day)
10000
1000
100
10
1
0
100
200
300
400
500
600
Time in Days
Predicted
Observed


Dichlorobiphenyl in Black Rubber Materials
Release rate (ng /g PCB-day)
10000
1000
100
10
1
0
2
4
6
8
10
12
14
16
Time in Years
Predicted
Observed

## Trichlorobiphenyl in Bulkhead Insulation

| ng/ g-PCB - d | Cl3 |
|---|---|
| 6.25E-03 | 0 |
| 1.17E+00 | 0 |
| 7.07E+00 | 211 |
| 1.41E+01 | 239 |
| 2.82E+01 | 143 |
| 4.92E+01 | 77.8 |
| 6.93E+01 | 114 |
| 1.04E+02 | 80.1 |
| 1.46E+02 | 101.1 |
| 1.88E+02 | 61.9 |
| 2.30E+02 | 216.1 |
| 2.86E+02 | 162.2 |
| 3.28E+02 | 32.8 |
| 3.70E+02 | 45.6 |
| 3.98E+02 | 86 |
| 4.75E+02 | 57.0 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 2.64E+00 | 1.41E+01 | 239 | 5.48E+00 |
| 3.34E+00 | 2.82E+01 | 143 | 4.97E+00 |
| 3.90E+00 | 4.92E+01 | 78 | 4.35E+00 |
| 4.24E+00 | 6.93E+01 | 114 | 4.74E+00 |
| 4.65E+00 | 1.04E+02 | 80 | 4.38E+00 |
| 4.98E+00 | 1.46E+02 | 101 | 4.62E+00 |
| 5.24E+00 | 1.88E+02 | 62 | 4.13E+00 |
| 5.44E+00 | 2.30E+02 | 216 | 5.38E+00 |
| 5.66E+00 | 2.86E+02 | 162 | 5.09E+00 |
| 5.79E+00 | 3.28E+02 | 33 | 3.49E+00 |
| 5.91E+00 | 3.70E+02 | 46 | 3.82E+00 |
| 5.99E+00 | 3.98E+02 | 86 | 4.45E+00 |
| 6.16E+00 | 4.75E+02 | 57 | 4.04E+00 |

**Maximum Release Rate at 14 days**
**239 ng/gPCB-d**

**Release rate at 2 years**
**56.6 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.5534 |
| R Square | 0.3063 |
| Standard Error | 0.5150 |
| Observations | 13 |

ANOVA

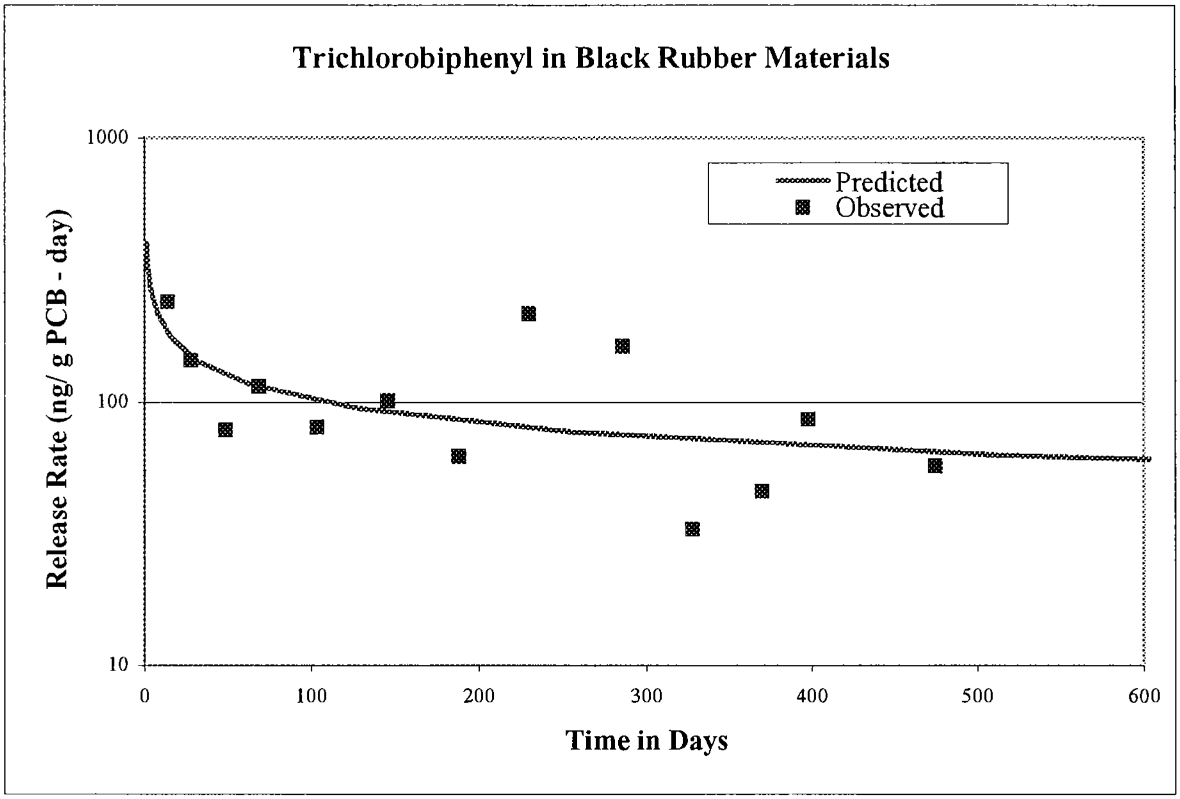
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 1.29E+00 | 1.29E+00 | 4.86E+00 | 4.98E-02 |
| Residual | 11 | 2.92E+00 | 2.65E-01 | | |
| Total | 12 | 4.21E+00 | | | |

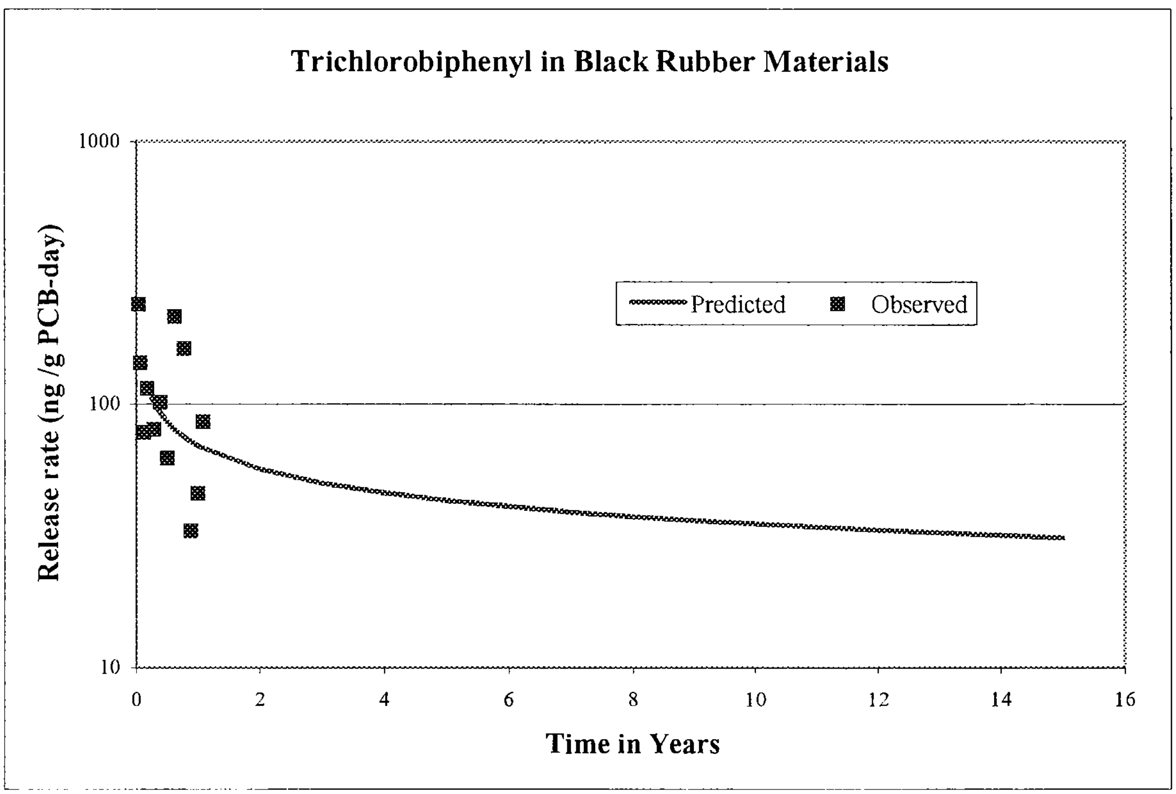
| | *Coefficients* | *andard Err* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 5.99E+00 | 6.78E-01 | 8.84E+00 | 2.49E-06 | 4.50E+00 | 7.48E+00 |
| ln(day) | -2.97E-01 | 1.35E-01 | -2.20E+00 | 4.98E-02 | -5.93E-01 | -3.71E-04 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 5.21E+00 | 2.69E-01 |
| 2 | 5.00E+00 | -3.64E-02 |
| 3 | 4.84E+00 | -4.83E-01 |
| 4 | 4.73E+00 | 3.60E-03 |
| 5 | 4.61E+00 | -2.31E-01 |
| 6 | 4.51E+00 | 1.02E-01 |
| 7 | 4.44E+00 | -3.13E-01 |
| 8 | 4.38E+00 | 9.97E-01 |
| 9 | 4.31E+00 | 7.75E-01 |
| 10 | 4.27E+00 | -7.81E-01 |
| 11 | 4.24E+00 | -4.17E-01 |

| | | |
|---|---|---|
| 12 | 4.22E+00 | 2.35E-01 |
| 13 | 4.16E+00 | -1.20E-01 |



## Tetrachlorobiphenyl in Bulkhead Insulation

| ng/ g-PCB - d | Cl4 |
|---|---|
| 6.25E-03 | 0 |
| 1.17E+00 | 0 |
| 7.07E+00 | 736 |
| 1.41E+01 | 922 |
| 2.82E+01 | 688 |
| 4.92E+01 | 654.5 |
| 6.93E+01 | 895 |
| 1.04E+02 | 486.2 |
| 1.46E+02 | 413.8 |
| 1.88E+02 | 295.1 |
| 2.30E+02 | 272.5 |
| 2.86E+02 | 137.5 |
| 3.28E+02 | 180.9 |
| 3.70E+02 | 204.3 |
| 3.98E+02 | 271 |
| 4.75E+02 | 163.3 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 2.64E+00 | 1.41E+01 | 922 | 6.83E+00 |
| 3.34E+00 | 2.82E+01 | 688 | 6.53E+00 |
| 3.90E+00 | 4.92E+01 | 654 | 6.48E+00 |
| 4.24E+00 | 6.93E+01 | 895 | 6.80E+00 |
| 4.65E+00 | 1.04E+02 | 486 | 6.19E+00 |
| 4.98E+00 | 1.46E+02 | 414 | 6.03E+00 |
| 5.24E+00 | 1.88E+02 | 295 | 5.69E+00 |
| 5.44E+00 | 2.30E+02 | 273 | 5.61E+00 |
| 5.66E+00 | 2.86E+02 | 137 | 4.92E+00 |
| 5.79E+00 | 3.28E+02 | 181 | 5.20E+00 |
| 5.91E+00 | 3.70E+02 | 204 | 5.32E+00 |
| 5.99E+00 | 3.98E+02 | 271 | 5.60E+00 |
| 6.16E+00 | 4.75E+02 | 163 | 5.10E+00 |

**Maximum Release Rate at 14 days**
**922 ng/gPCB-d**

**Release rate at 2 years**
**144 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.9041 |
| Adjusted R Squ | 0.8007 |
| Standard Error | 0.2921 |
| Observations | 13 |

ANOVA

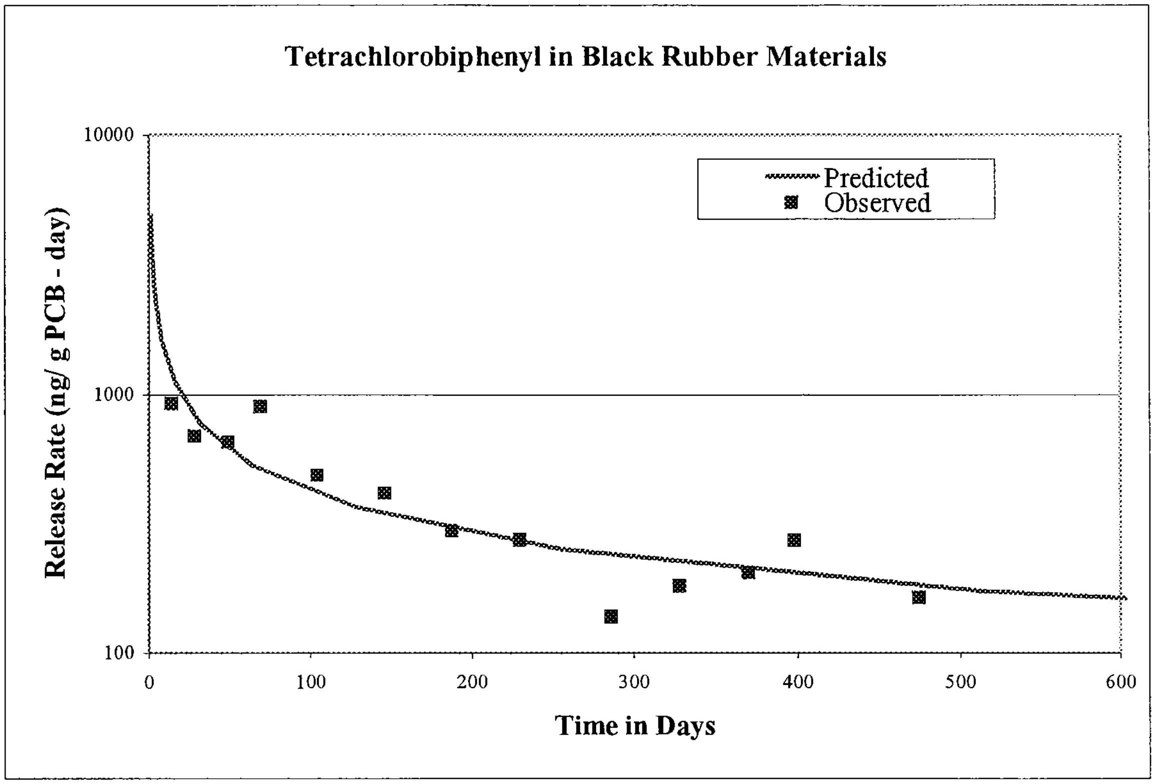
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 4.20E+00 | 4.20E+00 | 4.92E+01 | 2.22E-05 |
| Residual | 11 | 9.39E-01 | 8.53E-02 | | |
| Total | 12 | 5.14E+00 | | | |

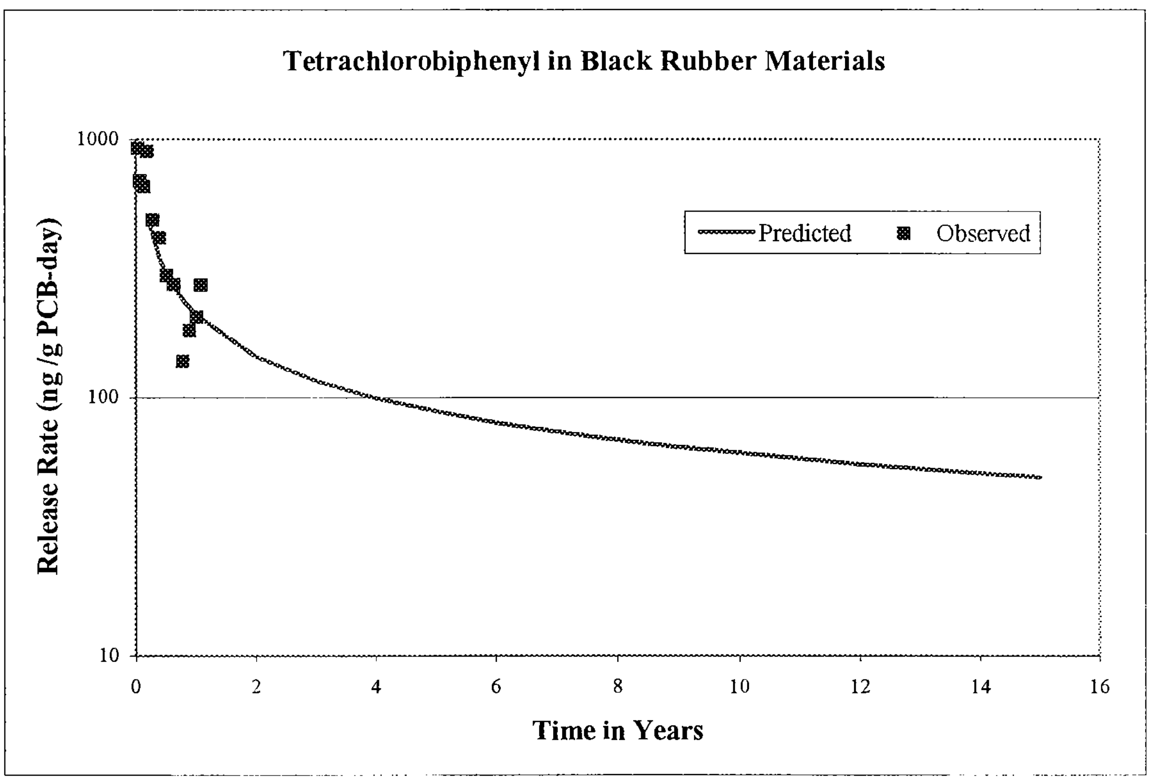
| | *Coefficients* | *andard Erro* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 8.50E+00 | 3.84E-01 | 2.21E+01 | 1.81E-10 | 7.66E+00 | 9.35E+00 |
| ln(day) | -5.36E-01 | 7.64E-02 | -7.02E+00 | 2.22E-05 | -7.04E-01 | -3.68E-01 |

RESIDUAL OUTPUT

| *Observation* | *cted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 7.09E+00 | -2.61E-01 |
| 2 | 6.72E+00 | -1.81E-01 |
| 3 | 6.42E+00 | 6.75E-02 |
| 4 | 6.23E+00 | 5.64E-01 |
| 5 | 6.01E+00 | 1.72E-01 |
| 6 | 5.83E+00 | 1.93E-01 |
| 7 | 5.70E+00 | -1.02E-02 |
| 8 | 5.59E+00 | 1.84E-02 |
| 9 | 5.47E+00 | -5.49E-01 |
| 10 | 5.40E+00 | -2.01E-01 |

| *Observation* | *dicted ln(ng/g-PCI* | *Residuals* |
|---|---|---|
| 11 | 5.33E+00 | -1.50E-02 |
| 12 | 5.30E+00 | 3.08E-01 |
| 13 | 5.20E+00 | -1.05E-01 |


Tetrachlorobiphenyl in Black Rubber Materials
Predicted
Observed
Release Rate (ng/ g PCB - day)
10000
1000
100
0
100
200
300
400
500
600
Time in Days


Tetrachlorobiphenyl in Black Rubber Materials
Predicted
Observed
Release Rate (ng /g PCB-day)
1000
100
10
0
2
4
6
8
10
12
14
16
Time in Years

**Pentachlorobiphenyl in Bulkhead Insulation**

| ng/ g-PCB - d | Cl5 |
|---|---|
| 6.25E-03 | 0 |
| 1.17E+00 | 0 |
| 7.07E+00 | 602 |
| 1.41E+01 | 461 |
| 2.82E+01 | 574 |
| 4.92E+01 | 379 |
| 6.93E+01 | 638 |
| 1.04E+02 | 458 |
| 1.46E+02 | 414 |
| 1.88E+02 | 248 |
| 2.30E+02 | 249 |
| 2.86E+02 | 53 |
| 3.28E+02 | 129 |
| 3.70E+02 | 109 |
| 3.98E+02 | 221 |
| 4.75E+02 | 111 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 4.24E+00 | 6.93E+01 | 638 | 6.46E+00 |
| 4.65E+00 | 1.04E+02 | 458 | 6.13E+00 |
| 4.98E+00 | 1.46E+02 | 414 | 6.03E+00 |
| 5.24E+00 | 1.88E+02 | 248 | 5.51E+00 |
| 5.44E+00 | 2.30E+02 | 249 | 5.52E+00 |
| 5.66E+00 | 2.86E+02 | 53 | 3.97E+00 |
| 5.79E+00 | 3.28E+02 | 129 | 4.86E+00 |
| 5.91E+00 | 3.70E+02 | 109 | 4.69E+00 |
| 5.99E+00 | 3.98E+02 | 221 | 5.40E+00 |
| 6.16E+00 | 4.75E+02 | 111 | 4.71E+00 |

**Maximum Release Rate at 69 days**
**638 ng/gPCB-d**

**Release rate at 2 years**
**63.1 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.8104 |
| R Square | 0.6567 |
| Standard Error | 0.4781 |
| Observations | 10 |

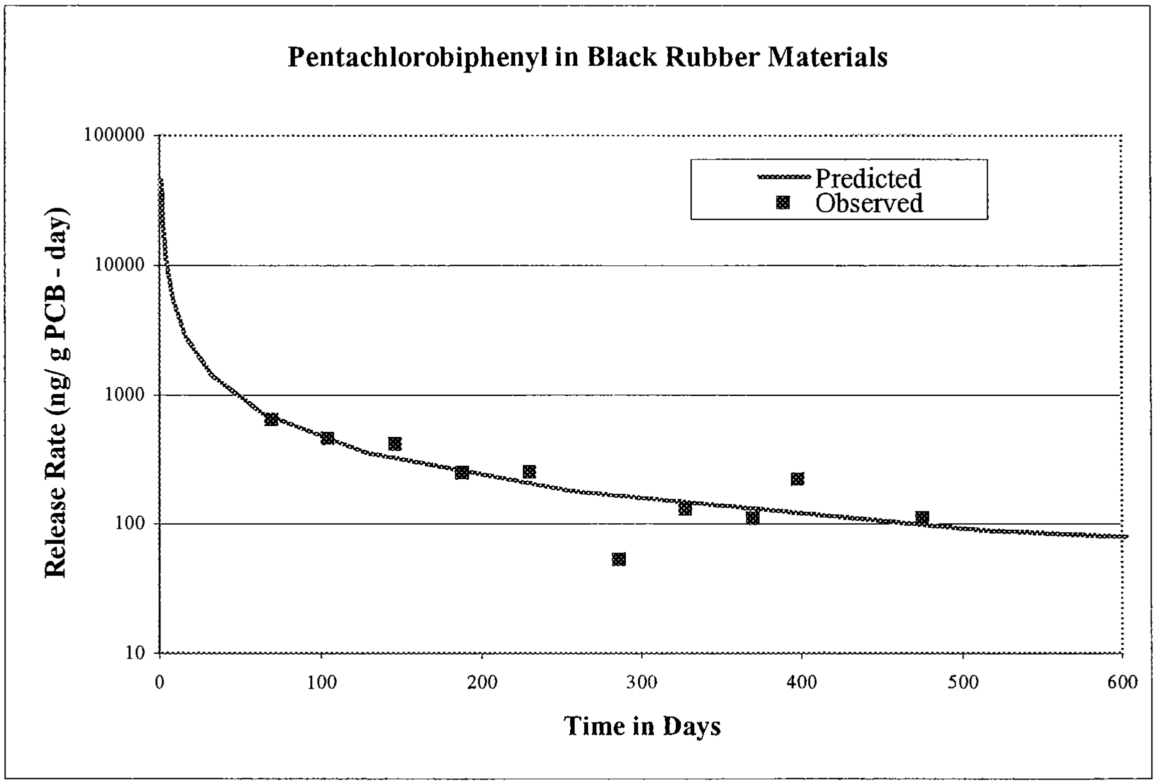
ANOVA

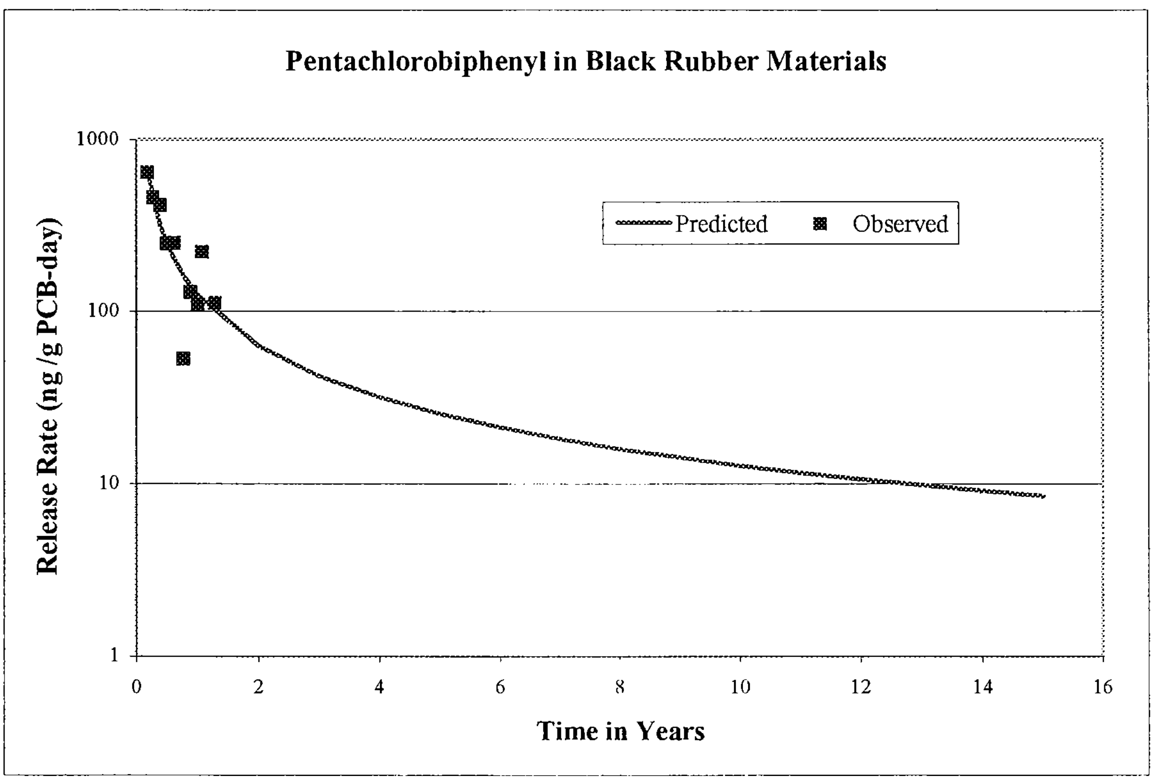
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 3.50E+00 | 3.50E+00 | 1.53E+01 | 4.47E-03 |
| Residual | 8 | 1.83E+00 | 2.29E-01 | | |
| Total | 9 | 5.33E+00 | | | |

| | *Coefficients* | *andard Err* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 1.07E+01 | 1.38E+00 | 7.74E+00 | 5.54E-05 | 7.52E+00 | 1.39E+01 |
| ln(day) | -9.95E-01 | 2.54E-01 | -3.91E+00 | 4.47E-03 | -1.58E+00 | -4.09E-01 |

RESIDUAL OUTPUT

| *Observation* | *cted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 6.49E+00 | -3.12E-02 |
| 2 | 6.08E+00 | 4.27E-02 |
| 3 | 5.75E+00 | 2.79E-01 |
| 4 | 5.50E+00 | 1.63E-02 |
| 5 | 5.29E+00 | 2.23E-01 |
| 6 | 5.08E+00 | -1.11E+00 |
| 7 | 4.94E+00 | -8.50E-02 |
| 8 | 4.82E+00 | -1.27E-01 |
| 9 | 4.75E+00 | 6.51E-01 |
| 10 | 4.57E+00 | 1.41E-01 |


Pentachlorobiphenyl in Black Rubber Materials
100000
10000
1000
100
10
Release Rate (ng/ g PCB - day)
0
100
200
300
400
500
600
Time in Days
Predicted
Observed


Pentachlorobiphenyl in Black Rubber Materials
1000
100
10
1
Release Rate (ng /g PCB-day)
0
2
4
6
8
10
12
14
16
Time in Years
Predicted
Observed

## Heptachlorobiphenyl in Bulkhead Insulation

| ng/ g-PCB - d | Cl7 |
|---|---|
| 6.25E-03 | 167503 |
| 1.17E+00 | 833 |
| 7.07E+00 | 311 |
| 1.41E+01 | 222 |
| 2.82E+01 | 0 |
| 4.92E+01 | 0 |
| 6.93E+01 | 0 |
| 1.04E+02 | 0 |
| 1.46E+02 | 0 |
| 1.88E+02 | 0 |
| 2.30E+02 | 0 |
| 2.86E+02 | 0 |
| 3.28E+02 | 0 |
| 3.70E+02 | 0 |
| 3.98E+02 | 0 |
| 4.75E+02 | 0 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| -5.08E+00 | 6.25E-03 | 167503 | 1.20E+01 |
| 1.56E-01 | 1.17E+00 | 833 | 6.72E+00 |
| 1.96E+00 | 7.07E+00 | 311 | 5.74E+00 |
| 2.64E+00 | 1.41E+01 | 222 | 5.40E+00 |

**Maximum Release Rate at less than 1 day**
**167503 ng/gPCB-d**

**Release rate at 2 years**
**5.04 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.9925 |
| R Square | 0.9850 |
| Standard Error | 0.4626 |
| Observations | 4 |

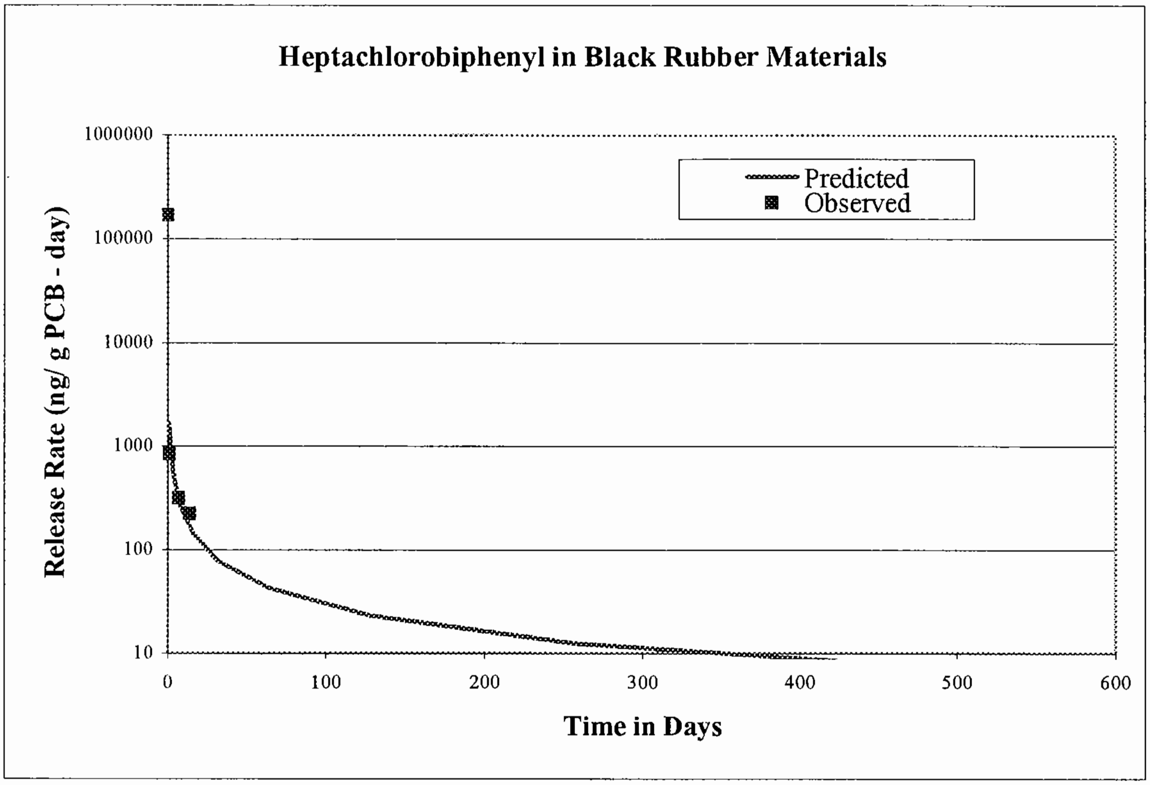
ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 2.82E+01 | 2.82E+01 | 1.32E+02 | 7.51E-03 |
| Residual | 2 | 4.28E-01 | 2.14E-01 | | |
| Total | 3 | 2.86E+01 | | | |

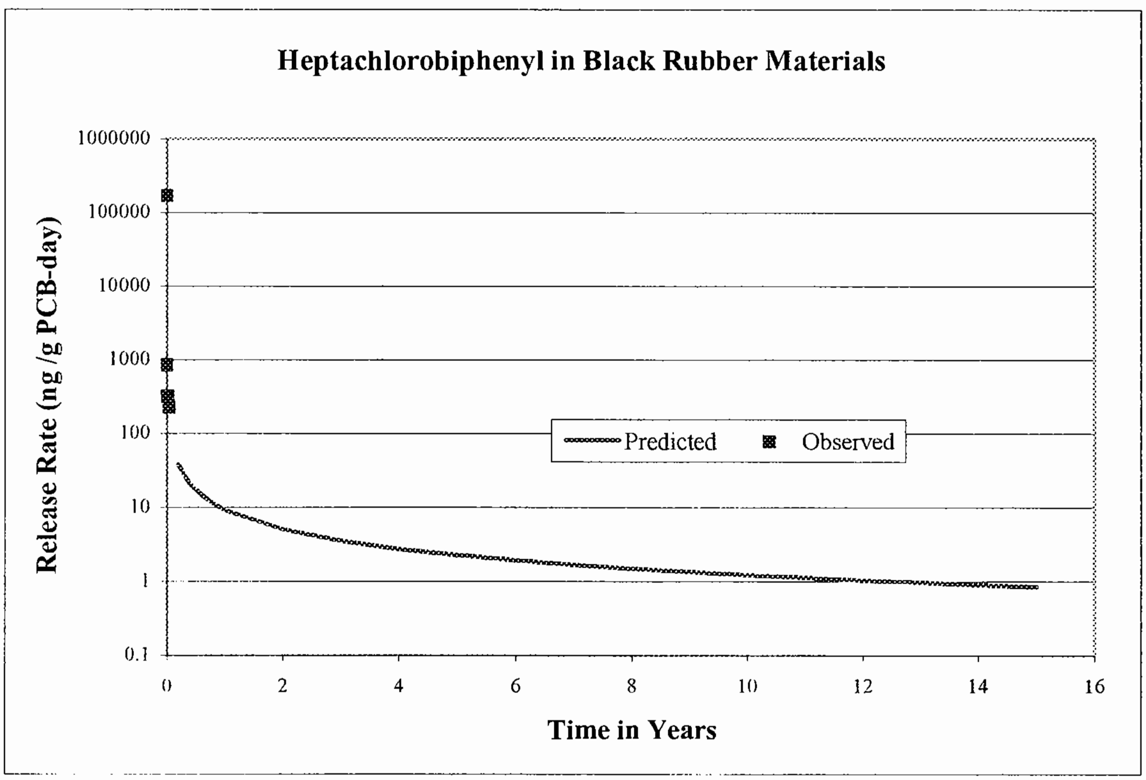
| | *Coefficients* | *andard Err* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 7.40E+00 | 2.31E-01 | 3.20E+01 | 9.75E-04 | 6.41E+00 | 8.40E+00 |
| ln(day) | -8.78E-01 | 7.65E-02 | -1.15E+01 | 7.51E-03 | -1.21E+00 | -5.49E-01 |

RESIDUAL OUTPUT

| *Observation* | *cted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 1.19E+01 | 1.70E-01 |
| 2 | 7.27E+00 | -5.43E-01 |
| 3 | 5.69E+00 | 5.33E-02 |
| 4 | 5.08E+00 | 3.19E-01 |



Heptachlorobiphenyl in Black Rubber Materials
Predicted
Observed
Release Rate (ng/ g PCB - day)
1000000
100000
10000
1000
100
10
0
100
200
300
400
500
600
Time in Days

Heptachlorobiphenyl in Black Rubber Materials
Predicted
Observed
Release Rate (ng /g PCB-day)
1000000
100000
10000
1000
100
10
1
0.1
0
2
4
6
8
10
12
14
16
Time in Years

**BULKHEAD INSULATION**

**Bulkhead Insulation**

| Leaching Time (days) | Homologue Leach Rates (ng PCB/g shipboard solid-day) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cl1 | Cl2 | Cl3 | Cl4 | Cl5 | Cl6 | Cl7 | Cl8 | Cl9 | Cl10 |
| 6.94E-03 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 1.17E+00 | 0.0E+00 | 0.0E+00 | 1.2E+00 | 2.7E+01 | 2.6E+01 | 0.0E+00 | 1.5E+01 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 7.08E+00 | 0.0E+00 | 2.6E+00 | 3.6E+00 | 4.5E+01 | 4.2E+01 | 7.0E+00 | 2.6E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 1.41E+01 | 0.0E+00 | 3.6E+00 | 3.1E+00 | 5.9E+01 | 6.4E+01 | 7.2E+00 | 1.6E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2.11E+01 | 0.0E+00 | 1.8E-01 | 2.8E+00 | 7.0E+01 | 1.3E+02 | 1.9E+01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 4.22E+01 | 0.0E+00 | 8.6E-02 | 1.5E+00 | 3.3E+01 | 4.9E+01 | 7.6E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 6.93E+01 | 0.0E+00 | 6.1E-02 | 1.3E+00 | 4.3E+01 | 1.0E+02 | 2.3E+01 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 8.31E+01 | 0.0E+00 | 0.0E+00 | 1.6E+00 | 4.7E+01 | 1.2E+02 | 2.1E+01 | 1.9E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 1.18E+02 | 0.0E+00 | 4.0E-02 | 9.2E-01 | 2.4E+01 | 4.5E+01 | 9.2E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 1.67E+02 | 0.0E+00 | 2.7E-02 | 6.5E-01 | 3.1E+01 | 8.7E+01 | 2.2E+01 | 1.6E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2.09E+02 | 0.0E+00 | 2.2E-02 | 6.0E-01 | 1.7E+01 | 3.5E+01 | 8.1E+00 | 8.1E-01 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2.51E+02 | 0.0E+00 | 0.0E+00 | 6.7E-01 | 2.0E+01 | 4.2E+01 | 8.4E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2.86E+02 | 0.0E+00 | 0.0E+00 | 5.1E-01 | 1.7E+01 | 2.5E+01 | 3.9E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 3.28E+02 | 0.0E+00 | 0.0E+00 | 5.1E-01 | 1.2E+01 | 2.4E+01 | 5.9E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 3.70E+02 | 0.0E+00 | 0.0E+00 | 5.5E-01 | 1.4E+01 | 2.1E+01 | 4.2E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 3.98E+02 | 0.0E+00 | 0.0E+00 | 1.1E+00 | 1.7E+01 | 2.9E+01 | 8.3E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 4.54E+02 | 0.0E+00 | 0.0E+00 | 6.0E-01 | 7.3E+00 | 1.2E+01 | 4.1E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | | | | | | | | | | |
| Max | 0.0E+00 | 3.6E+00 | 3.6E+00 | 7.0E+01 | 1.3E+02 | 2.3E+01 | 1.5E+01 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Min | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |

0.00044 g PCB / g bulkhead insulation (leachate study concentration)

| Leaching Time (days) | Homologue Leach Rates (ng PCB/g PCB-day) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ng/ g-PCB - d | Cl1 | Cl2 | Cl3 | Cl4 | Cl5 | Cl6 | Cl7 | Cl8 | Cl9 | Cl10 |
| 0.007 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.170 | 0 | 0 | 2662 | 62223 | 58766 | 0 | 34568 | 0 | 0 | 0 |
| 7.076 | 0 | 5988 | 8259 | 103242 | 96359 | 15830 | 5919 | 0 | 0 | 0 |
| 14.083 | 0 | 8209 | 7036 | 134856 | 146583 | 16417 | 3694 | 0 | 0 | 0 |
| 21.097 | 0 | 398 | 6443 | 158137 | 286990 | 42170 | 0 | 0 | 0 | 0 |
| 42.226 | 0 | 194 | 3306 | 73888 | 110832 | 17305 | 0 | 0 | 0 | 0 |
| 69.301 | 0 | 138 | 2873 | 97698 | 229878 | 53159 | 0 | 0 | 0 | 0 |
| 83.139 | 0 | 0 | 3525 | 105743 | 267294 | 46997 | 4406 | 0 | 0 | 0 |
| 118.135 | 0 | 92 | 2091 | 53427 | 103369 | 20906 | 0 | 0 | 0 | 0 |
| 167.104 | 0 | 62 | 1478 | 71438 | 197072 | 50089 | 3695 | 0 | 0 | 0 |
| 209.131 | 0 | 50 | 1354 | 38687 | 79308 | 18376 | 1838 | 0 | 0 | 0 |
| 251.192 | 0 | 0 | 1530 | 45887 | 95598 | 19120 | 0 | 0 | 0 | 0 |
| 286.150 | 0 | 0 | 1150 | 39107 | 56361 | 8972 | 0 | 0 | 0 | 0 |
| 328.092 | 0 | 0 | 1150 | 26843 | 55604 | 13422 | 0 | 0 | 0 | 0 |
| 370.117 | 0 | 0 | 1244 | 31575 | 47841 | 9568 | 0 | 0 | 0 | 0 |
| 398.079 | 0 | 0 | 2471 | 37794 | 66867 | 18897 | 0 | 0 | 0 | 0 |
| 454.319 | 0 | 0 | 1373 | 16623 | 28187 | 9396 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | |
| Max | 0 | 8209 | 8259 | 158137 | 286990 | 53159 | 34568 | 0 | 0 | 0 |
| Min | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Median | 0 | 0 | 2091 | 53427 | 95598 | 17305 | 0 | 0 | 0 | 0 |
| Simple Average | 0 | 890 | 2820 | 64539 | 113348 | 21213 | 3184 | 0 | 0 | 0 |
| Number of detects | 0 | 8 | 16 | 16 | 16 | 15 | 6 | 0 | 0 | 0 |
| Number of nondetects | 17 | 9 | 1 | 1 | 1 | 2 | 11 | 17 | 17 | 17 |
| | | | | | | | | | | |
| Intercept | --- | 1.16E+01 | 1.00E+01 | 1.38E+01 | 1.46E+01 | 1.45E+01 | 9.97E+00 | --- | --- | --- |
| Slope | --- | -1.50E+00 | -4.85E-01 | -5.89E-01 | -6.21E-01 | -8.69E-01 | -4.24E-01 | --- | --- | --- |
| alpha | --- | 7.11E-03 | 4.14E-07 | 2.63E-05 | 6.54E-04 | 1.37E-03 | 2.43E-02 | --- | --- | --- |

## Dichlorobiphenyl in Bulkhead Insulation

| ng/ g-PCB - d | Cl2 |
|---|---|
| 6.94E-03 | 0 |
| 1.17E+00 | 0 |
| 7.08E+00 | 5988 |
| 1.41E+01 | 8209 |
| 2.11E+01 | 398 |
| 4.22E+01 | 194 |
| 6.93E+01 | 138 |
| 8.31E+01 | 0 |
| 1.18E+02 | 92 |
| 1.67E+02 | 62 |
| 2.09E+02 | 50 |
| 2.51E+02 | 0 |
| 2.86E+02 | 0 |
| 3.28E+02 | 0 |
| 3.70E+02 | 0 |
| 3.98E+02 | 0 |
| 4.54E+02 | 0 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 2.64E+00 | 1.41E+01 | 8209 | 9.013E+00 |
| 3.05E+00 | 2.11E+01 | 398 | 5.987E+00 |
| 3.74E+00 | 4.22E+01 | 194 | 5.270E+00 |
| 4.24E+00 | 6.93E+01 | 138 | 4.927E+00 |
| 4.77E+00 | 1.18E+02 | 92 | 4.519E+00 |
| 5.12E+00 | 1.67E+02 | 62 | 4.134E+00 |
| 5.34E+00 | 2.09E+02 | 50 | 3.918E+00 |

**Maximum Release Rate at 7 day**
**8209 ng/gPCB-d**

**Release rate at 2 years**
**5.43 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.8909 |
| R Square | 0.7938 |
| Standard Error | 0.8668 |
| Observations | 7 |

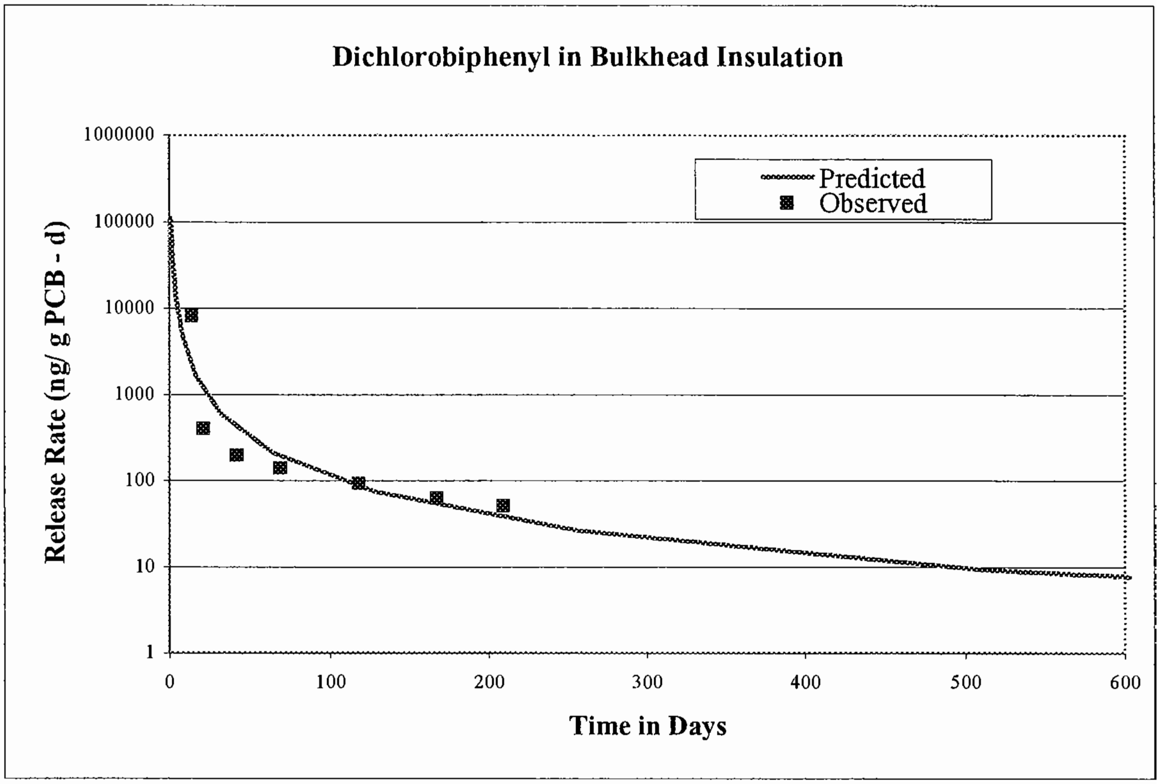
ANOVA

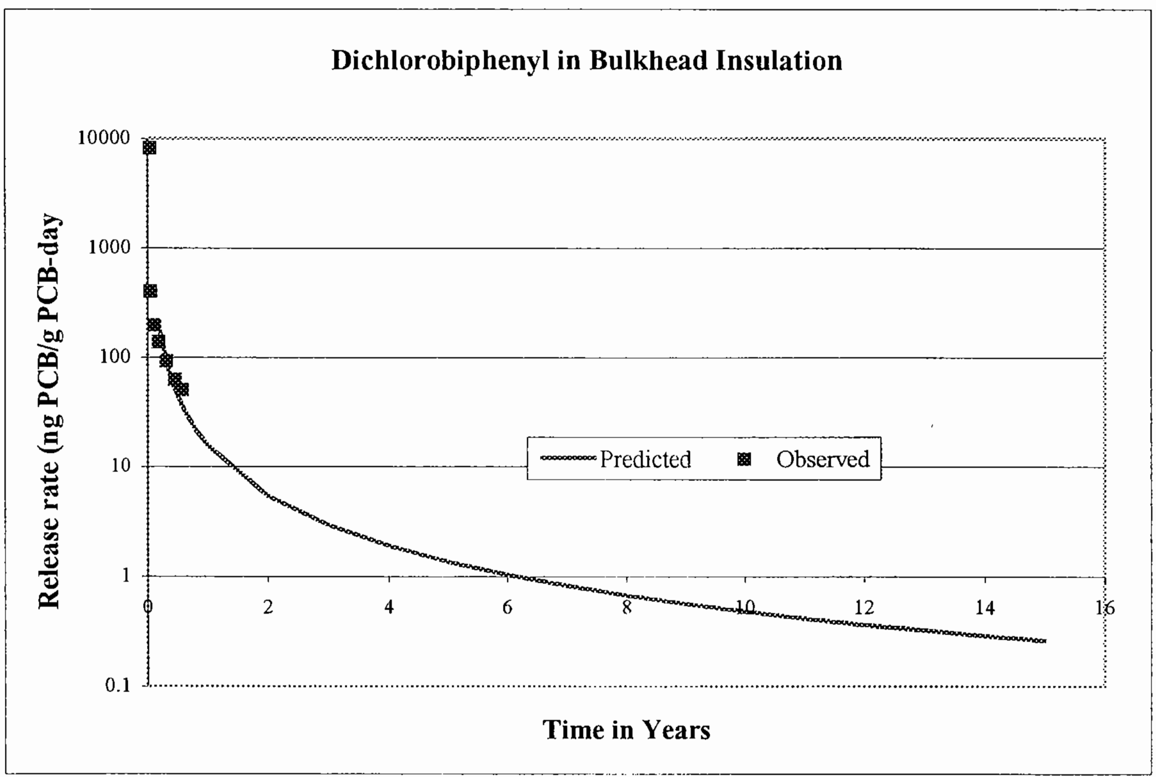
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 1.45E+01 | 1.45E+01 | 1.92E+01 | 7.11E-03 |
| Residual | 5 | 3.76E+00 | 7.51E-01 | | |
| Total | 6 | 1.82E+01 | | | |

| | *Coefficients* | *Std Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 1.16E+01 | 1.45E+00 | 7.99E+00 | 4.97E-04 | 7.87E+00 | 1.53E+01 |
| ln(day) | -1.50E+00 | 3.43E-01 | -4.39E+00 | 7.11E-03 | -2.38E+00 | -6.22E-01 |

RESIDUAL OUTPUT

| *Observation* | *cted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 7.63E+00 | 1.38E+00 |
| 2 | 7.02E+00 | -1.03E+00 |
| 3 | 5.98E+00 | -7.07E-01 |
| 4 | 5.23E+00 | -3.05E-01 |
| 5 | 4.43E+00 | 8.90E-02 |
| 6 | 3.91E+00 | 2.25E-01 |
| 7 | 3.57E+00 | 3.46E-01 |


Dichlorobiphenyl in Bulkhead Insulation
Predicted
Observed
Release Rate (ng/ g PCB - d)
1000000
100000
10000
1000
100
10
1
0
100
200
300
400
500
600
Time in Days


Dichlorobiphenyl in Bulkhead Insulation
Release rate (ng PCB/g PCB-day
10000
1000
100
10
1
0.1
0
2
4
6
8
10
12
14
16
Predicted
Observed
Time in Years

## Trichlorobiphenyl in Bulkhead Insulation

| ng/ g-PCB - d | Cl3 |
|---|---|
| 6.94E-03 | 0 |
| 1.17E+00 | 2662 |
| 7.08E+00 | 8259 |
| 1.41E+01 | 7036 |
| 2.11E+01 | 6443 |
| 4.22E+01 | 3306 |
| 6.93E+01 | 2873 |
| 8.31E+01 | 3525 |
| 1.18E+02 | 2091 |
| 1.67E+02 | 1478 |
| 2.09E+02 | 1354 |
| 2.51E+02 | 1530 |
| 2.86E+02 | 1150 |
| 3.28E+02 | 1150 |
| 3.70E+02 | 1244 |
| 3.98E+02 | 2471 |
| 4.54E+02 | 1373 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 1.96E+00 | 7.08E+00 | 8259 | 9.02E+00 |
| 2.64E+00 | 1.41E+01 | 7036 | 8.86E+00 |
| 3.05E+00 | 2.11E+01 | 6443 | 8.77E+00 |
| 3.74E+00 | 4.22E+01 | 3306 | 8.10E+00 |
| 4.24E+00 | 6.93E+01 | 2873 | 7.96E+00 |
| 4.42E+00 | 8.31E+01 | 3525 | 8.17E+00 |
| 4.77E+00 | 1.18E+02 | 2091 | 7.65E+00 |
| 5.12E+00 | 1.67E+02 | 1478 | 7.30E+00 |
| 5.34E+00 | 2.09E+02 | 1354 | 7.21E+00 |
| 5.53E+00 | 2.51E+02 | 1530 | 7.33E+00 |
| 5.66E+00 | 2.86E+02 | 1150 | 7.05E+00 |
| 5.79E+00 | 3.28E+02 | 1150 | 7.05E+00 |
| 5.91E+00 | 3.70E+02 | 1244 | 7.13E+00 |
| 5.99E+00 | 3.98E+02 | 2471 | 7.81E+00 |
| 6.12E+00 | 4.54E+02 | 1373 | 7.22E+00 |

**Maximum Release Rate at 7 day**
**8259 ng/gPCB-d**

**Release rate at 2 years**
**944 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.9324 |
| Adjusted R Squ | 0.8593 |
| Standard Error | 0.2566 |
| Observations | 15 |

ANOVA

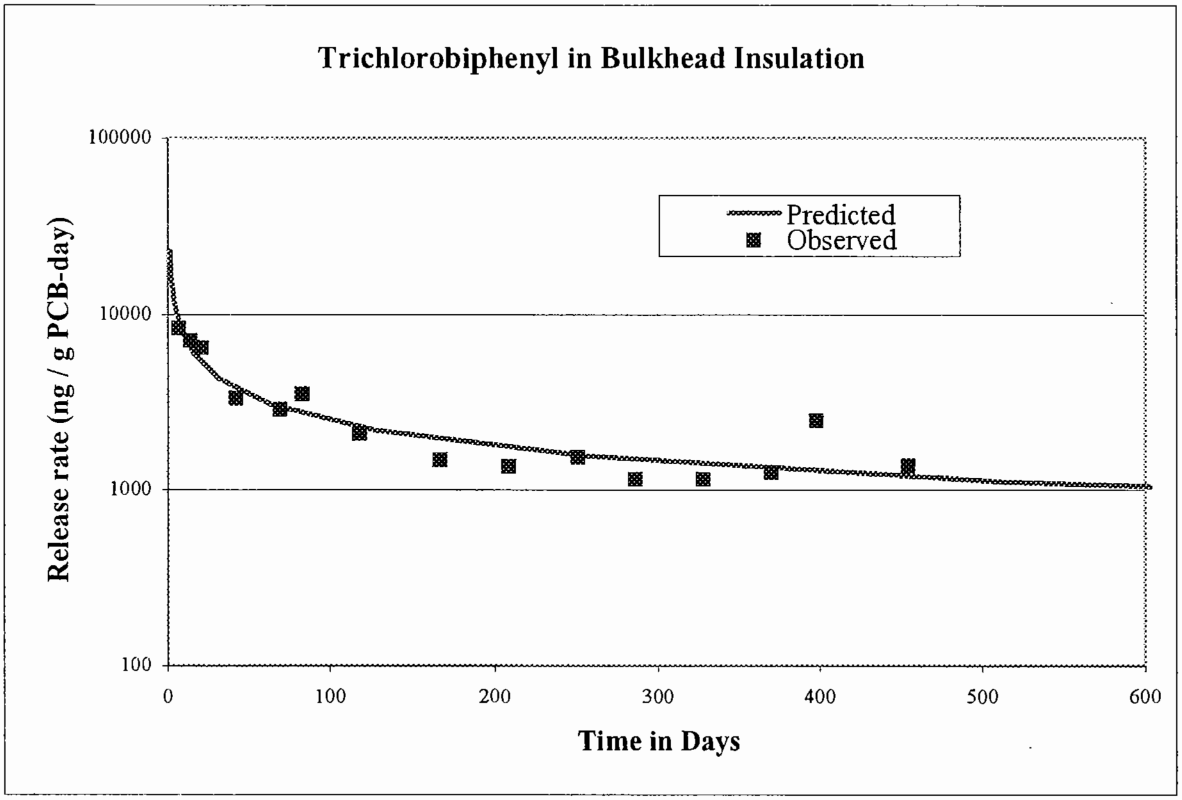
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 5.70E+00 | 5.70E+00 | 8.65E+01 | 4.14E-07 |
| Residual | 13 | 8.56E-01 | 6.58E-02 | | |
| Total | 14 | 6.55E+00 | | | |

| | *Coefficients* | *andard Err* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 1.00E+01 | 2.53E-01 | 3.97E+01 | 5.92E-15 | 9.50E+00 | 1.06E+01 |
| ln(day) | -4.85E-01 | 5.21E-02 | -9.30E+00 | 4.14E-07 | -5.98E-01 | -3.72E-01 |

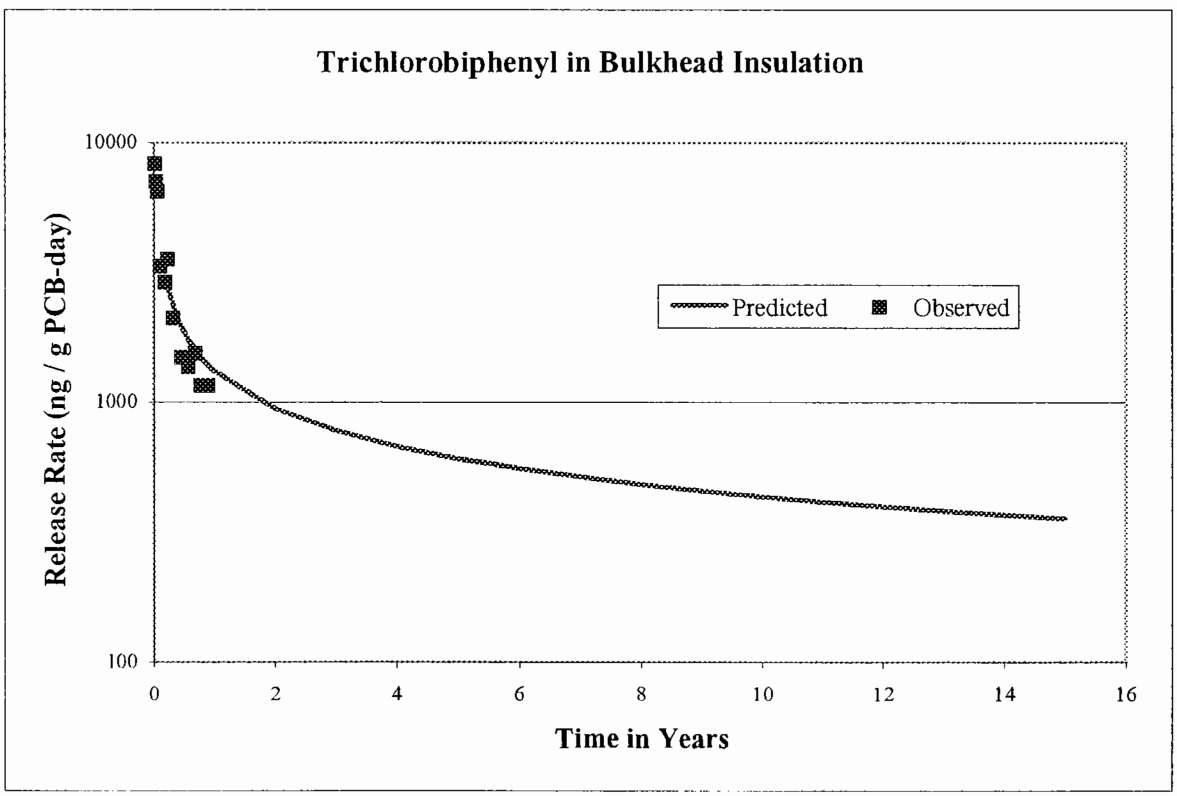
RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 9.10E+00 | -7.99E-02 |
| 2 | 8.77E+00 | 9.37E-02 |
| 3 | 8.57E+00 | 2.02E-01 |
| 4 | 8.23E+00 | -1.29E-01 |
| 5 | 7.99E+00 | -2.88E-02 |
| 6 | 7.90E+00 | 2.64E-01 |
| 7 | 7.73E+00 | -8.81E-02 |
| 8 | 7.57E+00 | -2.67E-01 |
| 9 | 7.46E+00 | -2.45E-01 |
| 10 | 7.37E+00 | -3.47E-02 |

| *Observation* | *dicted ln(ng/g-PCI* | *Residuals* |
|---|---|---|
| 11 | 7.30E+00 | -2.56E-01 |
| 12 | 7.24E+00 | -1.90E-01 |
| 13 | 7.18E+00 | -5.34E-02 |
| 14 | 7.14E+00 | 6.68E-01 |
| 15 | 7.08E+00 | 1.45E-01 |



Trichlorobiphenyl in Bulkhead Insulation
100000
10000
1000
100
Release rate (ng / g PCB-day)
Predicted
Observed
0
100
200
300
400
500
600
Time in Days

Trichlorobiphenyl in Bulkhead Insulation
10000
1000
100
Release Rate (ng / g PCB-day)
Predicted
Observed
0
2
4
6
8
10
12
14
16
Time in Years

## Tetrachlorobiphenyl in Bulkhead Insulation

| ng/ g-PCB - d | Cl4 |
|---|---|
| 6.94E-03 | 0 |
| 1.17E+00 | 62223 |
| 7.08E+00 | 103242 |
| 1.41E+01 | 134856 |
| 2.11E+01 | 158137 |
| 4.22E+01 | 73888 |
| 6.93E+01 | 97698 |
| 8.31E+01 | 105743 |
| 1.18E+02 | 53427 |
| 1.67E+02 | 71438 |
| 2.09E+02 | 38687 |
| 2.51E+02 | 45887 |
| 2.86E+02 | 39107 |
| 3.28E+02 | 26843 |
| 3.70E+02 | 31575 |
| 3.98E+02 | 37794 |
| 4.54E+02 | 16623 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 3.05E+00 | 2.11E+01 | 158137 | 1.20E+01 |
| 3.74E+00 | 4.22E+01 | 73888 | 1.12E+01 |
| 4.24E+00 | 6.93E+01 | 97698 | 1.15E+01 |
| 4.42E+00 | 8.31E+01 | 105743 | 1.16E+01 |
| 4.77E+00 | 1.18E+02 | 53427 | 1.09E+01 |
| 5.12E+00 | 1.67E+02 | 71438 | 1.12E+01 |
| 5.34E+00 | 2.09E+02 | 38687 | 1.06E+01 |
| 5.53E+00 | 2.51E+02 | 45887 | 1.07E+01 |
| 5.66E+00 | 2.86E+02 | 39107 | 1.06E+01 |
| 5.79E+00 | 3.28E+02 | 26843 | 1.02E+01 |
| 5.91E+00 | 3.70E+02 | 31575 | 1.04E+01 |
| 5.99E+00 | 3.98E+02 | 37794 | 1.05E+01 |
| 6.12E+00 | 4.54E+02 | 16623 | 9.72E+00 |

**Maximum Release Rate at 21 days**
**158137 ng/gPCB-d**

**Release rate at 2 years**
**20704 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.9010 |
| R Square | 0.8117 |
| Standard Error | 0.2816 |
| Observations | 13 |

ANOVA

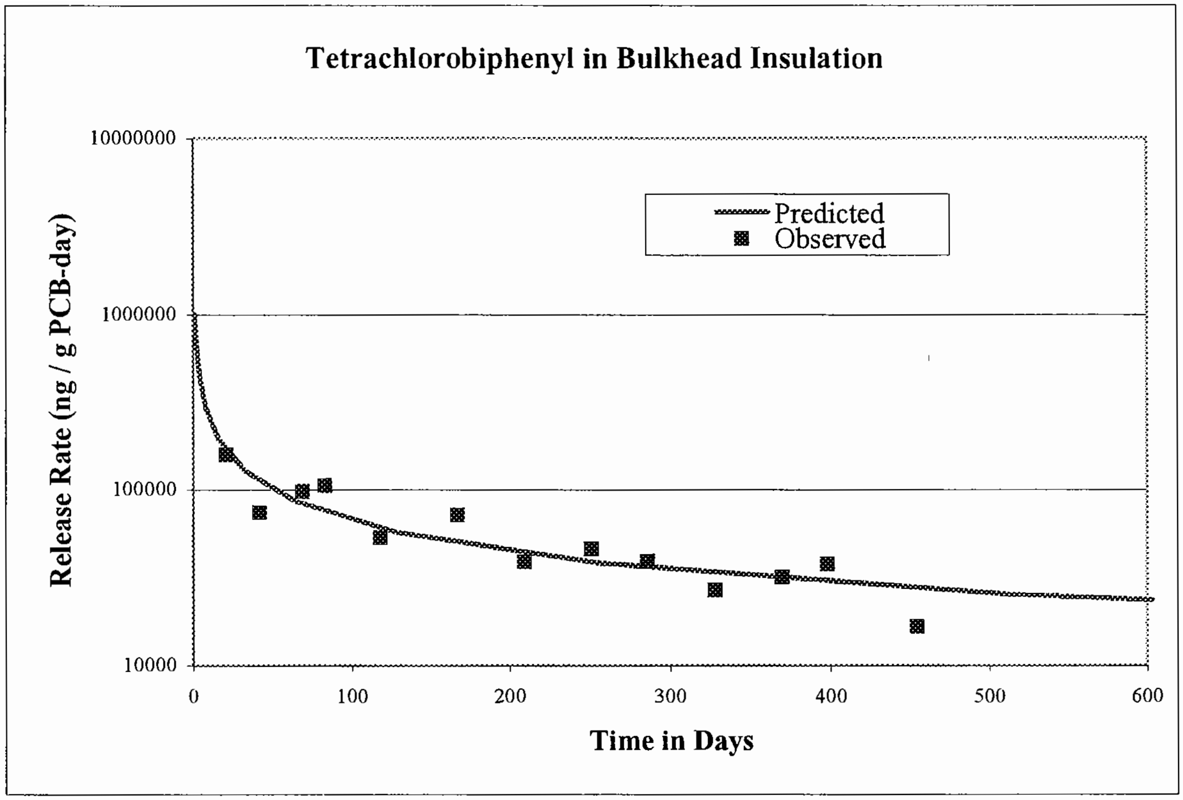
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 3.76E+00 | 3.76E+00 | 4.74E+01 | 2.63E-05 |
| Residual | 11 | 8.72E-01 | 7.93E-02 | | |
| Total | 12 | 4.63E+00 | | | |

| | *Coefficients* | *andard Erro* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 1.38E+01 | 4.39E-01 | 3.15E+01 | 3.95E-12 | 1.29E+01 | 1.48E+01 |
| ln(day) | -5.89E-01 | 8.55E-02 | -6.89E+00 | 2.63E-05 | -7.77E-01 | -4.01E-01 |

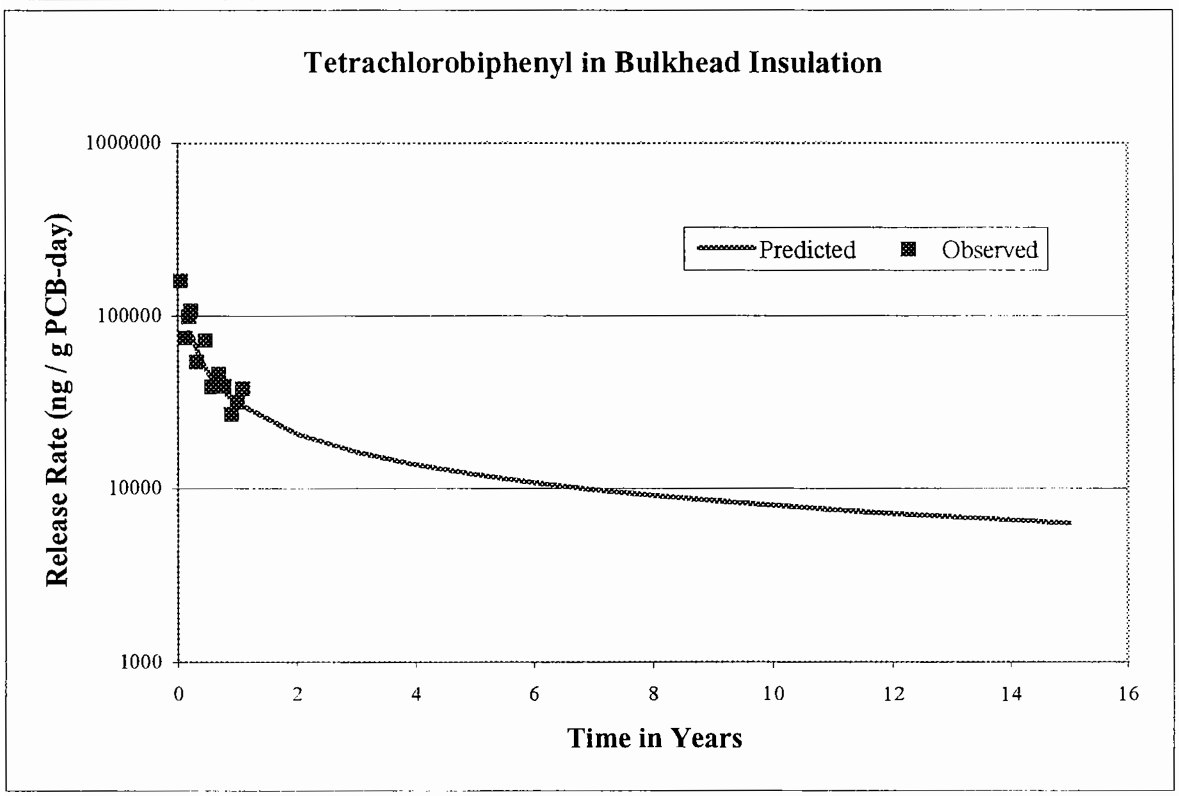
RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 1.20E+01 | -5.38E-02 |
| 2 | 1.16E+01 | -4.06E-01 |
| 3 | 1.13E+01 | 1.65E-01 |
| 4 | 1.12E+01 | 3.51E-01 |
| 5 | 1.10E+01 | -1.24E-01 |
| 6 | 1.08E+01 | 3.70E-01 |
| 7 | 1.07E+01 | -1.11E-01 |
| 8 | 1.06E+01 | 1.68E-01 |
| 9 | 1.05E+01 | 8.45E-02 |
| 10 | 1.04E+01 | -2.11E-01 |

| *Observation* | *dicted ln(ng/g-PC1* | *Residuals* |
|---|---|---|
| 11 | 1.03E+01 | 2.21E-02 |
| 12 | 1.03E+01 | 2.45E-01 |
| 13 | 1.02E+01 | -4.99E-01 |



Tetrachlorobiphenyl in Bulkhead Insulation
Release Rate (ng / g PCB-day)
10000000
1000000
100000
10000
0
100
200
300
400
500
600
Time in Days
Predicted
Observed

Tetrachlorobiphenyl in Bulkhead Insulation
Release Rate (ng / g PCB-day)
1000000
100000
10000
1000
0
2
4
6
8
10
12
14
16
Time in Years
Predicted
Observed

## Pentachlorobiphenyl in Bulkhead Insulation

| ng/ g-PCB - d | Cl5 |
|---|---|
| 0.007 | 0 |
| 1.170 | 58766 |
| 7.076 | 96359 |
| 14.083 | 146583 |
| 21.097 | 286990 |
| 42.226 | 110832 |
| 69.301 | 229878 |
| 83.139 | 267294 |
| 118.135 | 103369 |
| 167.104 | 197072 |
| 209.131 | 79308 |
| 251.192 | 95598 |
| 286.150 | 56361 |
| 328.092 | 55604 |
| 370.117 | 47841 |
| 398.079 | 66867 |
| 454.319 | 28187 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 3.05E+00 | 21.097 | 286990 | 1.26E+01 |
| 3.74E+00 | 42.226 | 110832 | 1.16E+01 |
| 4.24E+00 | 69.301 | 229878 | 1.23E+01 |
| 4.42E+00 | 83.139 | 267294 | 1.25E+01 |
| 4.77E+00 | 118.135 | 103369 | 1.15E+01 |
| 5.12E+00 | 167.104 | 197072 | 1.22E+01 |
| 5.34E+00 | 209.131 | 79308 | 1.13E+01 |
| 5.53E+00 | 251.192 | 95598 | 1.15E+01 |
| 5.66E+00 | 286.150 | 56361 | 1.09E+01 |
| 5.79E+00 | 328.092 | 55604 | 1.09E+01 |
| 5.91E+00 | 370.117 | 47841 | 1.08E+01 |
| 5.99E+00 | 398.079 | 66867 | 1.11E+01 |
| 6.12E+00 | 454.319 | 28187 | 1.02E+01 |

**Maximum Release Rate at 21 days**
**286990 ng/gPCB-d**

**Release rate at 2 years**
**37917 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.8168 |
| R Square | 0.6672 |
| Standard Error | 0.4358 |
| Observations | 13 |

ANOVA

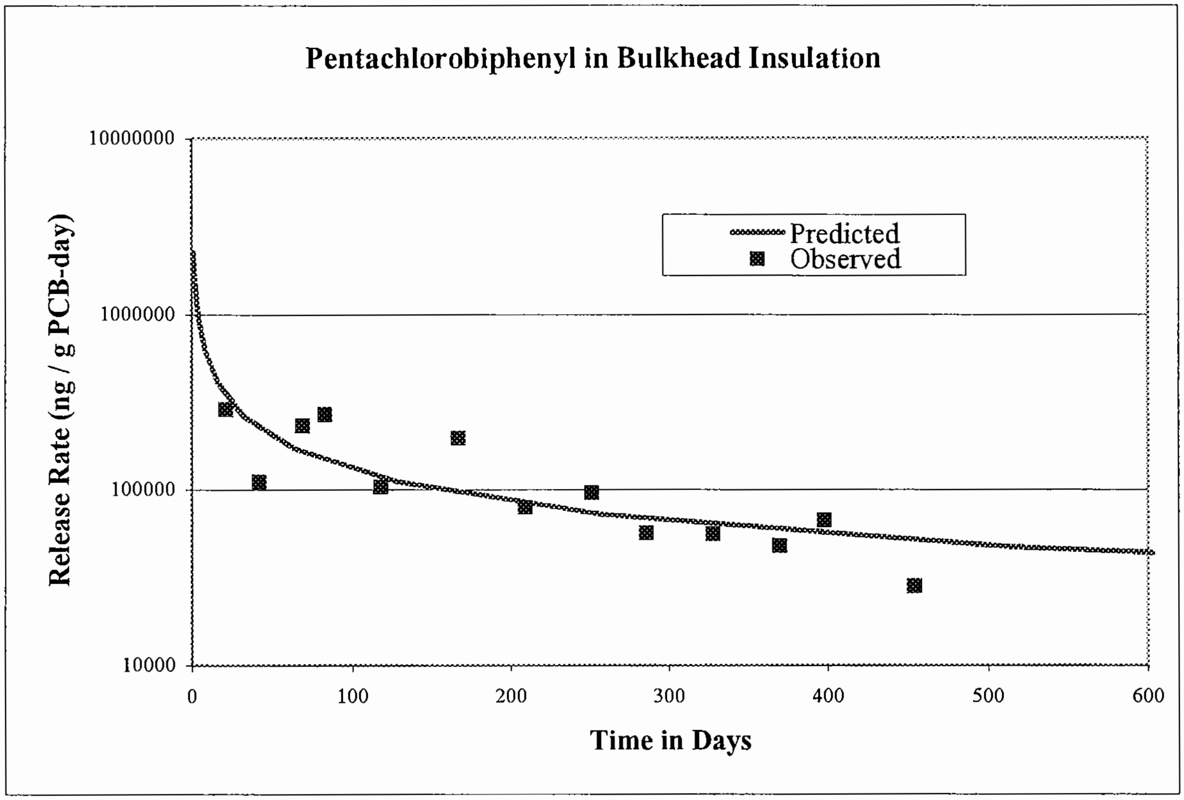
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 4.19E+00 | 4.19E+00 | 2.21E+01 | 6.54E-04 |
| Residual | 11 | 2.09E+00 | 1.90E-01 | | |
| Total | 12 | 6.28E+00 | | | |

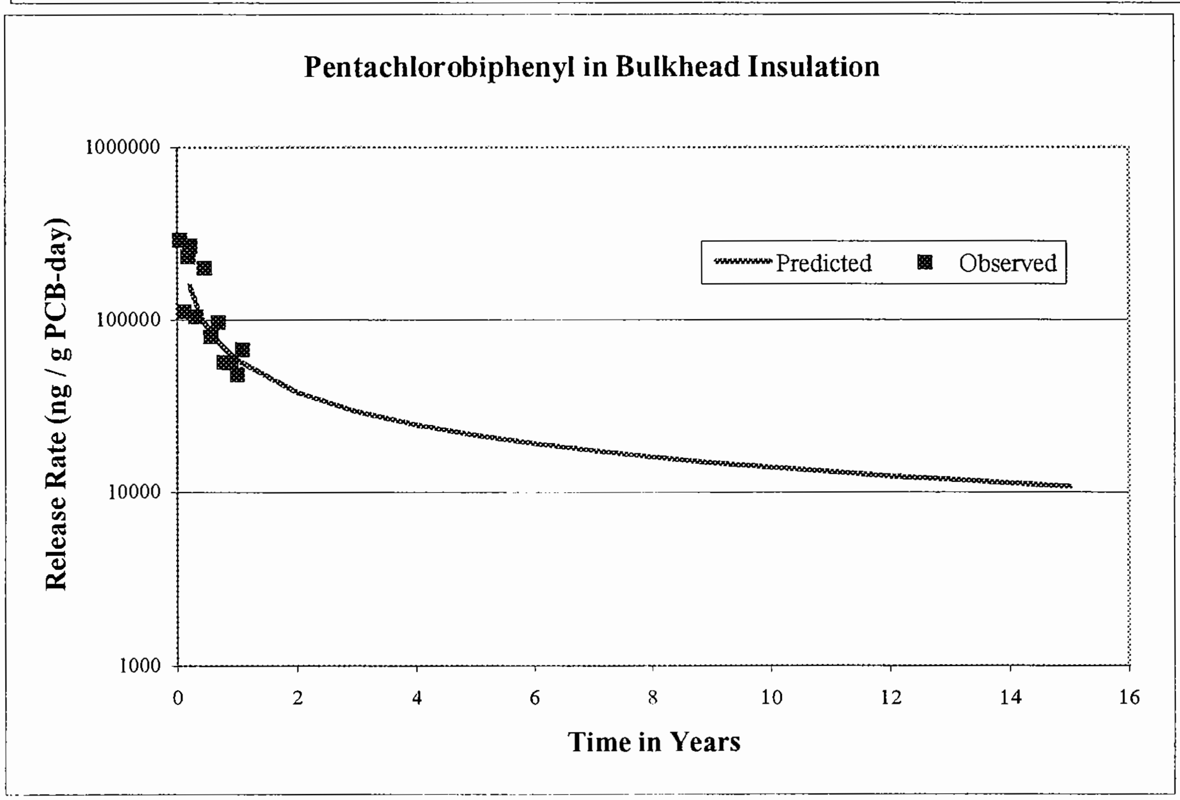
| | *Coefficients* | *andard Err* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 1.46E+01 | 6.79E-01 | 2.15E+01 | 2.40E-10 | 1.31E+01 | 1.61E+01 |
| ln(day) | -6.21E-01 | 1.32E-01 | -4.70E+00 | 6.54E-04 | -9.13E-01 | -3.30E-01 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 1.27E+01 | -1.78E-01 |
| 2 | 1.23E+01 | -6.99E-01 |
| 3 | 1.20E+01 | 3.39E-01 |
| 4 | 1.19E+01 | 6.03E-01 |
| 5 | 1.17E+01 | -1.29E-01 |
| 6 | 1.15E+01 | 7.32E-01 |
| 7 | 1.13E+01 | -3.90E-02 |
| 8 | 1.12E+01 | 2.62E-01 |
| 9 | 1.11E+01 | -1.86E-01 |
| 10 | 1.10E+01 | -1.14E-01 |

| *Observation* | *dicted ln(ng/g-PC1* | *Residuals* |
|---|---|---|
| 11 | 1.10E+01 | -1.90E-01 |
| 12 | 1.09E+01 | 1.90E-01 |
| 13 | 1.08E+01 | -5.91E-01 |


Pentachlorobiphenyl in Bulkhead Insulation
Predicted
Observed
Release Rate (ng / g PCB-day)
10000000
1000000
100000
10000
0
100
200
300
400
500
600
Time in Days


Pentachlorobiphenyl in Bulkhead Insulation
Predicted
Observed
Release Rate (ng / g PCB-day)
1000000
100000
10000
1000
0
2
4
6
8
10
12
14
16
Time in Years

## Hexachlorobiphenyl in Bulkhead Insulation

| ng/ g-PCB - d | Cl6 |
|---|---|
| 0.007 | 0 |
| 1.170 | 0 |
| 7.076 | 15830 |
| 14.083 | 16417 |
| 21.097 | 42170 |
| 42.226 | 17305 |
| 69.301 | 53159 |
| 83.139 | 46997 |
| 118.135 | 20906 |
| 167.104 | 50089 |
| 209.131 | 18376 |
| 251.192 | 19120 |
| 286.150 | 8972 |
| 328.092 | 13422 |
| 370.117 | 9568 |
| 398.079 | 18897 |
| 454.319 | 9396 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 4.24E+00 | 69.301 | 53159 | 1.09E+01 |
| 4.42E+00 | 83.139 | 46997 | 1.08E+01 |
| 4.77E+00 | 118.135 | 20906 | 9.95E+00 |
| 5.12E+00 | 167.104 | 50089 | 1.08E+01 |
| 5.34E+00 | 209.131 | 18376 | 9.82E+00 |
| 5.53E+00 | 251.192 | 19120 | 9.86E+00 |
| 5.66E+00 | 286.150 | 8972 | 9.10E+00 |
| 5.79E+00 | 328.092 | 13422 | 9.50E+00 |
| 5.91E+00 | 370.117 | 9568 | 9.17E+00 |
| 5.99E+00 | 398.079 | 18897 | 9.85E+00 |
| 6.12E+00 | 454.319 | 9396 | 9.15E+00 |

**Maximum Release Rate at 69 days**
**53159 ng/gPCB-d**

**Release rate at 2 years**
**6762 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.8352 |
| R Square | 0.6976 |
| Standard Error | 0.3870 |
| Observations | 11 |

ANOVA

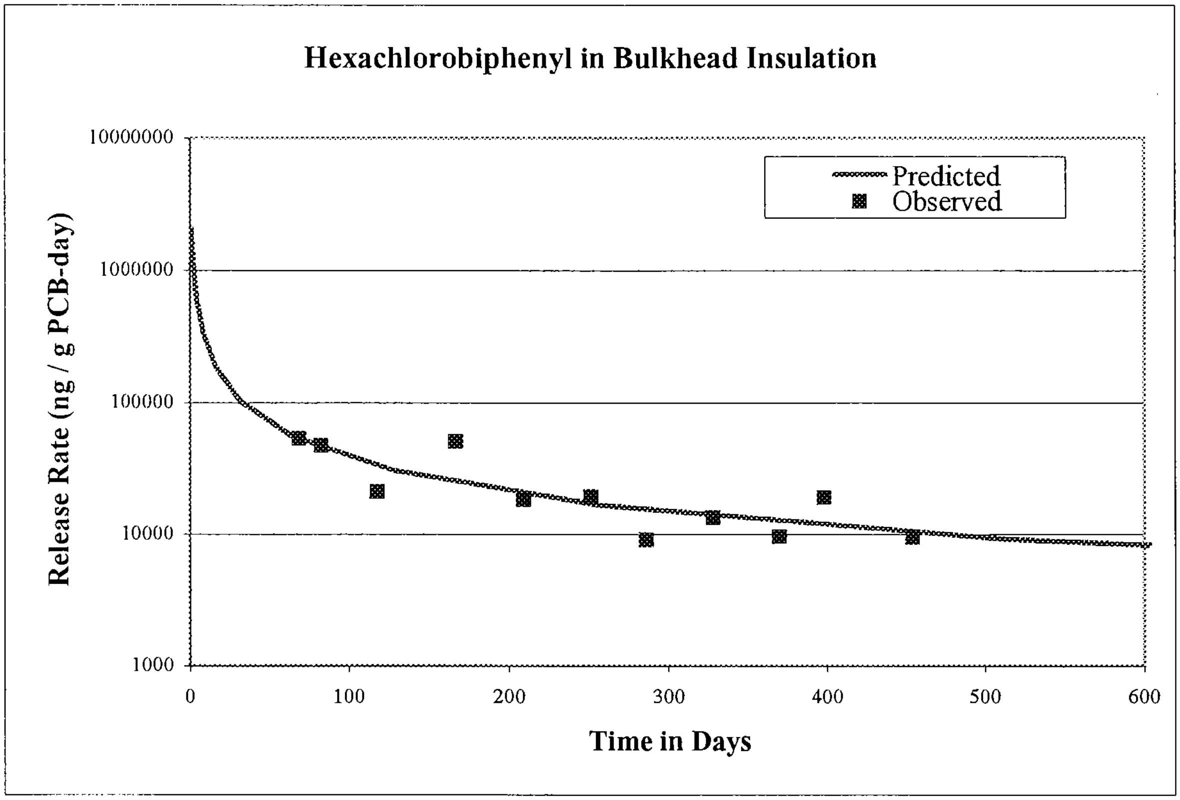
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 3.11E+00 | 3.11E+00 | 2.08E+01 | 1.37E-03 |
| Residual | 9 | 1.35E+00 | 1.50E-01 | | |
| Total | 10 | 4.46E+00 | | | |

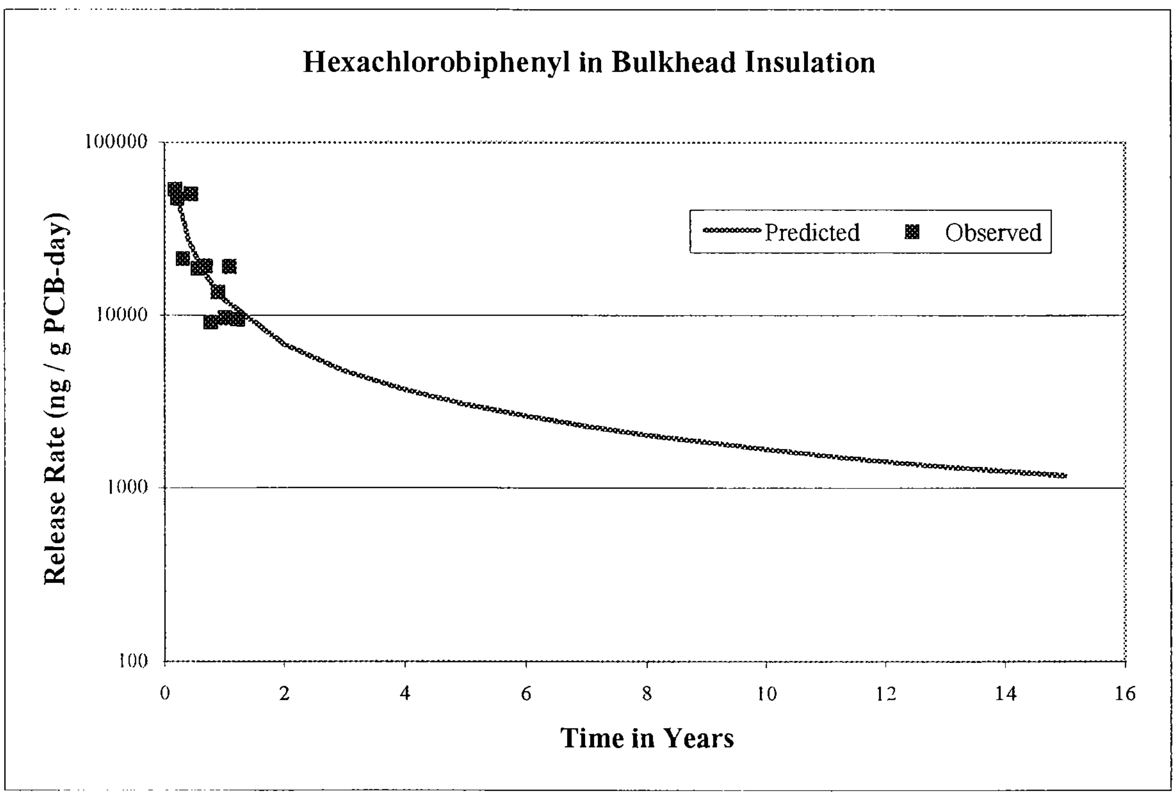
| | *Coefficients* | *andard Err* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 1.45E+01 | 1.03E+00 | 1.42E+01 | 1.86E-07 | 1.22E+01 | 1.69E+01 |
| ln(day) | -8.69E-01 | 1.91E-01 | -4.56E+00 | 1.37E-03 | -1.30E+00 | -4.37E-01 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 1.09E+01 | 1.69E-02 |
| 2 | 1.07E+01 | 5.18E-02 |
| 3 | 1.04E+01 | -4.53E-01 |
| 4 | 1.01E+01 | 7.22E-01 |
| 5 | 9.90E+00 | -8.60E-02 |
| 6 | 9.75E+00 | 1.13E-01 |
| 7 | 9.63E+00 | -5.31E-01 |
| 8 | 9.51E+00 | -9.06E-03 |
| 9 | 9.41E+00 | -2.43E-01 |
| 10 | 9.35E+00 | 5.01E-01 |

| | | |
|---|---|---|
| 11 | 9.23E+00 | -8.30E-02 |



## Heptaachlorobiphenyl in Bulkhead Insulation

| ng/ g-PCB - d | Cl7 |
|---|---|
| 0.007 | 0 |
| 1.170 | 34568 |
| 7.076 | 5919 |
| 14.083 | 3694 |
| 21.097 | 0 |
| 42.226 | 0 |
| 69.301 | 0 |
| 83.139 | 4406 |
| 118.135 | 0 |
| 167.104 | 3695 |
| 209.131 | 1838 |
| 251.192 | 0 |
| 286.150 | 0 |
| 328.092 | 0 |
| 370.117 | 0 |
| 398.079 | 0 |
| 454.319 | 0 |

| ln(day) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 1.57E-01 | 1.170 | 34568 | 1.05E+01 |
| 1.96E+00 | 7.076 | 5919 | 8.69E+00 |
| 2.64E+00 | 14.083 | 3694 | 8.21E+00 |
| 4.42E+00 | 83.139 | 4406 | 8.39E+00 |
| 5.12E+00 | 167.104 | 3695 | 8.21E+00 |
| 5.34E+00 | 209.131 | 1838 | 7.52E+00 |

**Maximum Release Rate at 1 day**
**34568 ng/gPCB-d**

**Release rate at 2 years**
**1303 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.8699 |
| R Square | 0.7568 |
| Standard Error | 0.5484 |
| Observations | 6 |

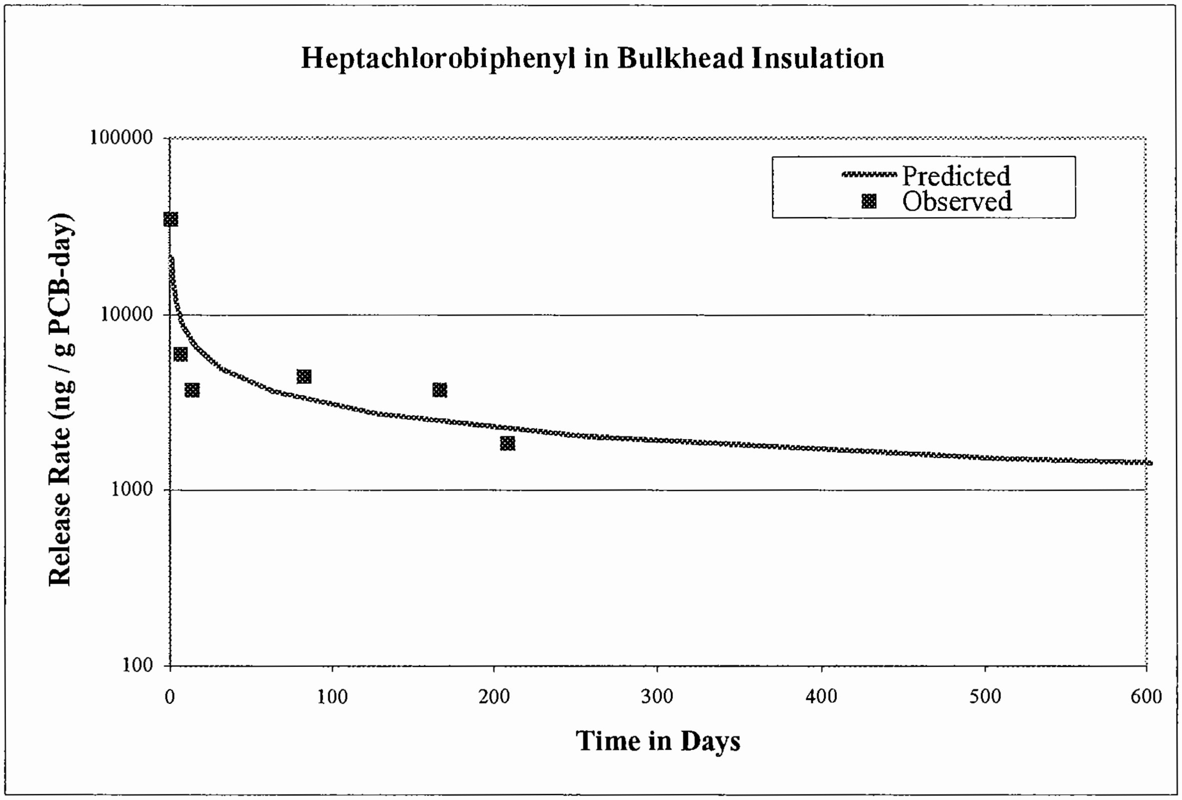
ANOVA

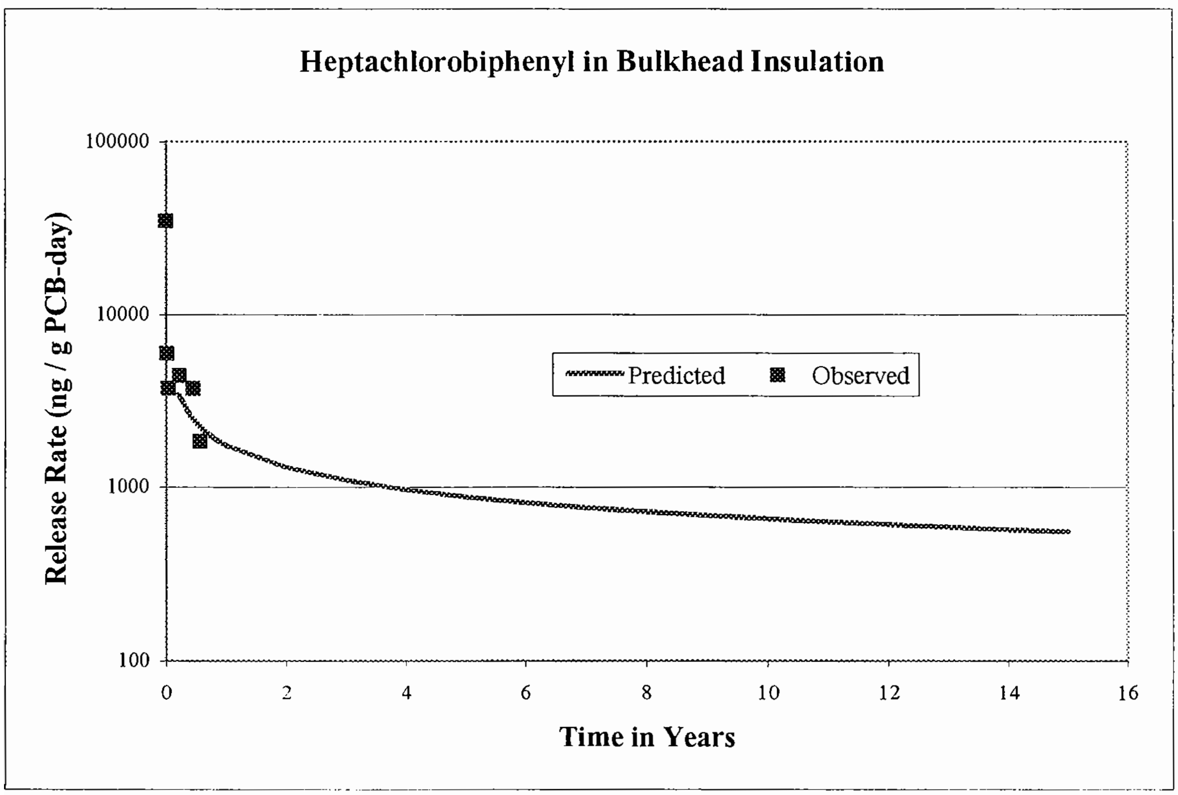
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 3.74E+00 | 3.74E+00 | 1.24E+01 | 2.43E-02 |
| Residual | 4 | 1.20E+00 | 3.01E-01 | | |
| Total | 5 | 4.95E+00 | | | |

| | *Coefficients* | *andard Err* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 9.97E+00 | 4.52E-01 | 2.20E+01 | 2.51E-05 | 8.71E+00 | 1.12E+01 |
| ln(day) | -4.24E-01 | 1.20E-01 | -3.53E+00 | 2.43E-02 | -7.57E-01 | -9.02E-02 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 9.90E+00 | 5.51E-01 |
| 2 | 9.14E+00 | -4.51E-01 |
| 3 | 8.85E+00 | -6.31E-01 |
| 4 | 8.09E+00 | 2.98E-01 |
| 5 | 7.80E+00 | 4.18E-01 |
| 6 | 7.70E+00 | -1.86E-01 |


Heptachlorobiphenyl in Bulkhead Insulation
Predicted
Observed
Release Rate (ng / g PCB-day)
100000
10000
1000
100
0
100
200
300
400
500
600
Time in Days


Heptachlorobiphenyl in Bulkhead Insulation
Predicted
Observed
Release Rate (ng / g PCB-day)
100000
10000
1000
100
0
2
4
6
8
10
12
14
16
Time in Years

# ELECTRICAL CABLE INSULATION

**Electrical Cable**

| Leaching Time (days) | Homologue Leach Rates (ng PCB/g shipboard solid-day) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cl1 | Cl2 | Cl3 | Cl4 | Cl5 | Cl6 | Cl7 | Cl8 | Cl9 | Cl10 |
| 0.002777778 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 1.077083333 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 6.009027778 | 0.0E+00 | 3.4E-01 | 0.0E+00 | 5.9E-02 | 1.2E-01 | 0.0E+00 | 2.4E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 20.03541667 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 6.1E-02 | 7.8E-02 | 6.6E-03 | 2.2E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 40.98888889 | 0.0E+00 | 9.9E-03 | 1.0E-03 | 6.5E-02 | 1.1E-01 | 2.6E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 62.23541667 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 5.1E-02 | 9.9E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 90.00972222 | 0.0E+00 | 2.2E-02 | 0.0E+00 | 4.2E-02 | 7.3E-02 | 2.6E-02 | 4.9E-03 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 125.0284722 | 0.0E+00 | 0.0E+00 | 1.9E-03 | 4.0E-02 | 6.7E-02 | 4.0E-02 | 0.0E+00 | 0.0E+00 | 2.5E-03 | 1.4E-03 |
| 166.9979167 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 3.6E-02 | 7.3E-02 | 2.3E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 208.9680556 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 3.3E-02 | 7.4E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 250.9819444 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 3.2E-02 | 4.4E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 300.0243056 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 2.5E-02 | 1.6E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 341.9638889 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 2.7E-02 | 4.1E-02 | 9.9E-03 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 383.9930556 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 4.3E-02 | 5.3E-02 | 1.7E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 411.9548611 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 5.8E-02 | 9.1E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 474.98125 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 2.1E-02 | 2.3E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Max | 0.0E+00 | 3.4E-01 | 1.9E-03 | 6.5E-02 | 1.2E-01 | 4.0E-02 | 2.4E-02 | 0.0E+00 | 2.5E-03 | 1.4E-03 |
| Min | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |

0.0012 g PCB / g electrical cable (leachate study concentration) - ratio of intact cable to cable insulation = 0.7226)

| Leaching Time (days) | Homologue Leach Rates (ng PCB/g PCB-day) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ng/ g-PCB - d | Cl1 | Cl2 | Cl3 | Cl4 | Cl5 | Cl6 | Cl7 | Cl8 | Cl9 | Cl10 |
| 0.002777778 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.077083333 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6.009027778 | 0 | 203 | 0 | 35.5 | 73 | 0 | 14.7 | 0 | 0 | 0 |
| 20.03541667 | 0 | 0 | 0 | 36.8 | 47.1 | 3.97 | 13.1 | 0 | 0 | 0 |
| 40.98888889 | 0 | 5.98 | 0.617 | 38.8 | 63.7 | 15.9 | 0 | 0 | 0 | 0 |
| 62.23541667 | 0 | 0 | 0 | 30.4 | 59.9 | 0 | 0 | 0 | 0 | 0 |
| 90.00972222 | 0 | 13.3 | 0 | 25.3 | 44.2 | 15.5 | 2.95 | 0 | 0 | 0 |
| 125.0284722 | 0 | 0 | 1.14 | 24.1 | 40.4 | 24.1 | 0 | 0 | 1.51 | 0.84 |
| 166.9979167 | 0 | 0 | 0 | 21.6 | 44.2 | 14.1 | 0 | 0 | 0 | 0 |
| 208.9680556 | 0 | 0 | 0 | 19.8 | 44.7 | 0 | 0 | 0 | 0 | 0 |
| 250.9819444 | 0 | 0 | 0 | 19.4 | 26.3 | 0 | 0 | 0 | 0 | 0 |
| 300.0243056 | 0 | 0 | 0 | 14.9 | 9.4 | 0 | 0 | 0 | 0 | 0 |
| 341.9638889 | 0 | 0 | 0 | 16.4 | 24.9 | 5.97 | 0 | 0 | 0 | 0 |
| 383.9930556 | 0 | 0 | 0 | 25.6 | 32.1 | 10.0 | 0 | 0 | 0 | 0 |
| 411.9548611 | 0 | 0 | 0 | 34.7 | 55.1 | 0 | 0 | 0 | 0 | 0 |
| 474.98125 | 0 | 0 | 0 | 12.7 | 14.1 | 0 | 0 | 0 | 0 | 0 |
| Max | 0 | 203 | 1.14 | 38.8 | 73.5 | 24.1 | 14.7 | 0 | 1.51 | 0.843 |
| Min | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Median | 0 | 0 | 0 | 22.9 | 42.3 | 0 | 0 | 0 | 0 | 0 |
| Simple Avergae | 0 | 13.9 | 0 | 22.2 | 36.2 | 5.60 | 1.92 | 0 | 0 | 0 |
| Detects | 0 | 3 | 2 | 14 | 14 | 7 | 3 | 0 | 1 | 1 |
| Non-detects | 15 | 12 | 13 | 1 | 1 | 8 | 12 | 15 | 14 | 14 |
| Intercept | --- | 7.11E+00 | --- | 5.60E-01 | 5.93E+00 | 7.61E+00 | 4.00E+00 | --- | --- | --- |
| Slope | --- | -1.16E+00 | --- | -2.62E-01 | -4.62E-01 | -9.45E-01 | -6.10E-01 | --- | --- | --- |
| alpha | --- | 3.22E-01 | --- | 3.30E-02 | 3.05E-02 | 1.20E-01 | 2.52E-01 | --- | --- | --- |

## Dichlorobiphenyl in Electrical Cable Insulation

| ng/ g-PCB - d | Cl2 |
|---|---|
| 2.78E-03 | 0 |
| 1.08E+00 | 0 |
| 6.01E+00 | 203 |
| 2.00E+01 | 0 |
| 4.10E+01 | 6 |
| 6.22E+01 | 0 |
| 9.00E+01 | 13 |
| 1.25E+02 | 0 |
| 1.67E+02 | 0 |
| 2.09E+02 | 0 |
| 2.51E+02 | 0 |
| 3.00E+02 | 0 |
| 3.42E+02 | 0 |
| 3.84E+02 | 0 |
| 4.12E+02 | 0 |
| 4.75E+02 | 0 |

| ln(d) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 1.79E+00 | 6.01E+00 | 203 | 5.31E+00 |
| 3.71E+00 | 4.10E+01 | 6 | 1.79E+00 |
| 4.50E+00 | 9.00E+01 | 13 | 2.59E+00 |

**Maximum Release Rate at 6 days**
**203 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.8749 |
| R Square | 0.7655 |
| Standard Error | 1.2657 |
| Observations | 3 |

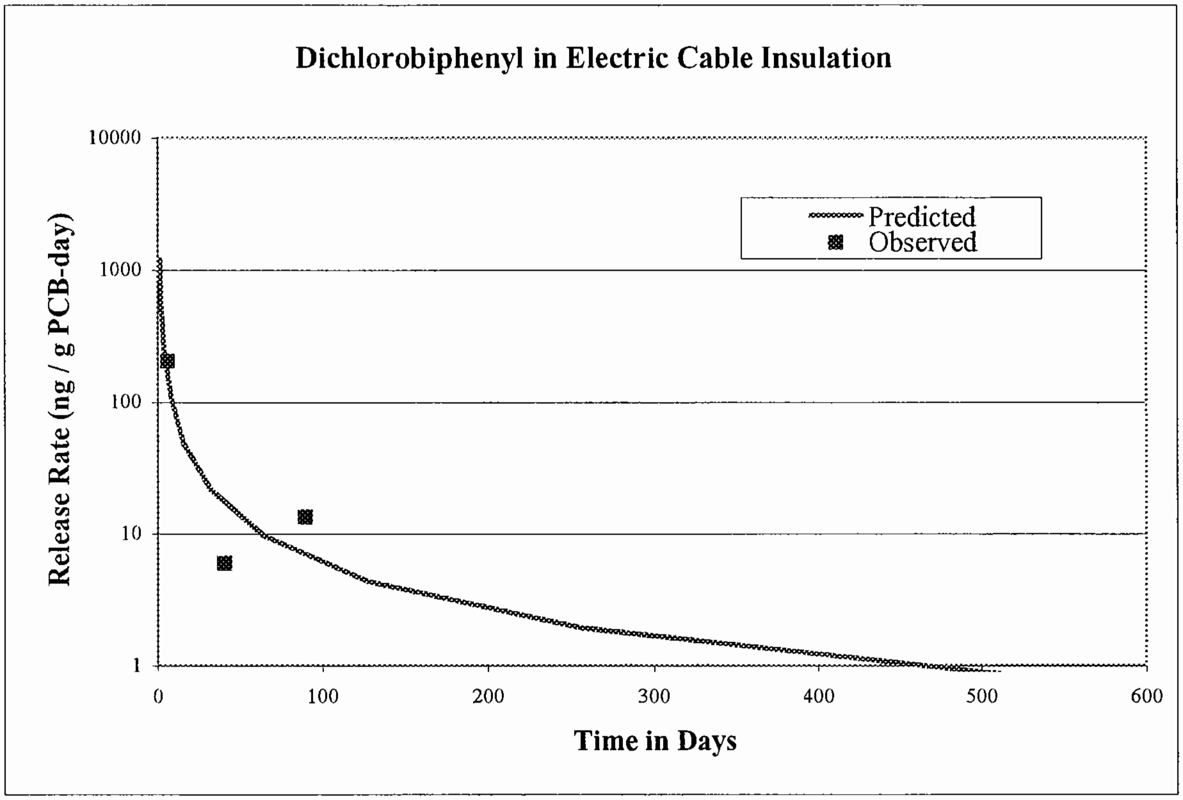
ANOVA

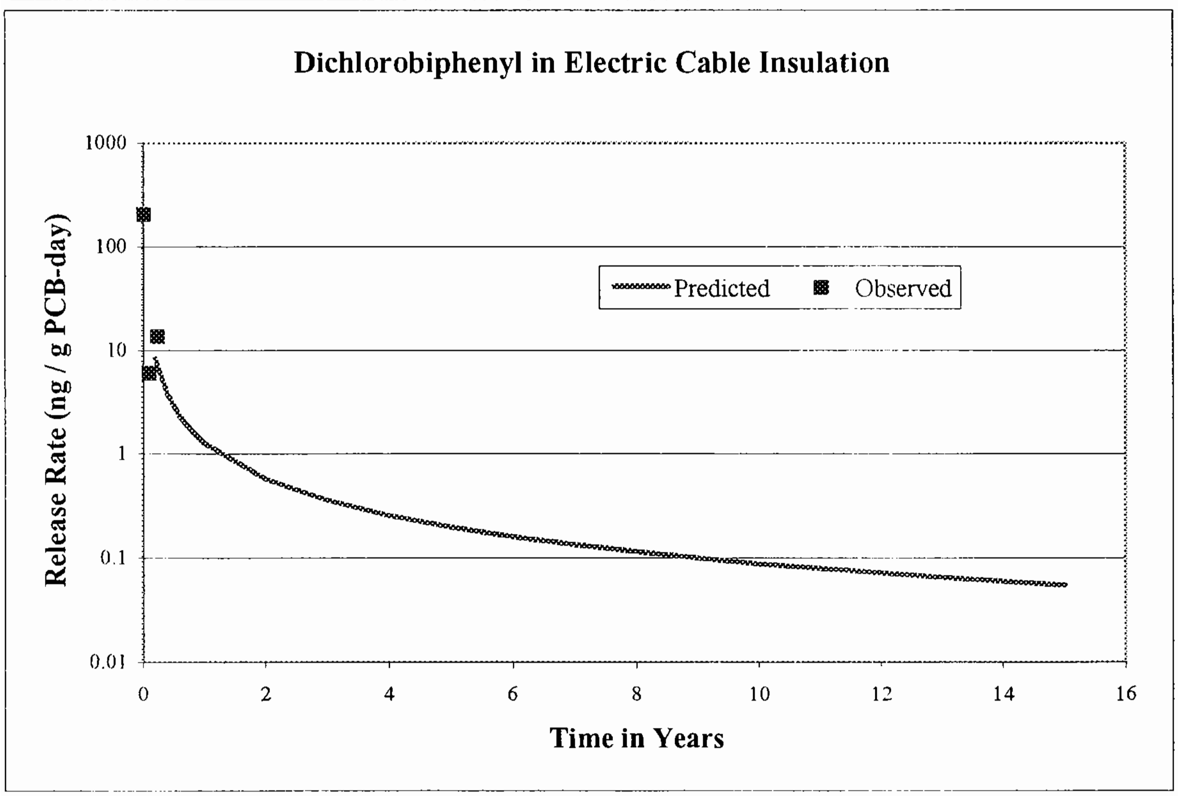
| | *df* | *SS* | *MS* | *F* | *Significance F* | |
|---|---|---|---|---|---|---|
| Regression | 1 | 5.23E+00 | 5.23E+00 | 3.26E+00 | 3.22E-01 | ***Not Significant*** |
| Residual | 1 | 1.60E+00 | 1.60E+00 | | | |
| Total | 2 | 6.83E+00 | | | | |

| | *Coefficients* | *andard Erro* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 7.11E+00 | 2.27E+00 | 3.14E+00 | 1.96E-01 | -2.17E+01 | 3.59E+01 |
| ln(d) | -1.16E+00 | 6.43E-01 | -1.81E+00 | 3.22E-01 | -9.33E+00 | 7.01E+00 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 5.02E+00 | 2.92E-01 |
| 2 | 2.79E+00 | -1.00E+00 |
| 3 | 1.88E+00 | 7.13E-01 |


Dichlorobiphenyl in Electric Cable Insulation
Release Rate (ng / g PCB-day)
10000
1000
100
10
1
0
100
200
300
400
500
600
Time in Days
Predicted
Observed


Dichlorobiphenyl in Electric Cable Insulation
Release Rate (ng / g PCB-day)
1000
100
10
1
0.1
0.01
0
2
4
6
8
10
12
14
16
Time in Years
Predicted
Observed

## Pentachlorobiphenyl in Electrical Cable Insulation

| ng/ g-PCB - d | Cl5 |
|---|---|
| 2.78E-03 | 0 |
| 1.08E+00 | 0 |
| 6.01E+00 | 73.5 |
| 2.00E+01 | 47.1 |
| 4.10E+01 | 63.7 |
| 6.22E+01 | 59.9 |
| 9.00E+01 | 44.2 |
| 1.25E+02 | 40.4 |
| 1.67E+02 | 44.2 |
| 2.09E+02 | 44.7 |
| 2.51E+02 | 26.3 |
| 3.00E+02 | 9.4 |
| 3.42E+02 | 24.9 |
| 3.84E+02 | 32.1 |
| 4.12E+02 | 55.1 |
| 4.75E+02 | 14.1 |

| ln(d) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 3.71E+00 | 40.989 | 63.7 | 4.15E+00 |
| 4.13E+00 | 62.235 | 59.9 | 4.09E+00 |
| 4.50E+00 | 90.010 | 44.2 | 3.79E+00 |
| 4.83E+00 | 125.028 | 40.4 | 3.70E+00 |
| 5.12E+00 | 166.998 | 44.2 | 3.79E+00 |
| 5.34E+00 | 208.968 | 44.7 | 3.80E+00 |
| 5.53E+00 | 250.982 | 26.3 | 3.27E+00 |
| 5.70E+00 | 300.024 | 9.4 | 2.24E+00 |
| 5.83E+00 | 341.964 | 24.9 | 3.21E+00 |
| 5.95E+00 | 383.993 | 32.1 | 3.47E+00 |
| 6.02E+00 | 411.955 | 55.1 | 4.01E+00 |
| 6.16E+00 | 474.981 | 14.1 | 2.64E+00 |

**Maximum Release Rate at 40 days**
**63.7 ng/gPCB-d**

**Release rate at 2 years**
**18.0 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.6229 |
| R Square | 0.3880 |
| Standard Error | 0.4823 |
| Observations | 12 |

ANOVA

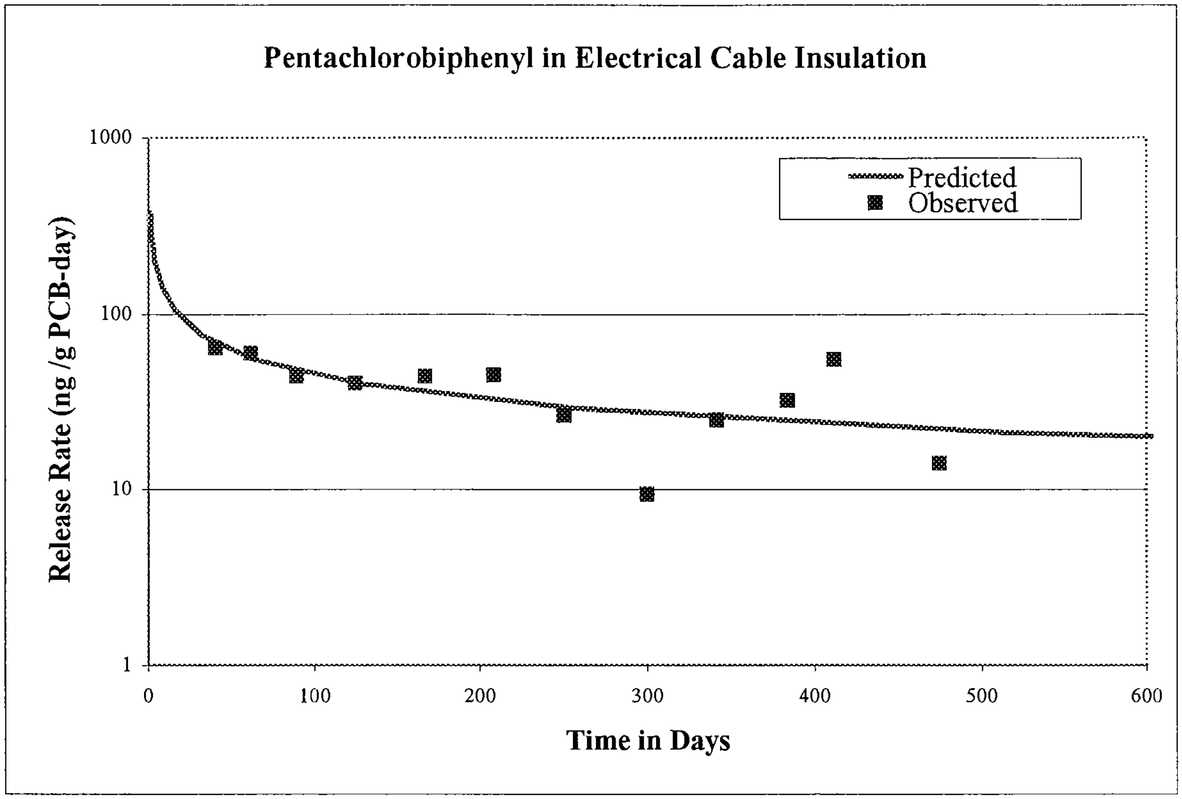
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 1.47E+00 | 1.47E+00 | 6.34E+00 | 3.05E-02 |
| Residual | 10 | 2.33E+00 | 2.33E-01 | | |
| Total | 11 | 3.80E+00 | | | |

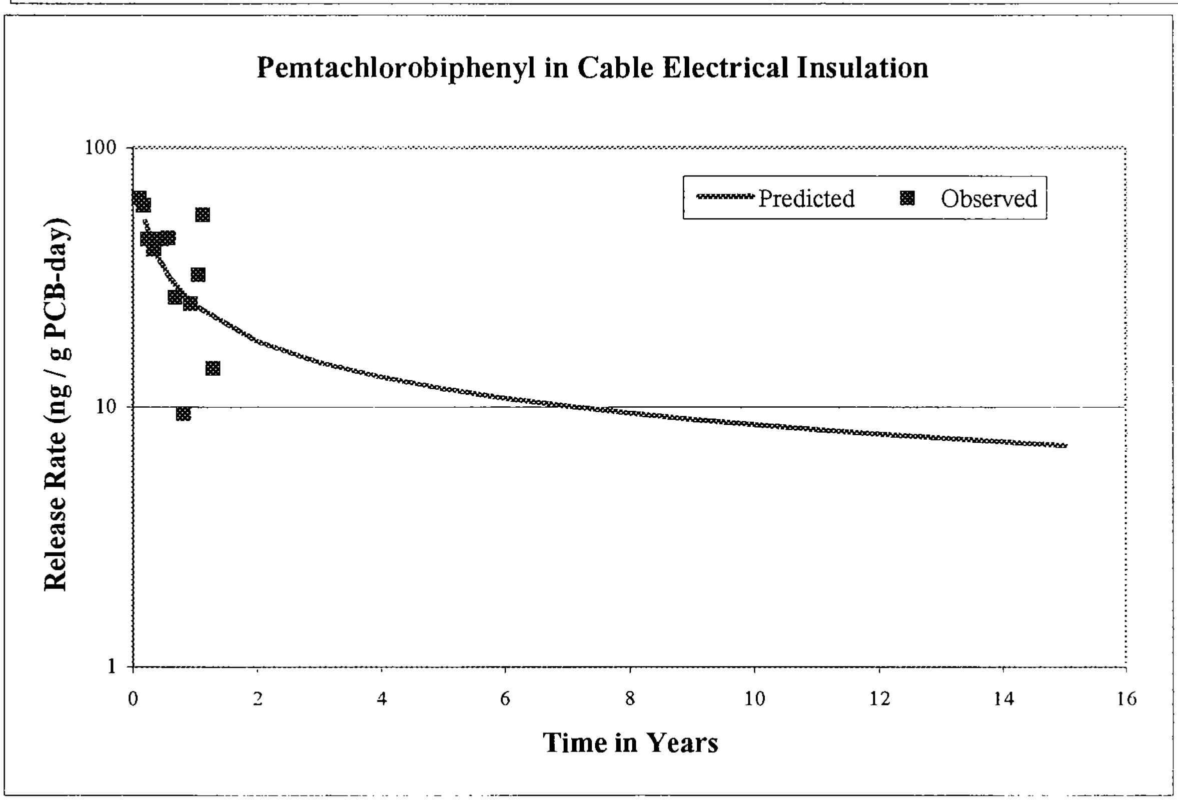
| | *Coefficients* | *andard Errc* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 5.93E+00 | 9.70E-01 | 6.11E+00 | 1.13E-04 | 3.77E+00 | 8.09E+00 |
| ln(d) | -4.62E-01 | 1.83E-01 | -2.52E+00 | 3.05E-02 | -8.70E-01 | -5.31E-02 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 4.22E+00 | -6.20E-02 |
| 2 | 4.02E+00 | 6.88E-02 |
| 3 | 3.85E+00 | -6.39E-02 |
| 4 | 3.70E+00 | -4.23E-03 |
| 5 | 3.57E+00 | 2.21E-01 |
| 6 | 3.47E+00 | 3.36E-01 |
| 7 | 3.38E+00 | -1.10E-01 |
| 8 | 3.30E+00 | -1.06E+00 |
| 9 | 3.24E+00 | -2.37E-02 |
| 10 | 3.18E+00 | 2.85E-01 |

| | | |
|---|---|---|
| 11 | 3.15E+00 | 8.57E-01 |
| 12 | 3.09E+00 | -4.43E-01 |



## Hexachlorobiphenyl in Electrical Cable Insulation

| ng/ g-PCB - d | Cl6 |
|---|---|
| 2.78E-03 | 0 |
| 1.08E+00 | 0 |
| 6.01E+00 | 0.0 |
| 2.00E+01 | 4.0 |
| 4.10E+01 | 15.9 |
| 6.22E+01 | 0.0 |
| 9.00E+01 | 15.5 |
| 1.25E+02 | 24.1 |
| 1.67E+02 | 14.1 |
| 2.09E+02 | 0.0 |
| 2.51E+02 | 0.0 |
| 3.00E+02 | 0.0 |
| 3.42E+02 | 6.0 |
| 3.84E+02 | 10.0 |
| 4.12E+02 | 0.0 |
| 4.75E+02 | 0.0 |

| ln(d) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 4.83E+00 | 1.25E+02 | 24.1 | 3.18E+00 |
| 5.12E+00 | 1.67E+02 | 14.1 | 2.64E+00 |
| 5.83E+00 | 3.42E+02 | 6.0 | 1.79E+00 |
| 5.95E+00 | 3.84E+02 | 10.0 | 2.31E+00 |

**Maximum Release Rate at 125 days**
**24.1 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.8798 |
| R Square | 0.7741 |
| Standard Error | 0.3411 |
| Observations | 4 |

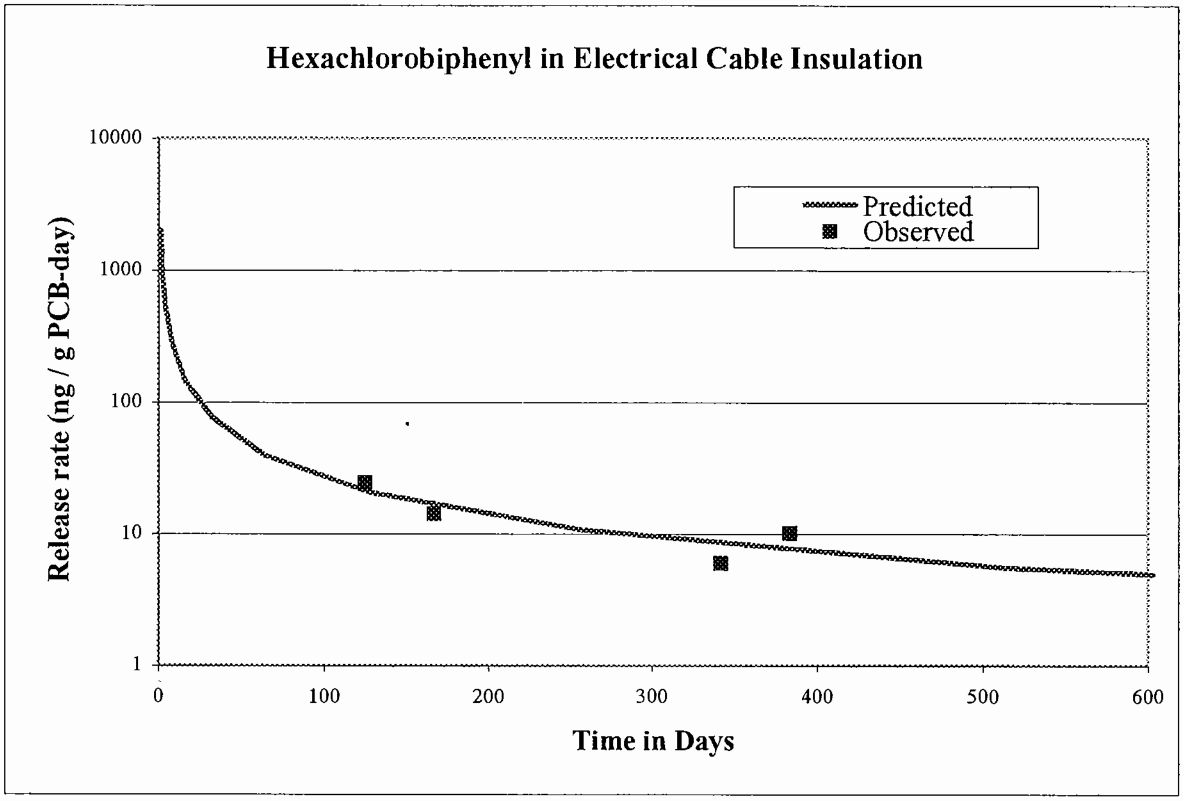
ANOVA

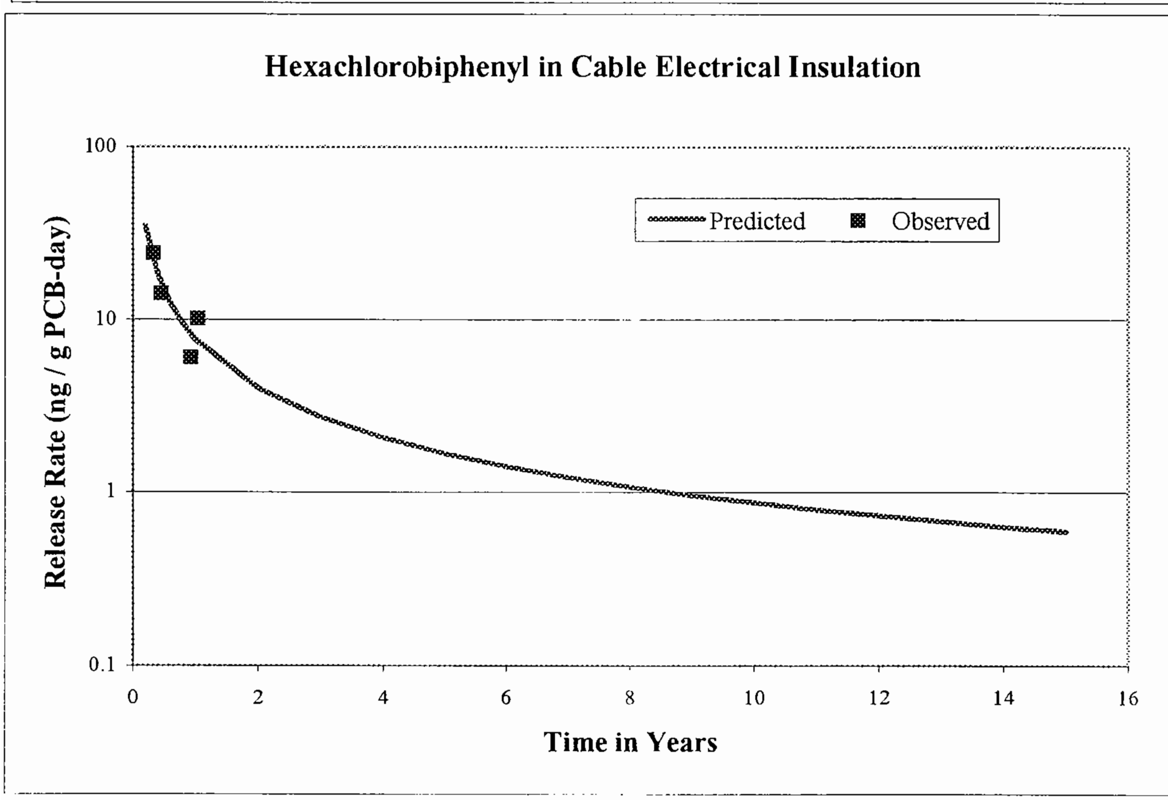
| | *df* | *SS* | *MS* | *F* | *Significance F* | |
|---|---|---|---|---|---|---|
| Regression | 1 | 7.98E-01 | 7.98E-01 | 6.85E+00 | 1.20E-01 | ***Not Significant*** |
| Residual | 2 | 2.33E-01 | 1.16E-01 | | | |
| Total | 3 | 1.03E+00 | | | | |

| | *Coefficients* | *andard Erro* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 7.61E+00 | 1.97E+00 | 3.87E+00 | 6.08E-02 | -8.55E-01 | 1.61E+01 |
| ln(d) | -9.45E-01 | 3.61E-01 | -2.62E+00 | 1.20E-01 | -2.50E+00 | 6.08E-01 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 3.05E+00 | 1.31E-01 |
| 2 | 2.78E+00 | -1.33E-01 |
| 3 | 2.10E+00 | -3.14E-01 |
| 4 | 1.99E+00 | 3.15E-01 |


Hexachlorobiphenyl in Electrical Cable Insulation
Release rate (ng / g PCB-day)
10000
1000
100
10
1
0
100
200
300
400
500
600
Time in Days
Predicted
Observed


Hexachlorobiphenyl in Cable Electrical Insulation
Release Rate (ng / g PCB-day)
100
10
1
0.1
0
2
4
6
8
10
12
14
16
Time in Years
Predicted
Observed

## Heptachlorobiphenyl in Electrical Cable Insulation

| ng/ g-PCB - d | Cl7 |
|---|---|
| 2.78E-03 | 0 |
| 1.08E+00 | 0 |
| 6.01E+00 | 14.7 |
| 2.00E+01 | 13.1 |
| 4.10E+01 | 0 |
| 6.22E+01 | 0 |
| 9.00E+01 | 2.95 |
| 1.25E+02 | 0 |
| 1.67E+02 | 0 |
| 2.09E+02 | 0 |
| 2.51E+02 | 0 |
| 3.00E+02 | 0 |
| 3.42E+02 | 0 |
| 3.84E+02 | 0 |
| 4.12E+02 | 0 |
| 4.75E+02 | 0 |

| ln(d) | day | ng/gPCB-d | ln(ng/g-PCB-d) |
|---|---|---|---|
| 1.79E+00 | 6.01E+00 | 14.7 | 2.69E+00 |
| 3.00E+00 | 2.00E+01 | 13.1 | 2.57E+00 |
| 4.50E+00 | 9.00E+01 | 2.95 | 1.08E+00 |

**Maximum Release Rate at 6 days**
**14.7 ng/gPCB-d**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.9227 |
| R Square | 0.8515 |
| Standard Error | 0.4882 |
| Observations | 3 |

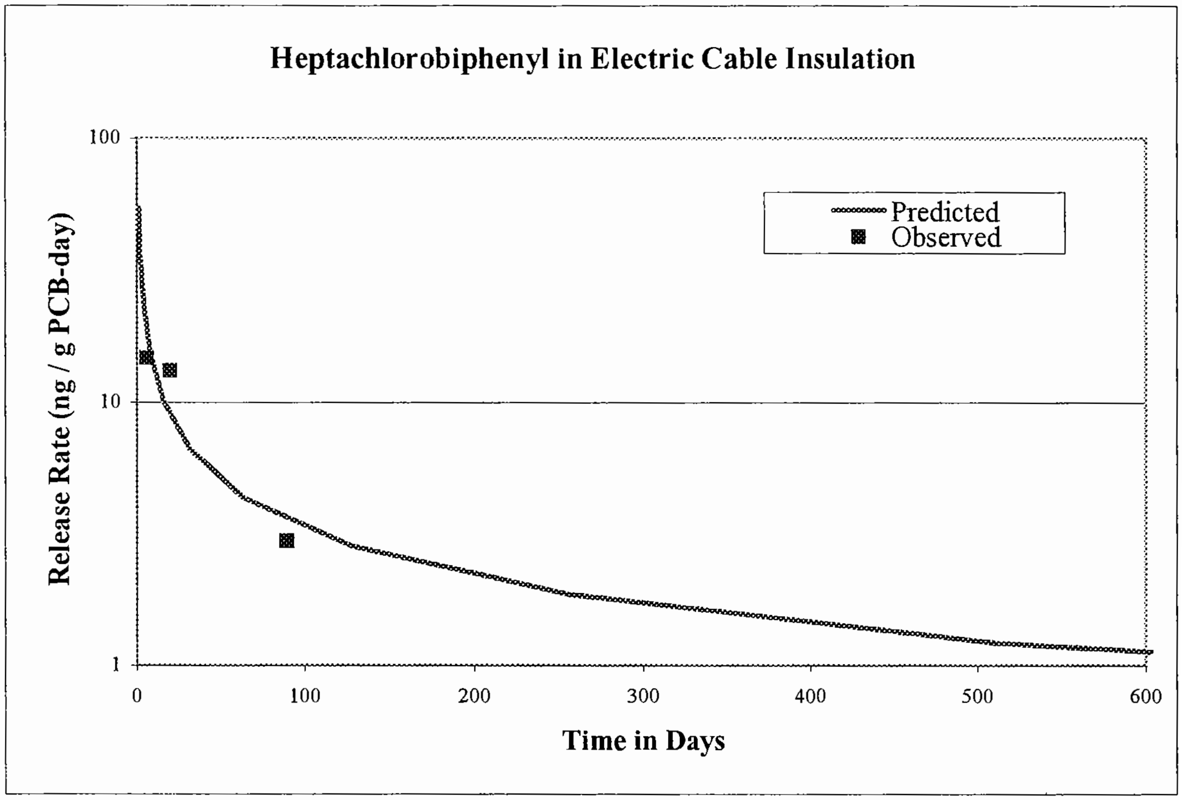
ANOVA

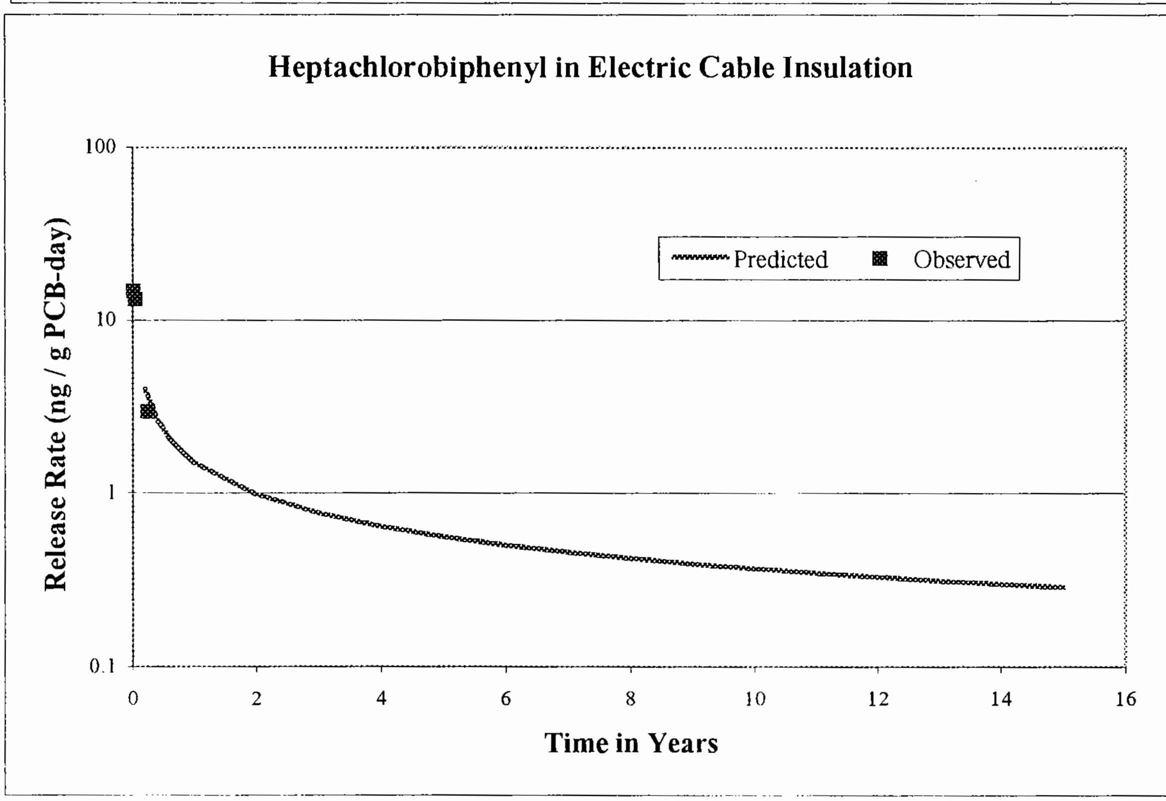
| | *df* | *SS* | *MS* | *F* | *Significance F* | |
|---|---|---|---|---|---|---|
| Regression | 1 | 1.37E+00 | 1.37E+00 | 5.73E+00 | 2.52E-01 | ***Not Significant*** |
| Residual | 1 | 2.38E-01 | 2.38E-01 | | | |
| Total | 2 | 1.60E+00 | | | | |

| | *Coefficients* | *andard Erro* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 4.00E+00 | 8.37E-01 | 4.78E+00 | 1.31E-01 | -6.64E+00 | 1.46E+01 |
| ln(d) | -6.10E-01 | 2.55E-01 | -2.39E+00 | 2.52E-01 | -3.84E+00 | 2.63E+00 |

RESIDUAL OUTPUT

| *Observation* | *icted ln(ng/g-PC* | *Residuals* |
|---|---|---|
| 1 | 2.91E+00 | -2.21E-01 |
| 2 | 2.17E+00 | 3.98E-01 |
| 3 | 1.26E+00 | -1.77E-01 |


Heptachlorobiphenyl in Electric Cable Insulation
Release Rate (ng / g PCB-day)
100
10
1
0
100
200
300
400
500
600
Time in Days
Predicted
Observed


Heptachlorobiphenyl in Electric Cable Insulation
Release Rate (ng / g PCB-day)
100
10
1
0.1
0
2
4
6
8
10
12
14
16
Time in Years
Predicted
Observed

**MATERIAL FRACTIONS**

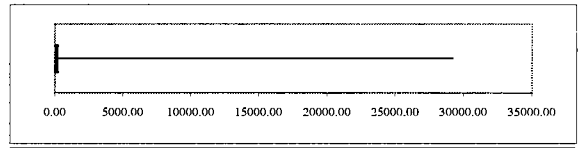
# PCB Concentrations in Cable Onboard the Ex-ORISKANY

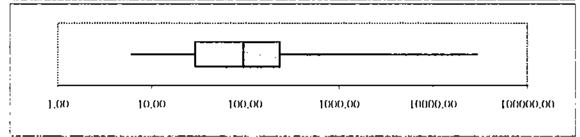
There is a sufficient number of values for statistical analysis - the data were found to be non-normal with high skewness, however, the Hall's transformed t bootstrap failed to normalize the dataset - use the Standard Bootstrap mean and UCLs as the EPCs

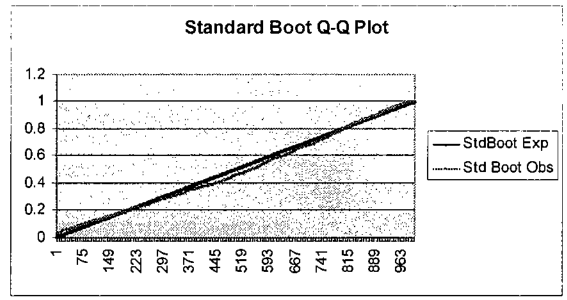
Units = PPM

| Sample# | Value | Qualifier |
|---|---|---|
| 95PS00034-001 | 110 | |
| 95PS00034-002 | 580 | |
| 95PS00034-003 | 10 | |
| 95PS00034-004 | 22 | |
| 95PS00034-005 | 9.5 | |
| 95PS00034-006 | 80 | |
| 95PS00034-007 | 67 | |
| 95PS00034-008 | 61 | |
| 95PS00034-009 | 38 | |
| 95PS00034-010 | 6.2 | |
| 95PS00034-011 | 400 | |
| 95PS00034-01 | 140 | |
| 95PS00034-01 | 290 | |
| 95PS00034-01 | 110 | |
| 95PS00034-01 | 2200 | |
| 95PS00034-01 | 5 | U |
| 95PS00034-01 | 56 | |
| 95PS00034-01 | 12000 | |
| 95PS00034-01 | 94 | |
| 95PS00034-02 | 85 | |
| 95PS00034-02 | 37 | |
| 95PS00034-02 | 24 | |
| 95PS00034-02 | 23 | |
| 95PS00034-02 | 12 | |
| 95PS00034-02 | 11000 | |
| 95PS00034-02 | 63 | |
| 95PS00034-02 | 100 | |
| 95PS00034-02 | 13 | |
| 95PS00034-02 | 45 | |
| 95PS00034-03 | 29000 | |
| 95PS00034-03 | 80 | |
| 95PS00034-03 | 150 | |
| 95PS00035-00 | 42 | |
| 95PS00035-00 | 290 | |
| 95PS00035-00 | 19000 | |
| 95PS00035-00 | 71 | |
| 95PS00035-00 | 30 | |
| 95PS00035-00 | 38 | |
| 95PS00035-00 | 85 | |
| 95PS00035-00 | 180 | |
| 95PS00035-00 | 95 | |
| 95PS00035-01 | 67 | |
| 95PS00035-01 | 59 | |
| 95PS00035-01 | 18 | |
| 95PS00035-01 | 65 | |
| 95PS00035-01 | 110 | |
| 95PS00032-01 | 580 | |
| 95PS00032-01 | 150 | |
| 95PS00032-01 | 140 | |
| 95PS00032-02 | 10000 | |
| 91NN00999-0 | 1 | U |
| 91NN00999-0 | 29 | |
| 91NN00999-0 | 78 | |
| 91NN00999-0 | 15 | |
| 91NN00999-0 | 33 | |
| 91NN00999-0 | 13 | |
| 91NN00999-0 | 23 | |
| 91NN00999-0 | 8 | |
| 91NN00999-0 | 70 | |

| | | | | | |
|---|---|---|---|---|---|
| ***Low-End EPC*** | Bootstrap Mean | | 1494 | | |
| ***High-End EPC*** | Standard Bootstrap UCL | | 2559 | | |
| **Raw Data Results** | | | | | |
| Number of Samples | 59 | | | | |
| Percent Detection | 97% | 57 of 59 | Percent Detects J-coded | 0% | |
| Maximum Detection | 2.90E+04 | | Minimum Detection | 6.10E+00 | |
| Maximum Non-detection[1] | 5.00E+00 | | Minimum Non-detection[1] | 1.00E+00 | |
| **Normal (Non-transformed) Results** | | | | | |
| Normal Mean | 1.49E+03 | | Mean Standard Error | 6.49E+02 | |
| Standard Deviation | 4.99E+03 | | Coefficient of Variance (%) | 334% | |
| Dataset Skewness | Fail | 3.92E+00 | Dataset Kurtosis | Fail | 1.90E+01 |
| Tested for Normality | D-Test | | NormalityResult (a = 0.05) | Fail | |
| Critical Value | -2.705 or 1.107 | | Calculated Value for dataset | -3.73E-01 | |
| 90% UCL using t-statistic | 2.34E+03 | | 95% UCL using -t-statistic | 2.58E+03 | |
| **Natural Log-Transformed Results** | | | | | |
| MVUE of the log-mean | 6.20E+02 | | Standard error of the log-mean | 2.50E+02 | |
| Standard Deviation | 2.06E+00 | | Coefficient of Variance (%) | 47% | |
| Dataset Skewness | Fail | 1.08E+00 | Dataset Kurtosis | Pass | 4.34E+00 |
| Tested for Normality | D-Test | | Normality Result (a = 0.05) | Fail | |
| Critical Value | -2.705 or 1.107 | | Calculated Value for dataset | -5.70E+00 | |
| Anderson Darling (AD) $A^2$ | 2.19E+00 | | AD Probability | Fail | 7.23E-02 |
| 90% UCL of the MVUE | 1.42E+03 | | 95% UCL of the MVUE | 1.80E+03 | |
| EPA Concentration Term | 1.80E+03 | | Chebychev 95% UCL | 1.74E+03 | |
| **Jackknife Results** | | | | | |
| Jackknifed Mean | 1.49E+03 | | Jackknifed Standard Error | 6.49E+02 | |
| 90% UCL of the mean | 2.34E+03 | | 95% UCL of the mean | 2.58E+03 | |
| 90% UCL of the MVUE[2] | 1.03E+03 | | 95% UCL of the MVUE[2] | 1.18E+03 | |
| **Bootstrap Results (Raw Data)** | | | | | |
| Standard Bootstrap | Mean | 1.49E+03 | 90% UCL | 2.32E+03 | 95% UCL 2.56E+03 |
| Skewness | 6.08E-01 | | Kurtosis | 3.39E+00 | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 2.86E+03 | 95% UCL | 3.77E+03 | |
| Skewness | -1.65E+01 | | Kurtosis | 3.68E+02 | |
| Quantile fit is poor do not use Bootstrap Results | | | | | |
| Hall's t Bootstrap | 90% UCL | 2.97E+03 | 95% UCL | 3.85E+03 | |
| Skewness | -2.73E+01 | | Kurtosis | 7.90E+02 | |
| Quantile fit is poor do not use Bootstrap Results | | | | | |




| Quantiles for the data set | |
|---|---|
| Minimum | 6.10 |
| Lower Quartile | 23.0 |
| Median | 67.0 |
| Upper Quartile | 140 |
| Maximum | 29000 |

| Percentiles of the bootstrap distribution | |
|---|---|
| 5th Percentile | 525 |
| 25th Percentile | 1025 |
| 50th Percentile | 1421 |
| 75th Percentile | 1883 |
| 95th Percentile | 2685 |



1 = Equals 1/2 of the reporting limit
2 = Using the Jackknife

EPC=Environmental Exposure Concentration
MVUE=Minimum Variance Unbiased Estimator
UCL=Upper Confidence Interval

# PCB Concentrations in Lubricants Onboard the Ex-ORISKANY

There is a sufficient number of values for statistical analysis - the data were found to be non-normally distributed and the number of samples is below 15 - use the Jackknife mean and UCL as the EPCs

Units = PPM

| Sample# | Value | Qualifier |
|---|---|---|
| 91NN00999-001 | 0.5 | U |
| 95PS00029-001 | 150 | |
| 95PS00029-002 | 230 | |
| 95PS00029-003 | 0.5 | U |
| 95PS00029-004 | 0.5 | U |
| 95PS00029-005 | 4 | |
| 95PS00029-006 | 0.5 | U |
| 95PS00029-007 | 67 | |
| 95PS00029-008 | 100 | |
| 95PS00029-009 | 0.5 | U |
| 95PS00029-010 | 110 | |

| | | |
|---|---|---|
| ***Low-End EPC*** | Jackknife Mean | 60.3 |
| ***High-End EPC*** | Jackknifed UCL | 103 |

**Raw Data Results**

| | | | | |
|---|---|---|---|---|
| Number of Samples | 11 | | | |
| Percent Detection | 55% | 6 of 11 | Percent Detects J-coded | 0% |
| Maximum Detection | 2.30E+02 | | Minimum Detection | 4.00E+00 |
| Maximum Non-detection[1] | 5.00E-01 | | Minimum Non-detection[1] | 5.00E-01 |

**Normal (Non-transformed) Results**

| | | | | | |
|---|---|---|---|---|---|
| Normal Mean | | 6.03E+01 | Mean Standard Error | | 2.37E+01 |
| Standard Deviation | | 7.87E+01 | Coefficient of Variance (%) | | 131% |
| Dataset Skewness | Pass | 8.46E-01 | Dataset Kurtosis | Pass | 2.31E+00 |
| Tested for Normality | | W-Test | NormalityResult (a = 0.05) | | Fail |
| Critical Value | | 8.50E-01 | Calculated Value for dataset | | 7.93E-01 |
| 90% UCL using t-statistic | | 9.29E+01 | 95% UCL using -t-statistic | | 1.03E+02 |

**Natural Log-Transformed Results**

| | | | | | |
|---|---|---|---|---|---|
| MVUE of the log-mean | | 1.25E+02 | Standard error of the log-mean | | 1.01E+02 |
| Standard Deviation | | 2.77E+00 | Coefficient of Variance (%) | | 139% |
| Dataset Skewness | Pass | 8.87E-02 | Dataset Kurtosis | Fail | 9.47E-01 |
| Tested for Normality | | W-Test | Normality Result (a = 0.05) | | Fail |
| Critical Value | | 8.50E-01 | Calculated Value for dataset | | 7.64E-01 |
| Anderson Darling (AD) $A^2$ | | 1.14E+00 | AD Probability | Fail | 2.90E-01 |
| 90% UCL of the MVUE | | 2.17E+04 | 95% UCL of the MVUE | | 1.43E+05 |
| EPA Concentration Term | | 1.43E+05 | Chebychev 95% UCL | | 5.78E+02 |

**Jackknife Results**

| | | | |
|---|---|---|---|
| Jackknifed Mean | 6.03E+01 | Jackknifed Standard Error | 2.37E+01 |
| 90% UCL of the mean | 9.29E+01 | 95% UCL of the mean | 1.03E+02 |
| 90% UCL of the MVUE[2] | 2.99E+02 | 95% UCL of the MVUE[2] | 3.47E+02 |

**Bootstrap Results (Raw Data)**

| | | | | | | |
|---|---|---|---|---|---|---|
| Standard Bootstrap | Mean | 6.12E+01 | 90% UCL | 8.99E+01 | 95% UCL | 9.80E+01 |
| Skewness | 3.32E-01 | | Kurtosis | 3.02E+00 | | |

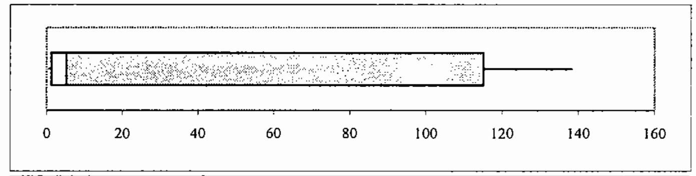
Quantile fit is good - Bootstrap Output is Normal or nearly so

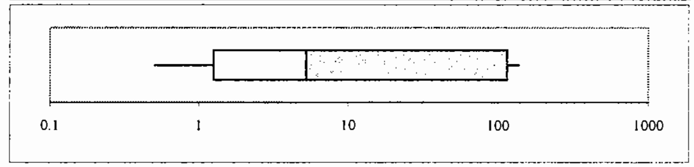
| | | | | |
|---|---|---|---|---|
| Pivitol (t) Bootstrap | 90% UCL | 1.01E+02 | 95% UCL | 1.17E+02 |
| Skewness | -1.30E+00 | Kurtosis | 8.49E+00 | |

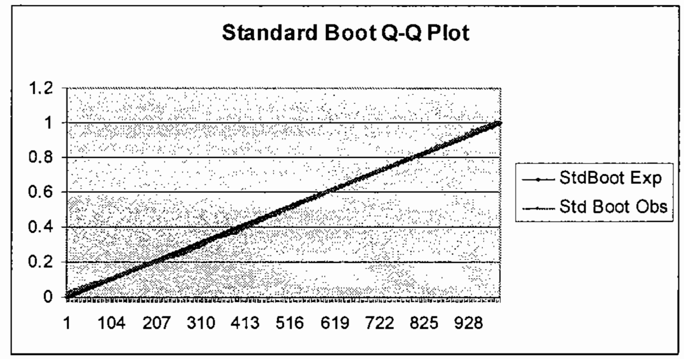
Quantile fit is good - Bootstrap Output is Normal or nearly so

| | | | | |
|---|---|---|---|---|
| Hall's t Bootstrap | 90% UCL | 1.04E+02 | 95% UCL | 1.20E+02 |
| Skewness | -1.22E+01 | Kurtosis | 2.11E+02 | |

Quantile fit is poor do not use Bootstrap Results




| Quantiles for the data set | |
|---|---|
| Minimum | 0.5 |
| Lower Quartile | 0.76 |
| Median | 4 |
| Upper Quartile | 110 |
| Maximum | 23 |

| Percentiles of the bootstrap distribution | |
|---|---|
| $5^{th}$ Percentile | 26.8 |
| $25^{th}$ Percentile | 44.6 |
| $50^{th}$ Percentile | 60.6 |
| $75^{th}$ Percentile | 76.1 |
| $95^{th}$ Percentile | 99.9 |



1 = Equals 1/2 of the reporting limit
2 = Using the Jackknife

EPC=Environmental Exposure Concentration
MVUE=Minimum Variance Unbiased Estimator
UCL=Upper Confidence Interval

# PCB Concentrations in Ventilation Gasket Material Onboard the Ex-ORISKANY

There is a sufficient number of values for statistical analysis - the data were found to be non-normal with high skewness, however, the Hall's transformed t bootstrap failed to normalize the dataset - use the Standard Bootstrap mean and UCLs as the EPCs

| Units = | mg/kg | |
|---|---|---|
| Sample# | Value | Qualifier |
| 91NN00999-045 | 0.5 | U |
| 91NN00999-047 | 0.5 | U |
| 91NN00999-049 | 7 | |
| 91NN00999-050 | 0.5 | U |
| 91NN00999-051 | 0.5 | U |
| 91NN00999-052 | 0.5 | U |
| 91NN00999-053 | 0.5 | U |
| 91NN00999-055 | 49 | |
| 91NN00999-056 | 0.5 | U |
| 91NN00999-058 | 22 | |
| 91NN00999-059 | 6 | |
| 91NN00999-060 | 5 | |
| 91NN00999-061 | 6 | |
| 91NN00999-062 | 210 | |
| 91NN00999-063 | 8 | |
| 91NN00999-064 | 11 | |
| 91NN00999-065 | 50 | |
| 91NN00999-068 | 13 | |
| 91NN00999-069 | 33 | |
| 91NN00999-070 | 0.5 | U |
| 91NN00999-071 | 0.5 | U |
| 91NN00999-072 | 5 | |
| 91NN00999-073 | 41 | |
| 91NN00999-074 | 0.5 | U |
| 91NN00999-075 | 78 | |
| 91NN00999-076 | 0.5 | U |
| 91NN00999-077 | 0.5 | U |
| 91NN00999-078 | 63 | |
| 91NN00999-079 | 0.5 | U |
| 91NN00999-081 | 35 | |
| 91NN00999-083 | 0.5 | U |
| 91NN00999-084 | 0.5 | U |
| 91NN00999-086 | 25 | |
| 91NN00999-087 | 15 | |

*(Nondetect data presented as 1/2 the DL)*

| | | | |
|---|---|---|---|
| ***Low-End EPC*** | Bootstrap Mean | 20.3 | |
| ***High-End EPC*** | Standard Bootstrap UCL | 31.5 | |

**Raw Data Results**

| | | | |
|---|---|---|---|
| Number of Samples | 34 | | |
| Percent Detection | 56% 19 of 34 | Percent Detects J-coded | 0% |
| Maximum Detection | 2.10E+02 | Minimum Detection | 5.00E+00 |
| Maximum Non-detection[1] | 5.00E-01 | Minimum Non-detection[1] | 5.00E-01 |

**Normal (Non-transformed) Results**

| | | | |
|---|---|---|---|
| Normal Mean | 2.03E+01 | Mean Standard Error | 6.74E+00 |
| Standard Deviation | 3.93E+01 | Coefficient of Variance (%) | 194% |
| Dataset Skewness | Fail 3.41E+00 | Dataset Kurtosis | Fail 1.62E+01 |
| Tested for Normality | W-Test | NormalityResult (a = 0.05) | Fail |
| Critical Value | 9.33E-01 | Calculated Value for dataset | 5.53E-01 |
| 90% UCL using t-statistic | 2.91E+01 | 95% UCL using -t-statistic | 3.17E+01 |

**Natural Log-Transformed Results**

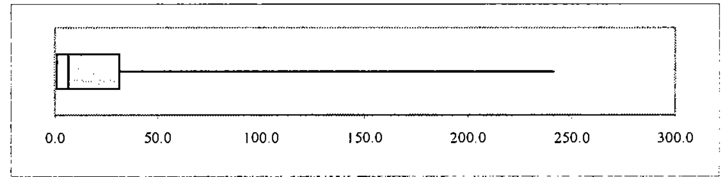
| | | | |
|---|---|---|---|
| MVUE of the log-mean | 2.64E+01 | Standard error of the log-mean | 1.27E+01 |
| Standard Deviation | 2.03E+00 | Coefficient of Variance (%) | 147% |
| Dataset Skewness | Pass 2.07E-01 | Dataset Kurtosis | Fail 1.46E+00 |
| Tested for Normality | W-Test | Normality Result (a = 0.05) | Fail |
| Critical Value | 9.33E-01 | Calculated Value for dataset | 8.25E-01 |
| Anderson Darling (AD) $A^2$ | 2.36E+00 | AD Probability | Fail 5.89E-02 |
| 90% UCL of the MVUE | 8.36E+01 | 95% UCL of the MVUE | 1.18E+02 |
| EPA Concentration Term | 1.18E+02 | Chebychev 95% UCL | 8.31E+01 |

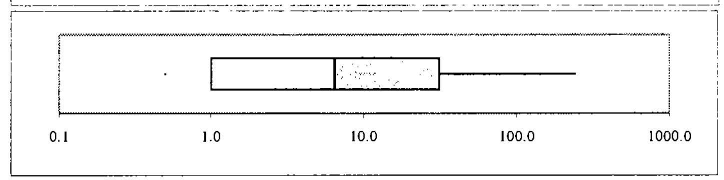
**Jackknife Results**

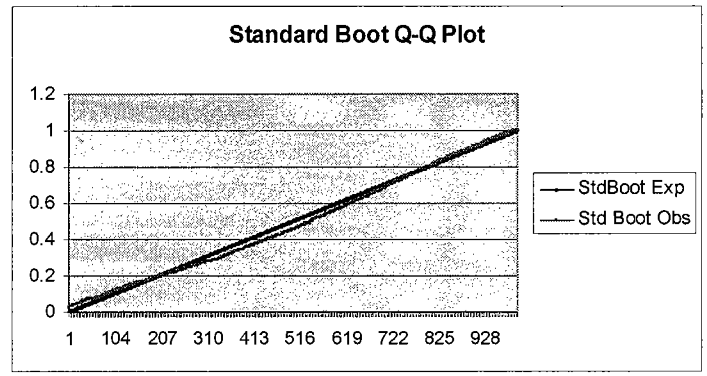
| | | | |
|---|---|---|---|
| Jackknifed Mean | 2.03E+01 | Jackknifed Standard Error | 6.74E+00 |
| 90% UCL of the mean | 2.91E+01 | 95% UCL of the mean | 3.17E+01 |
| 90% UCL of the MVUE[2] | 4.28E+01 | 95% UCL of the MVUE[2] | 4.73E+01 |

**Bootstrap Results (Raw Data)**

| | | | | | | |
|---|---|---|---|---|---|---|
| Standard Bootstrap | Mean | 2.03E+01 | 90% UCL | 2.90E+01 | 95% UCL | 3.15E+01 |
| Skewness | 7.76E-01 | | Kurtosis | 3.66E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 3.72E+01 | 95% UCL | 4.21E+01 | | |
| Skewness | -1.03E+00 | | Kurtosis | 4.34E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Hall's t Bootstrap | 90% UCL | 3.88E+01 | 95% UCL | 3.98E+01 | | |
| Skewness | -2.39E+00 | | Kurtosis | 1.35E+01 | | |
| Quantile fit is poor do not use Bootstrap Results | | | | | | |




| Quantiles for the data set | |
|---|---|
| Minimum | 0.5 |
| Lower Quartile | 0.5 |
| Median | 5.5 |
| Upper Quartile | 25.0 |
| Maximum | 210 |

| Percentiles of the bootstrap distribution | |
|---|---|
| $5^{th}$ Percentile | 10.7 |
| $25^{th}$ Percentile | 15.6 |
| $50^{th}$ Percentile | 20.3 |
| $75^{th}$ Percentile | 24.7 |
| $95^{th}$ Percentile | 32.1 |



1 = Equals 1/2 of the reporting limit
2 = Using the Jackknife

EPC=Environmental Exposure Concentration
MVUE=Minimum Variance Unbiased Estimator
UCL=Upper Confidence Interval

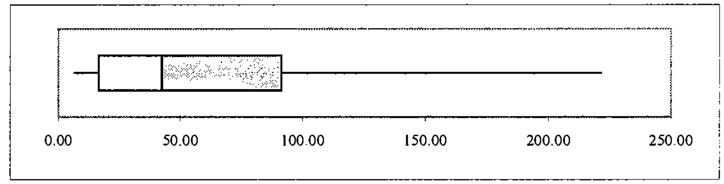
# PCB Concentrations in Rubber Material Onboard the Ex-ORISKANY

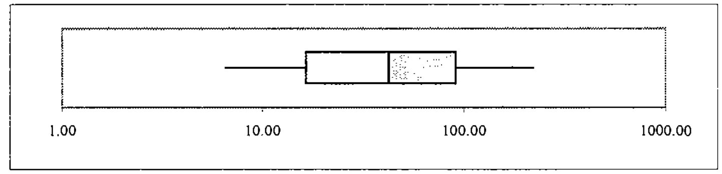
There is a sufficient number of values for statistical analysis - the data were found to be non-normally distributed with high skewness - use the Standard Bootstrap mean and Hall's Adjusted Bootstrap UCLs as the EPCs

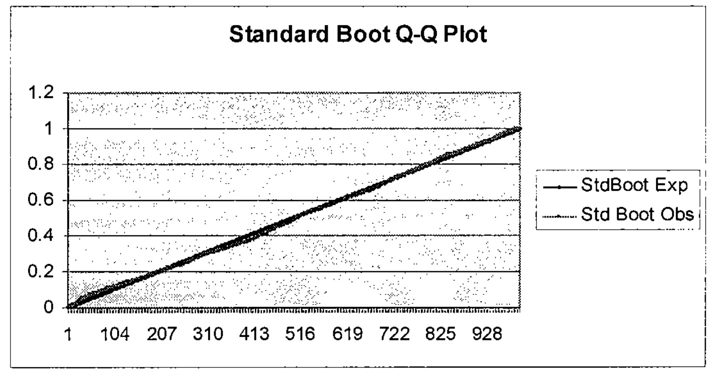
| Units = | mg/kg | |
|---|---|---|
| Sample# | Value | Qualifier |
| 95PS00032-001 | 32 | |
| 95PS00032-002 | 10 | |
| 95PS00032-003 | 24 | |
| 95PS00032-004 | 130 | |
| 95PS00032-005 | 6.5 | |
| 95PS00032-006 | 54 | |
| 95PS00032-007 | 29 | |
| 95PS00032-008 | 14 | |
| 95PS00032-009 | 2.5 | U |
| 95PS00032-010 | 19 | |
| 95PS00032-011 | 8.9 | |
| 95PS00035-015 | 12 | |
| 95PS00035-016 | 58 | |
| 95PS00035-017 | 2.5 | U |
| 95PS00035-018 | 110 | |
| 95PS00035-019 | 2.5 | U |
| 95PS00035-020 | 17 | |
| 95PS00035-021 | 46 | |
| 95PS00035-022 | 13 | |
| 95PS00035-023 | 2.5 | U |
| 95PS00035-024 | 28 | |
| 95PS00035-025 | 12 | |
| 95PS00035-026 | 110 | |
| 95PS00035-027 | 92 | |
| 95PS00035-028 | 39 | |
| 95PS00035-029 | 120 | |
| 95PS00035-030 | 33 | |
| 95PS00035-031 | 49 | |
| 95PS00035-032 | 42 | |
| 91NN00999-044 | 2.5 | U |

*(Nondetect data presented as 1/2 the DL)*

| | | | | |
|---|---|---|---|---|
| ***Low-End EPC*** | Bootstrap Mean | 37.2 | | |
| ***High-End EPC*** | Hall Adjusted Bootstrap | 52.9 | | |
| **Raw Data Results** | | | | |
| Number of Samples | 30 | | | |
| Percent Detection | 83% 25 of 30 | Percent Detects J-coded | 0% | |
| Maximum Detection | 1.30E+02 | Minimum Detection | 6.50E+00 | |
| Maximum Non-detection[1] | 2.50E+00 | Minimum Non-detection[1] | 2.50E+00 | |
| **Normal (Non-transformed) Results** | | | | |
| Normal Mean | 3.74E+01 | Mean Standard Error | 6.95E+00 | |
| Standard Deviation | 3.81E+01 | Coefficient of Variance (%) | 102% | |
| Dataset Skewness | Fail 1.17E+00 | Dataset Kurtosis | Pass 3.12E+00 | |
| Tested for Normality | W-Test | NormalityResult (a = 0.05) | Fail | |
| Critical Value | 9.27E-01 | Calculated Value for dataset | 8.12E-01 | |
| 90% UCL using t-statistic | 4.65E+01 | 95% UCL using -t-statistic | 4.92E+01 | |
| **Natural Log-Transformed Results** | | | | |
| MVUE of the log-mean | 4.25E+01 | Standard error of the log-mean | 1.17E+01 | |
| Standard Deviation | 1.25E+00 | Coefficient of Variance (%) | 41% | |
| Dataset Skewness | Pass -3.46E-01 | Dataset Kurtosis | Pass 2.02E+00 | |
| Tested for Normality | W-Test | Normality Result (a = 0.05) | Fail | |
| Critical Value | 9.27E-01 | Calculated Value for dataset | 9.25E-01 | |
| Anderson Darling (AD) $A^2$ | 5.53E-01 | AD Probability | Pass 6.93E-01 | |
| 90% UCL of the MVUE | 7.12E+01 | 95% UCL of the MVUE | 8.38E+01 | |
| EPA Concentration Term | 8.38E+01 | Chebychev 95% UCL | 9.48E+01 | |
| **Jackknife Results** | | | | |
| Jackknifed Mean | 3.74E+01 | Jackknifed Standard Error | 6.95E+00 | |
| 90% UCL of the mean | 4.65E+01 | 95% UCL of the mean | 4.92E+01 | |
| 90% UCL of the MVUE[2] | 5.55E+01 | 95% UCL of the MVUE[2] | 5.92E+01 | |
| **Bootstrap Results (Raw Data)** | | | | |
| Standard Bootstrap | Mean 3.72E+01 | 90% UCL 4.63E+01 | 95% UCL 4.88E+01 | |
| Skewness | 2.38E-01 | Kurtosis | 3.04E+00 | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 4.81E+01 | 95% UCL | 5.22E+01 |
| Skewness | -9.47E-01 | Kurtosis | 6.05E+00 | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | |
| Hall's t Bootstrap | 90% UCL | 4.75E+01 | 95% UCL | 5.29E+01 |
| Skewness | -2.02E+00 | Kurtosis | 1.15E+01 | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | |




| Quantiles for the data set | |
|---|---|
| Minimum | 6.50 |
| Lower Quartile | 10.0 |
| Median | 26.0 |
| Upper Quartile | 49.0 |
| Maximum | 130 |

| Percentiles of the bootstrap distribution | |
|---|---|
| $5^{th}$ Percentile | 26.7 |
| $25^{th}$ Percentile | 32.1 |
| $50^{th}$ Percentile | 36.9 |
| $75^{th}$ Percentile | 41.9 |
| $95^{th}$ Percentile | 49.1 |

PCB-Data_Stats2.xls Rubber-Stats
4/18/2005 3:27 PM
URS

1 = Equals 1/2 of the reporting limit
2 = Using the Jackknife

EPC=Environmental Exposure Concentration
MVUE=Minimum Variance Unbiased Estimator
UCL=Upper Confidence Interval

# PCB Concentrations in Paint Material Onboard the Ex-ORISKANY

There is a sufficient number of values for statistical analysis - the data were found to be non-normally distributed and the number of samples is below 15 - use the Jackknife mean and UCL as the EPCs

Units = mg/kg

| Sample# | Value | Qualifier |
|---|---|---|
| Analab 7 | 24.4 | |
| Analab 8 | 15.2 | |
| 95PS0032-012 | 5 | U |
| 95PS0032-013 | 5 | U |
| 95PS0032-014 | 5 | U |
| 95PS0032-015 | 28 | |
| 95PS0032-016 | 5.8 | |

*(Nondetect data presented as 1/2 the DL)*

| | | |
|---|---|---|
| ***Low-End EPC*** | Jackknife Mean | 12.6 |
| ***High-End EPC*** | Jackknifed UCL | 20.0 |

**Raw Data Results**

| | | | | | |
|---|---|---|---|---|---|
| Number of Samples | 7 | | | | |
| Percent Detection | 57% | 4 of 7 | Percent Detects J-coded | | 0% |
| Maximum Detection | 2.80E+01 | | Minimum Detection | | 5.80E+00 |
| Maximum Non-detection[1] | 5.00E+00 | | Minimum Non-detection[1] | | 5.00E+00 |

**Normal (Non-transformed) Results**

| | | | | | |
|---|---|---|---|---|---|
| Normal Mean | 1.26E+01 | | Mean Standard Error | | 3.79E+00 |
| Standard Deviation | 1.00E+01 | | Coefficient of Variance (%) | | 79% |
| Dataset Skewness | Pass | 5.15E-01 | Dataset Kurtosis | Fail | 1.24E+00 |
| Tested for Normality | W-Test | | NormalityResult (a = 0.05) | | Fail |
| Critical Value | 8.03E-01 | | Calculated Value for dataset | | 7.77E-01 |
| 90% UCL using t-statistic | 1.81E+01 | | 95% UCL using -t-statistic | | 2.00E+01 |

**Natural Log-Transformed Results**

| | | | | | |
|---|---|---|---|---|---|
| MVUE of the log-mean | 1.25E+01 | | Standard error of the log-mean | | 3.75E+00 |
| Standard Deviation | 7.91E-01 | | Coefficient of Variance (%) | | 35% |
| Dataset Skewness | Pass | 3.38E-01 | Dataset Kurtosis | Fail | 9.91E-01 |
| Tested for Normality | W-Test | | Normality Result (a = 0.05) | | Fail |
| Critical Value | 8.03E-01 | | Calculated Value for dataset | | 7.78E-01 |
| Anderson Darling (AD) $A^2$ | 7.22E-01 | | AD Probability | Pass | 5.39E-01 |
| 90% UCL of the MVUE | 2.59E+01 | | 95% UCL of the MVUE | | 3.61E+01 |
| EPA Concentration Term | 3.61E+01 | | Chebychev 95% UCL | | 2.92E+01 |

**Jackknife Results**

| | | | |
|---|---|---|---|
| Jackknifed Mean | 1.26E+01 | Jackknifed Standard Error | 3.79E+00 |
| 90% UCL of the mean | 1.81E+01 | 95% UCL of the mean | 2.00E+01 |
| 90% UCL of the MVUE[2] | 1.84E+01 | 95% UCL of the MVUE[2] | 2.05E+01 |

**Bootstrap Results (Raw Data)**

| | | | | | | |
|---|---|---|---|---|---|---|
| Standard Bootstrap | Mean | 1.25E+01 | 90% UCL | 1.71E+01 | 95% UCL | 1.84E+01 |
| Skewness | 2.61E-01 | | Kurtosis | 2.67E+00 | | |

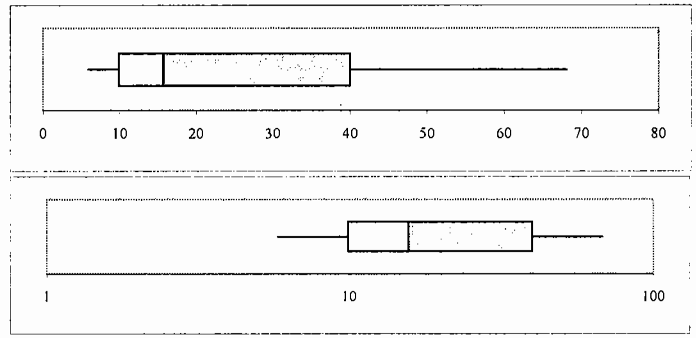
Quantile fit is good - Bootstrap Output is Normal or nearly so

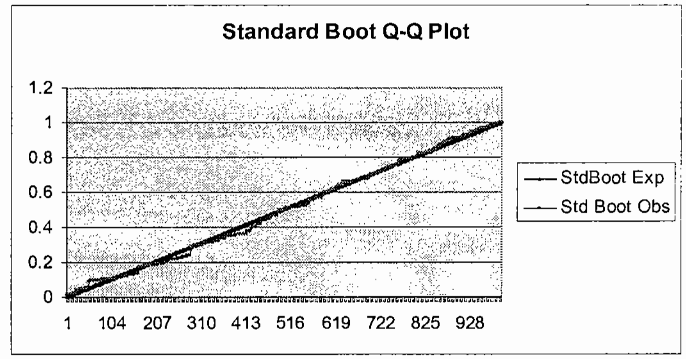
| | | | | |
|---|---|---|---|---|
| Pivitol (t) Bootstrap | 90% UCL | 1.97E+01 | 95% UCL | 2.95E+01 |
| Skewness | -6.61E+00 | Kurtosis | 4.71E+01 | |

Quantile fit is poor do not use Bootstrap Results

| | | | | |
|---|---|---|---|---|
| Hall's t Bootstrap | 90% UCL | 1.97E+01 | 95% UCL | 2.95E+01 |
| Skewness | -1.47E+01 | Kurtosis | 2.26E+02 | |

Quantile fit is poor do not use Bootstrap Results




| **Quantiles for the data set** | |
|---|---|
| Minimum | 5.8 |
| Lower Quartile | 4.12 |
| Median | 5.8 |
| Upper Quartile | 24.4 |
| Maximum | 28 |

| **Percentiles of the bootstrap distribution** | |
|---|---|
| $5^{th}$ Percentile | 6.80 |
| $25^{th}$ Percentile | 9.74 |
| $50^{th}$ Percentile | 12.5 |
| $75^{th}$ Percentile | 14.9 |
| $95^{th}$ Percentile | 18.7 |



1 = Equals 1/2 of the reporting limit
2 = Using the Jackknife

EPC=Environmental Exposure Concentration
MVUE=Minimum Variance Unbiased Estimator
UCL=Upper Confidence Interval

# PCB Concentrations in Bulkhead Insulation Material Onboard the Ex-ORISKANY

There is a sufficient number of values for statistical analysis - the data were found to be non-normal, however, the bootstrap methods failed to normalize the dataset - use the Jackknife mean and UCL as the EPCs

| Units = | mg/kg | |
|---|---|---|
| Sample# | Value | Qualifier |
| 95PS00019-002 | 6100 | |
| 95PS00019-023 | 320 | |
| 95PS00019-021 | 130 | |
| 95PS00019-003 | 60 | |
| 95PS00019-001 | 53 | |
| 95PS00019-004 | 45 | |
| 95PS00019-022 | 39 | |
| 95PS00019-014 | 18 | |
| 95PS00019-024 | 15 | |
| 95PS00019-011 | 11 | |
| 95PS00019-027 | 11 | |
| 95PS00019-015 | 7.4 | |
| 95PS00019-018 | 7.3 | |
| 95PS00019-025 | 6.9 | |
| 95PS00019-020 | 6.6 | |
| 95PS00019-017 | 6.4 | |
| 95PS00019-006 | 5.9 | |
| 95PS00019-019 | 5.5 | |
| 95PS00019-005 | 2.5 | U |
| 95PS00019-007 | 2.5 | U |
| 95PS00019-008 | 2.5 | U |
| 95PS00019-009 | 2.5 | U |
| 95PS00019-010 | 2.5 | U |
| 95PS00019-012 | 2.5 | U |
| 95PS00019-013 | 2.5 | U |
| 95PS00019-016 | 2.5 | U |
| 95PS00019-026 | 2.5 | U |
| 95PS00019-028 | 2.5 | U |
| 95PS00019-029 | 2.5 | U |
| 95PS00019-030 | 2.5 | U |
| 95PS00019-031 | 2.5 | U |
| 95PS00019-032 | 2.5 | U |

*(Nondetect data presented as 1/2 the DL)*

| | | | |
|---|---|---|---|
| *Low-End EPC* | Jackknife Mean | 215 | |
| *High-End EPC* | Jackknifed UCL | 537 | |

**Raw Data Results**

| | | | |
|---|---|---|---|
| Number of Samples | 32 | | |
| Percent Detection | 56% 18 of 32 | Percent Detects J-coded | 0% |
| Maximum Detection | 6.10E+03 | Minimum Detection | 5.50E+00 |
| Maximum Non-detection[1] | 2.50E+00 | Minimum Non-detection[1] | 2.50E+00 |

**Normal (Non-transformed) Results**

| | | | |
|---|---|---|---|
| Normal Mean | 2.15E+02 | Mean Standard Error | 1.90E+02 |
| Standard Deviation | 1.08E+03 | Coefficient of Variance (%) | 500% |
| Dataset Skewness | Fail 5.11E+00 | Dataset Kurtosis | Fail 2.80E+01 |
| Tested for Normality | W-Test | NormalityResult (a = 0.05) | Fail |
| Critical Value | 9.30E-01 | Calculated Value for dataset | 2.06E-01 |
| 90% UCL using t-statistic | 4.64E+02 | 95% UCL using -t-statistic | 5.37E+02 |

**Natural Log-Transformed Results**

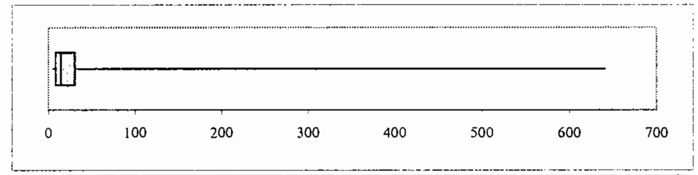
| | | | |
|---|---|---|---|
| MVUE of the log-mean | 4.04E+01 | Standard error of the log-mean | 1.69E+01 |
| Standard Deviation | 1.78E+00 | Coefficient of Variance (%) | 80% |
| Dataset Skewness | Fail 1.79E+00 | Dataset Kurtosis | Fail 6.37E+00 |
| Tested for Normality | W-Test | Normality Result (a = 0.05) | Fail |
| Critical Value | 9.30E-01 | Calculated Value for dataset | 7.57E-01 |
| Anderson Darling (AD) $A^2$ | 2.47E+00 | AD Probability | Fail 5.16E-02 |
| 90% UCL of the MVUE | 1.03E+02 | 95% UCL of the MVUE | 1.37E+02 |
| EPA Concentration Term | 1.37E+02 | Chebychev 95% UCL | 1.16E+02 |

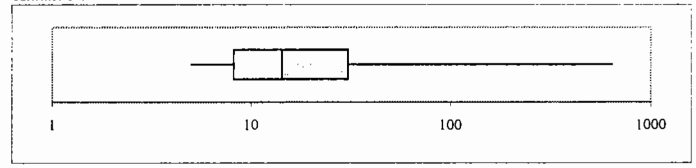
**Jackknife Results**

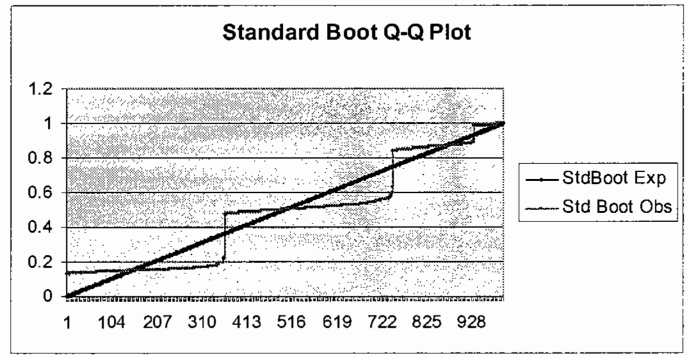
| | | | |
|---|---|---|---|
| Jackknifed Mean | 2.15E+02 | Jackknifed Standard Error | 1.90E+02 |
| 90% UCL of the mean | 4.64E+02 | 95% UCL of the mean | 5.37E+02 |
| 90% UCL of the MVUE[2] | 6.73E+01 | 95% UCL of the MVUE[2] | 7.79E+01 |

**Bootstrap Results (Raw Data)**

| | | | | | | |
|---|---|---|---|---|---|---|
| Standard Bootstrap | Mean | 2.09E+02 | 90% UCL | 4.40E+02 | 95% UCL | 5.06E+02 |
| Skewness | 8.81E-01 | | Kurtosis | 3.59E+00 | | |
| Quantile fit is poor do not use Bootstrap Results | | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 7.77E+03 | 95% UCL | 1.15E+04 | | |
| Skewness | -2.70E+00 | | Kurtosis | 1.18E+01 | | |
| Quantile fit is poor do not use Bootstrap Results | | | | | | |
| Hall's t Bootstrap | 90% UCL | 6.91E+03 | 95% UCL | 9.00E+03 | | |
| Skewness | -1.90E+01 | | Kurtosis | 4.60E+02 | | |
| Quantile fit is poor do not use Bootstrap Results | | | | | | |




| Quantiles for the data set | |
|---|---|
| Minimum | 5 |
| Lower Quartile | 3.18 |
| Median | 6.15 |
| Upper Quartile | 16.5 |
| Maximum | 610 |

| Percentiles of the bootstrap distribution | |
|---|---|
| 5th Percentile | 13.2 |
| 25th Percentile | 28.7 |
| 50th Percentile | 210 |
| 75th Percentile | 387 |
| 95th Percentile | 590 |

PCB-Data_Stats2.xls BHI-Stats1
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URS

1 = Equals 1/2 of the reporting limit
2 = Using the Jackknife

EPC=Environmental Exposure Concentration
MVUE=Minimum Variance Unbiased Estimator
UCL=Upper Confidence Interval

# APPENDIX B

# CALCULATION OF HOMOLOG-SPECIFIC $K_{OW}$s

# OCTANOL TO WATER PARTITIONING COEFFICIENTS ($LOG_{10}K_{OW}$) FOR PCB CONGENERS AS OBTAINED FROM EISLER AND BELISLE (1996)

| Monochlorobiphenyls | | Dichlorobiphenyls | | Trichlorobiphenyls | | Tetrachlorobiphenyls | | Pentachlorobiphenyls | | Hexachlorobiphenyls | | Heptachlorobiphenyls | | Octachlorobiphenyls | | Nonachlorobiphenyls | | Decachlorobiphenyls | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.601 | 4 | 5.023 | 16 | 5.311 | 40 | 5.561 | 82 | 6.142 | 128 | 6.961 | 170 | 7.277 | 194 | 8.683 | 206 | 9.143 | 209 | 9.603 |
| 2 | 4.421 | 5 | NA | 17 | 5.761 | 41 | 6.111 | 83 | 6.267 | 129 | 7.321 | 171 | 6.704 | 195 | 7.567 | 207 | 7.747 | | |
| 3 | 4.401 | 6 | 5.021 | 18 | 5.551 | 42 | 5.767 | 84 | 6.041 | 130 | 7.391 | 172 | 7.337 | 196 | 7.657 | 208 | 8.164 | | |
| | | 7 | 5.15 | 19 | 5.481 | 43 | 5.757 | 85 | 6.611 | 131 | 6.587 | 173 | 7.027 | 197 | 7.307 | | | | |
| | | 8 | 5.301 | 20 | 5.577 | 44 | 5.811 | 86 | 6.204 | 132 | 6.587 | 174 | 7.117 | 198 | 7.627 | | | | |
| | | 9 | 5.18 | 21 | 5.17 | 45 | 5.537 | 87 | 6.371 | 133 | 6.867 | 175 | 7.177 | 199 | 7.207 | | | | |
| | | 10 | 5.311 | 22 | 5.421 | 46 | 5.537 | 88 | 7.516 | 134 | 7.304 | 176 | 6.767 | 200 | 7.277 | | | | |
| | | 11 | 5.343 | 23 | 5.577 | 47 | 6.291 | 89 | 6.077 | 135 | 7.151 | 177 | 7.087 | 201 | 7.627 | | | | |
| | | 12 | 5.295 | 24 | 5.671 | 48 | 5.787 | 90 | 6.367 | 136 | 6.511 | 178 | 7.147 | 202 | 8.423 | | | | |
| | | 13 | NA | 25 | 5.677 | 49 | 6.221 | 91 | 6.137 | 137 | 7.711 | 179 | 6.737 | 203 | 7.657 | | | | |
| | | 14 | 5.404 | 26 | 5.667 | 50 | 5.637 | 92 | 6.357 | 138 | 7.441 | 180 | 7.367 | 204 | 7.307 | | | | |
| | | 15 | 5.335 | 27 | 5.447 | 51 | 5.637 | 93 | 6.047 | 139 | 6.677 | 181 | 7.117 | 205 | 8.007 | | | | |
| | | | | 28 | 5.691 | 52 | 6.091 | 94 | 6.137 | 140 | 6.677 | 182 | 7.207 | | | | | | |
| | | | | 29 | 5.743 | 53 | 5.627 | 95 | 6.137 | 141 | 7.592 | 183 | 7.207 | | | | | | |
| | | | | 30 | 5.504 | 54 | 5.904 | 96 | 5.717 | 142 | 6.517 | 184 | 6.857 | | | | | | |
| | | | | 31 | 5.677 | 55 | 6.117 | 97 | 6.671 | 143 | 6.607 | 185 | 7.933 | | | | | | |
| | | | | 32 | 5.751 | 56 | 6.117 | 98 | 6.137 | 144 | 6.677 | 186 | 6.697 | | | | | | |
| | | | | 33 | 5.572 | 57 | 6.177 | 99 | 7.211 | 145 | 6.257 | 187 | 7.177 | | | | | | |
| | | | | 34 | 5.667 | 58 | 6.177 | 100 | 6.237 | 146 | 6.897 | 188 | 6.827 | | | | | | |
| | | | | 35 | 5.827 | 59 | 5.957 | 101 | 7.071 | 147 | 6.647 | 189 | 7.717 | | | | | | |
| | | | | 36 | 4.151 | 60 | 5.452 | 102 | 6.167 | 148 | 6.737 | 190 | 7.467 | | | | | | |
| | | | | 37 | 4.941 | 61 | 5.943 | 103 | 6.227 | 149 | 7.281 | 191 | 7.557 | | | | | | |
| | | | | 38 | 5.767 | 62 | 5.897 | 104 | 5.817 | 150 | 6.327 | 192 | 7.527 | | | | | | |
| | | | | 39 | 5.897 | 63 | 6.177 | 105 | 6.657 | 151 | 6.647 | 193 | 7.527 | | | | | | |
| | | | | | | 64 | 5.957 | 106 | 6.647 | 152 | 6.227 | | | | | | | | |
| | | | | | | 65 | 5.867 | 107 | 6.717 | 153 | 7.751 | | | | | | | | |
| | | | | | | 66 | 5.452 | 108 | 6.717 | 154 | 6.767 | | | | | | | | |
| | | | | | | 67 | 6.207 | 109 | 6.487 | 155 | 7.123 | | | | | | | | |
| | | | | | | 68 | 6.267 | 110 | 6.532 | 156 | 7.187 | | | | | | | | |
| | | | | | | 69 | 6.047 | 111 | 6.767 | 157 | 7.187 | | | | | | | | |
| | | | | | | 70 | 6.231 | 112 | 6.457 | 158 | 7.027 | | | | | | | | |
| | | | | | | 71 | 5.987 | 113 | 6.547 | 159 | 7.247 | | | | | | | | |
| | | | | | | 72 | 6.267 | 114 | 6.657 | 160 | 6.937 | | | | | | | | |
| | | | | | | 73 | 6.047 | 115 | 6.497 | 161 | 7.087 | | | | | | | | |
| | | | | | | 74 | 6.671 | 116 | 6.304 | 162 | 7.247 | | | | | | | | |
| | | | | | | 75 | 6.057 | 117 | 6.467 | 163 | 6.997 | | | | | | | | |
| | | | | | | 76 | 6.137 | 118 | 7.121 | 164 | 7.027 | | | | | | | | |
| | | | | | | 77 | 6.523 | 119 | 6.587 | 165 | 7.057 | | | | | | | | |
| | | | | | | 78 | 6.357 | 120 | 6.797 | 166 | 6.937 | | | | | | | | |
| | | | | | | 79 | 6.427 | 121 | 6.647 | 167 | 7.277 | | | | | | | | |
| | | | | | | 80 | 6.583 | 122 | 6.647 | 168 | 7.117 | | | | | | | | |
| | | | | | | 81 | 6.367 | 123 | 6.747 | 169 | 7.427 | | | | | | | | |
| | | | | | | | | 124 | 6.737 | | | | | | | | | | |
| | | | | | | | | 125 | 6.517 | | | | | | | | | | |
| | | | | | | | | 126 | 6.897 | | | | | | | | | | |
| | | | | | | | | 127 | 6.957 | | | | | | | | | | |

NA = not available

# STATISTICAL ANALYSIS OF OCTANOL-WATER PARTITIONING COEFFICIENTS OBTAINED FROM EISLER AND BELISLE (1996)

## Dichlorobiphenyls

The data are best described as normally distributed and there were a sufficient number of detected values to perform a statistical analysis.

| Congener | Value | $Log_{10}Kow$ |
|---|---|---|
| 4 | 105439 | 5.023 |
| 6 | 104954 | 5.021 |
| 7 | 141254 | 5.150 |
| 8 | 199986 | 5.301 |
| 9 | 151356 | 5.180 |
| 10 | 204644 | 5.311 |
| 11 | 220293 | 5.343 |
| 12 | 197242 | 5.295 |
| 14 | 253513 | 5.404 |
| 15 | 216272 | 5.335 |

*No values were presented for congeners 5 and 13*

| | | | | |
|---|---|---|---|---|
| Recommended Mean | Normal Mean | 179495 | $Log_{10}$ | 5.254 |
| Recommended UCL | UCL based on t-statistic | 208900 | $Log_{10}$ | 5.320 |

| | | | | | |
|---|---|---|---|---|---|
| **Raw Data Results** | | | | | |
| Number of Values | | 10 | | | |
| Maximum Value | | 2.54E+05 | Minimum Value | | 1.05E+05 |
| **Normal (Non-transformed) Results** | | | | | |
| Normal Mean | | 1.79E+05 | Mean Standard Error | | 1.60E+04 |
| Standard Deviation | | 5.07E+04 | Coefficient of Variance (%) | | 28% |
| Dataset Skewness | Pass | -2.65E-01 | Dataset Kurtosis | Fail | 1.50E+00 |
| Tested for Normality | | W-Test | Normality Result (a = 0.05) | | Pass |
| Critical Value | | 8.42E-01 | Calculated Value for dataset | | 9.17E-01 |
| 90% UCL using t-statistic | | 2.02E+05 | 95% UCL using -t-statistic | | 2.09E+05 |
| **Natural Log-Transformed Results** | | | | | |
| MVUE of the log-mean | | 1.80E+05 | Standard error of the log-me | | 1.79E+04 |
| Standard Deviation | | 3.12E-01 | Coefficient of Variance (%) | | 3% |
| Dataset Skewness | Pass | -5.13E-01 | Dataset Kurtosis | Fail | 1.60E+00 |
| Tested for Normality | | W-Test | Normality Result (a = 0.05) | | Pass |
| Critical Value | | 8.42E-01 | Calculated Value for dataset | | 8.80E-01 |
| Anderson Darling (AD) $A^2$ | | 5.55E-01 | AD Probability | Pass | 6.91E-01 |
| 90% UCL of the MVUE | | 2.11E+05 | 95% UCL of the MVUE | | 2.22E+05 |
| **Jackknife Results** | | | | | |
| Jackknifed Mean | | 1.79E+05 | Jackknifed Standard Error | | 1.60E+04 |
| 90% UCL of the mean | | 2.02E+05 | 95% UCL of the mean | | 2.09E+05 |
| 90% UCL of the MVUE[2] | | 2.03E+05 | 95% UCL of the MVUE[2] | | 2.10E+05 |

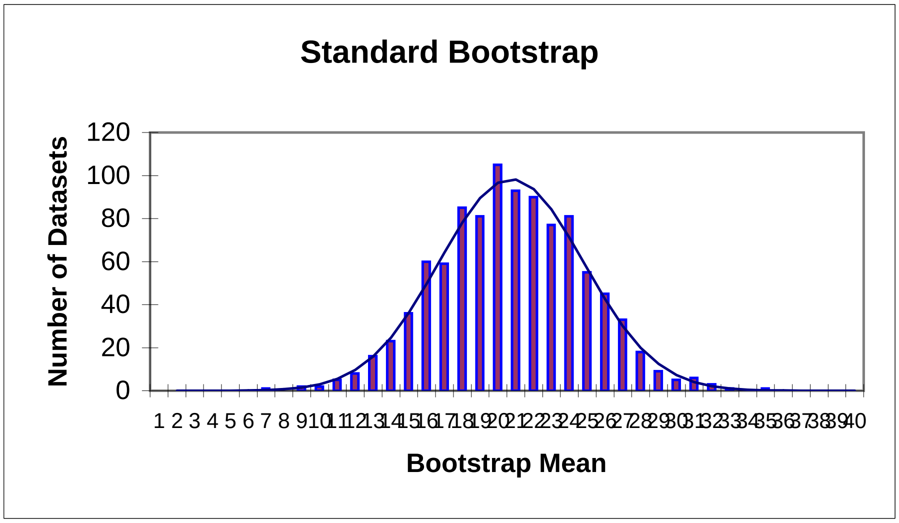
| | | | | | |
|---|---|---|---|---|---|
| **Bootstrap Results (Raw Data)** | | | | | |
| Standard Bootstrap | Mean | 1.79E+05 | 90% UCL | 1.98E+05 | 95% UCL 2.03E+05 |
| Skewness | 5.37E-02 | | Kurtosis | 2.99E+00 | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 2.00E+05 | 95% UCL | | 2.06E+05 |
| Skewness | 1.19E+00 | | Kurtosis | 9.29E+00 | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | |
| Hall's t Bootstrap | 90% UCL | 1.98E+05 | 95% UCL | | 2.06E+05 |
| Skewness | 3.34E-01 | | Kurtosis | 8.40E+00 | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | |

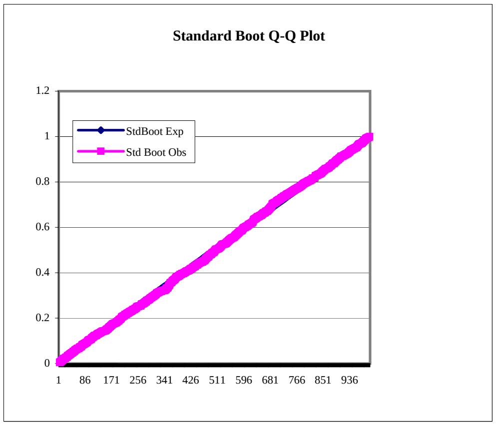


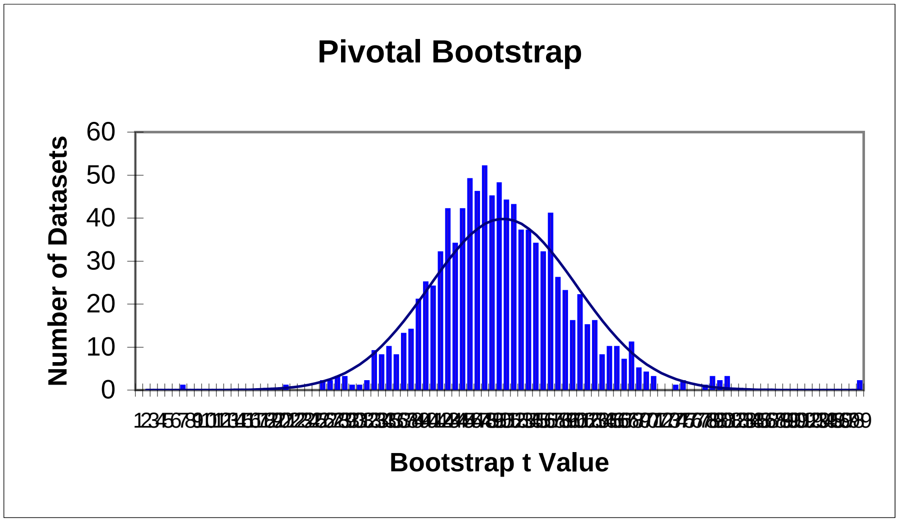
2 = Using the Jackknife

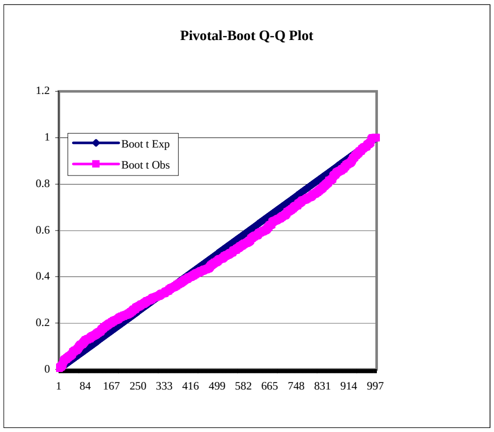
MVUE=Minimum Variance Unbiased Estimator
UCL=Upper Confidence Interval

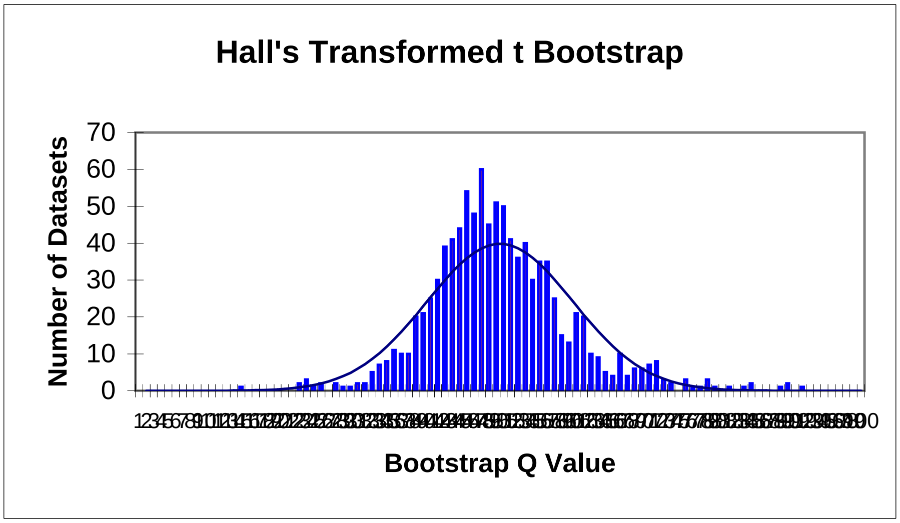
# BOOTSTRAP RESULTS FOR OCTANOL-WATER PARTITIONING COEFFCIENTS FOR DICHLOROBIPHENYLS OBTAINED FROM EISLER AND BELISLE (1996)

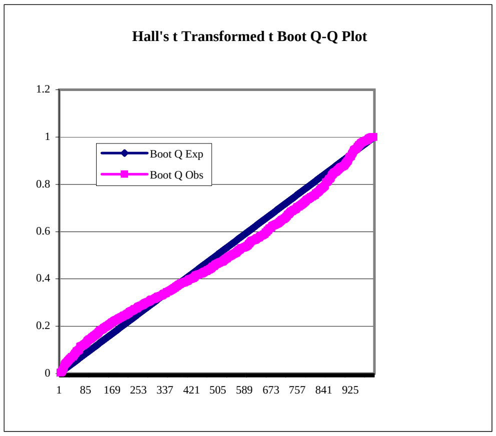


# STATISTICAL ANALYSIS OF OCTANOL-WATER PARTITIONING COEFFICIENTS OBTAINED FROM EISLER AND BELISLE (1996)

## Trichlorobiphenyls

The data are best described as normally distributed and there were a sufficient number of detected values to perform a statistical analysis.

| Congener | Value | $Log_{10}$Kow |
|---|---|---|
| 16 | 204644 | 5.311 |
| 17 | 576766 | 5.761 |
| 18 | 355631 | 5.551 |
| 19 | 302691 | 5.481 |
| 20 | 377572 | 5.577 |
| 21 | 147911 | 5.170 |
| 22 | 263633 | 5.421 |
| 23 | 377572 | 5.577 |
| 24 | 468813 | 5.671 |
| 25 | 475335 | 5.677 |
| 26 | 464515 | 5.667 |
| 27 | 279898 | 5.447 |
| 28 | 490908 | 5.691 |
| 29 | 553350 | 5.743 |
| 30 | 319154 | 5.504 |
| 31 | 475335 | 5.677 |
| 32 | 563638 | 5.751 |
| 33 | 373250 | 5.572 |
| 34 | 464515 | 5.667 |
| 35 | 671429 | 5.827 |
| 36 | 14158 | 4.151 |
| 37 | 87297 | 4.941 |
| 38 | 584790 | 5.767 |
| 39 | 788860 | 5.897 |

| | | | | |
|---|---|---|---|---|
| Recommended Mean | Normal Mean | 403403 | $Log_{10}$ | 5.606 |
| Recommended UCL | UCL based on t-statistic | 467582 | $Log_{10}$ | 5.670 |

| | | | | | |
|---|---|---|---|---|---|
| **Raw Data Results** | | | | | |
| Number of Values | | 24 | | | |
| Maximum Value | | 7.89E+05 | Minimum Value | | 1.42E+04 |
| **Normal (Non-transformed) Results** | | | | | |
| Normal Mean | | 4.03E+05 | Mean Standard Error | | 3.74E+04 |
| Standard Deviation | | 1.83E+05 | Coefficient of Variance (%) | | 45% |
| Dataset Skewness | Pass | -1.63E-01 | Dataset Kurtosis | Pass | 2.58E+00 |
| Tested for Normality | | W-Test | NormalityResult (a = 0.05) | | Pass |
| Critical Value | | 9.16E-01 | Calculated Value for dataset | | 9.85E-01 |
| 90% UCL using t-statistic | | 4.53E+05 | 95% UCL using -t-statistic | | 4.68E+05 |
| **Natural Log-Transformed Results** | | | | | |
| MVUE of the log-mean | | 4.60E+05 | Standard error of the log-me | | 8.60E+04 |
| Standard Deviation | | 8.32E-01 | Coefficient of Variance (%) | | 7% |
| Dataset Skewness | Fail | -2.3E+00 | Dataset Kurtosis | Fail | 9.02E+00 |
| Tested for Normality | | W-Test | Normality Result (a = 0.05) | | Fail |
| Critical Value | | 9.16E-01 | Calculated Value for dataset | | 7.23E-01 |
| Anderson Darling (AD) $A^2$ | | 2.03E+00 | AD Probability | Fail | 8.82E-02 |
| 90% UCL of the MVUE | | 6.31E+05 | 95% UCL of the MVUE | | 6.99E+05 |
| **Jackknife Results** | | | | | |
| Jackknifed Mean | | 4.03E+05 | Jackknifed Standard Error | | 3.74E+04 |
| 90% UCL of the mean | | 4.53E+05 | 95% UCL of the mean | | 4.68E+05 |
| 90% UCL of the MVUE² | | 5.35E+05 | 95% UCL of the MVUE² | | 5.55E+05 |

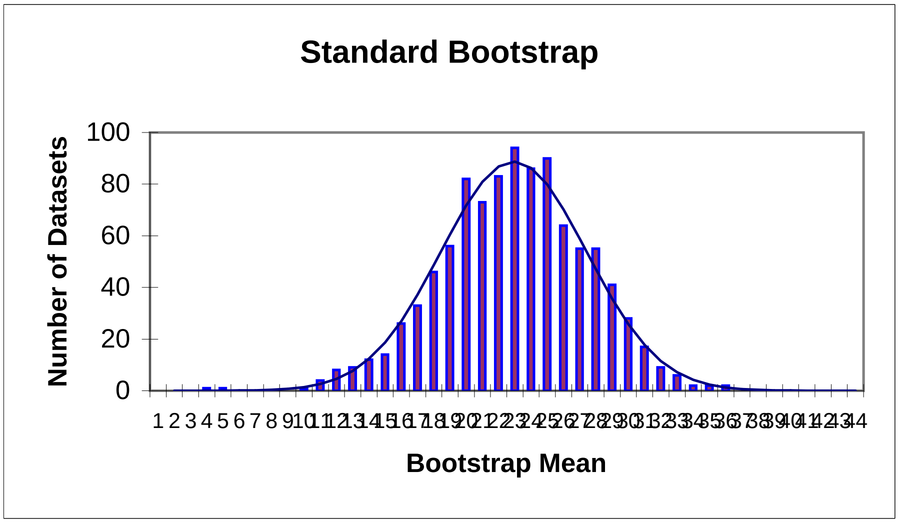
| | | | | | | |
|---|---|---|---|---|---|---|
| **Bootstrap Results (Raw Data)** | | | | | | |
| Standard Bootstrap | Mean | 4.02E+05 | 90% UCL | 4.48E+05 | 95% UCL | 4.61E+05 |
| Skewness | -2.19E-01 | | Kurtosis | 3.25E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 4.52E+05 | 95% UCL | 4.71E+05 | | |
| Skewness | -1.48E-01 | | Kurtosis | 3.65E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Hall's t Bootstrap | 90% UCL | 4.53E+05 | 95% UCL | 4.73E+05 | | |
| Skewness | -9.08E-02 | | Kurtosis | 4.21E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |

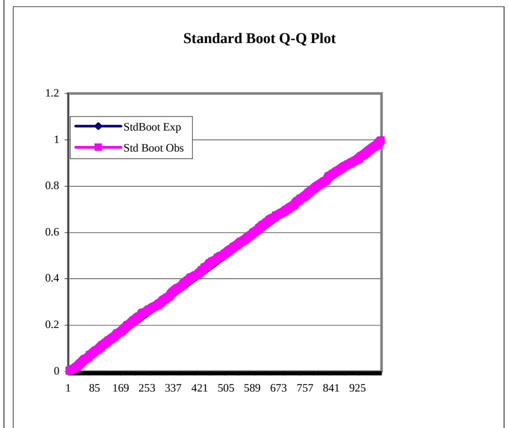


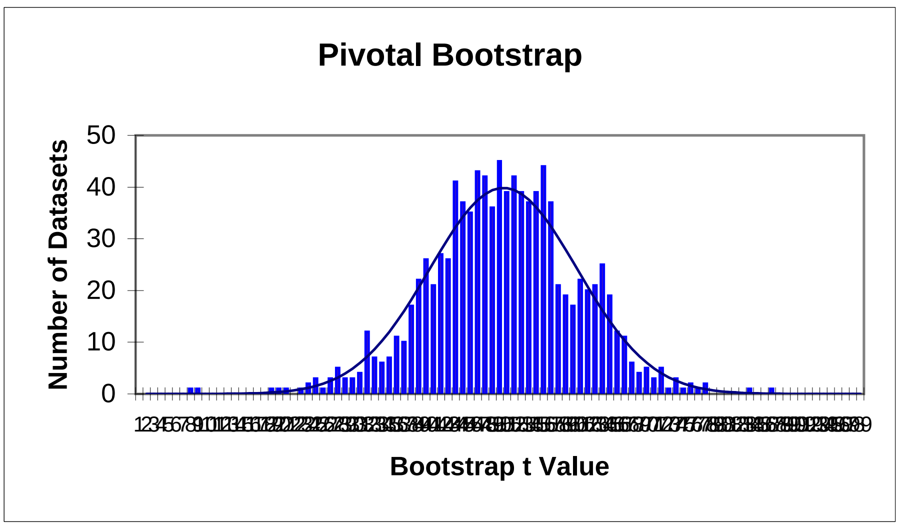
2 = Using the Jackknife

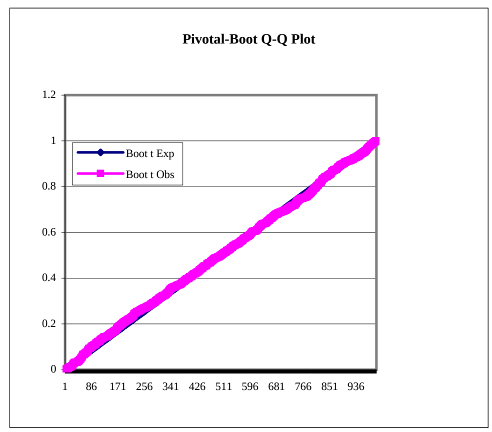
MVUE=Minimum Variance Unbiased Estimator
UCL=Upper Confidence Interval

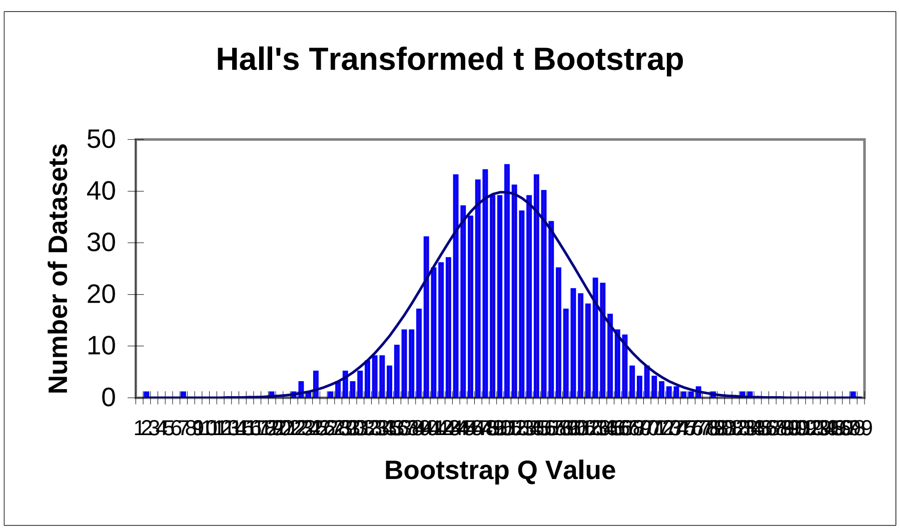
## BOOTSTRAP RESULTS FOR OCTANOL-WATER PARTITIONING COEFFCIENTS FOR TRICHLOROBIPHENYLS OBTAINED FROM EISLER AND BELISLE (1996)

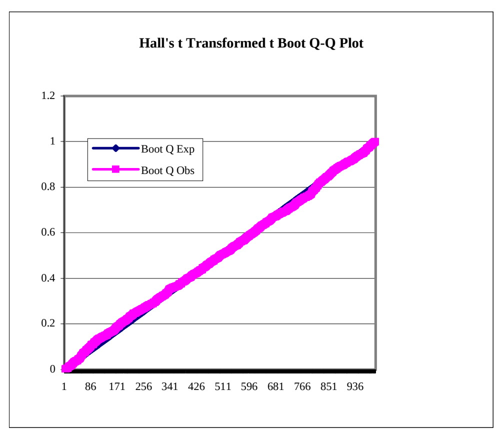


# STATISTICAL ANALYSIS OF OCTANOL-WATER PARTITIONING COEFFICIENTS OBTAINED FROM EISLER AND BELISLE (1996)

## Tetrachlorobiphenyls

The data are best described as log-normally distributed and there were a sufficient number of detected values to perform statistical analysis. The CV is less than 100%

| Congener | Value | $Log_{10}Kow$ |
|---|---|---|
| 40 | 363915 | 5.561 |
| 41 | 1291219 | 6.111 |
| 42 | 584790 | 5.767 |
| 43 | 571479 | 5.757 |
| 44 | 647143 | 5.811 |
| 45 | 344350 | 5.537 |
| 46 | 344350 | 5.537 |
| 47 | 1954339 | 6.291 |
| 48 | 612350 | 5.787 |
| 49 | 1663413 | 6.221 |
| 50 | 433511 | 5.637 |
| 51 | 433511 | 5.637 |
| 52 | 1233105 | 6.091 |
| 53 | 423643 | 5.627 |
| 54 | 801678 | 5.904 |
| 55 | 1309182 | 6.117 |
| 56 | 1309182 | 6.117 |
| 57 | 1503142 | 6.177 |
| 58 | 1503142 | 6.177 |
| 59 | 905733 | 5.957 |
| 60 | 283139 | 5.452 |
| 61 | 877001 | 5.943 |
| 62 | 788860 | 5.897 |
| 63 | 1503142 | 6.177 |
| 64 | 905733 | 5.957 |
| 65 | 736207 | 5.867 |
| 66 | 283139 | 5.452 |
| 67 | 1610646 | 6.207 |
| 68 | 1849269 | 6.267 |
| 69 | 1114295 | 6.047 |
| 70 | 1702159 | 6.231 |
| 71 | 970510 | 5.987 |
| 72 | 1849269 | 6.267 |
| 73 | 1114295 | 6.047 |
| 74 | 4688134 | 6.671 |
| 75 | 1140250 | 6.057 |
| 76 | 1370882 | 6.137 |
| 77 | 3334264 | 6.523 |
| 78 | 2275097 | 6.357 |
| 79 | 2673006 | 6.427 |
| 80 | 3828247 | 6.583 |
| 81 | 2328091 | 6.367 |

| | | | | |
|---|---|---|---|---|
| Recommended Mean | MVUE of the log-mean | 1330250 | $Log_{10}$ | 6.124 |
| Recommended UCL | UCL based on H-statistic | 1683184 | $Log_{10}$ | 6.226 |

| | | | | | |
|---|---|---|---|---|---|
| **Raw Data Results** | | | | | |
| Number of Values | | 42 | | | |
| Maximum Value | | 4.69E+06 | Minimum Value | | 2.83E+05 |
| **Normal (Non-transformed) Results** | | | | | |
| Normal Mean | | 1.32E+06 | Mean Standard Error | | 1.48E+05 |
| Standard Deviation | | 9.62E+05 | Coefficient of Variance (%) | | 73% |
| Dataset Skewness | Fail | 1.55E+00 | Dataset Kurtosis | Fail | 5.52E+00 |
| Tested for Normality | | W-Test | NormalityResult (a = 0.05) | | Fail |
| Critical Value | | 9.42E-01 | Calculated Value for dataset | | 8.51E-01 |
| 90% UCL using t-statistic | | 1.51E+06 | 95% UCL using -t-statistic | | 1.57E+06 |
| **Natural Log-Transformed Results** | | | | | |
| MVUE of the log-mean | | 1.33E+06 | Standard error of the log-me | | 1.59E+05 |
| Standard Deviation | | 7.10E-01 | Coefficient of Variance (%) | | 5% |
| Dataset Skewness | Pass | -6.40E-02 | Dataset Kurtosis | Pass | 2.27E+00 |
| Tested for Normality | | W-Test | Normality Result (a = 0.05) | | Pass |
| Critical Value | | 9.42E-01 | Calculated Value for dataset | | 9.71E-01 |
| Anderson Darling (AD) $A^2$ | | 2.77E-01 | AD Probability | Pass | 9.54E-01 |
| 90% UCL of the MVUE | | 1.59E+06 | 95% UCL of the MVUE | | 1.68E+06 |
| **Jackknife Results** | | | | | |
| Jackknifed Mean | | 1.32E+06 | Jackknifed Standard Error | | 1.48E+05 |
| 90% UCL of the mean | | 1.51E+06 | 95% UCL of the mean | | 1.57E+06 |
| 90% UCL of the MVUE[2] | | 1.53E+06 | 95% UCL of the MVUE[2] | | 1.59E+06 |

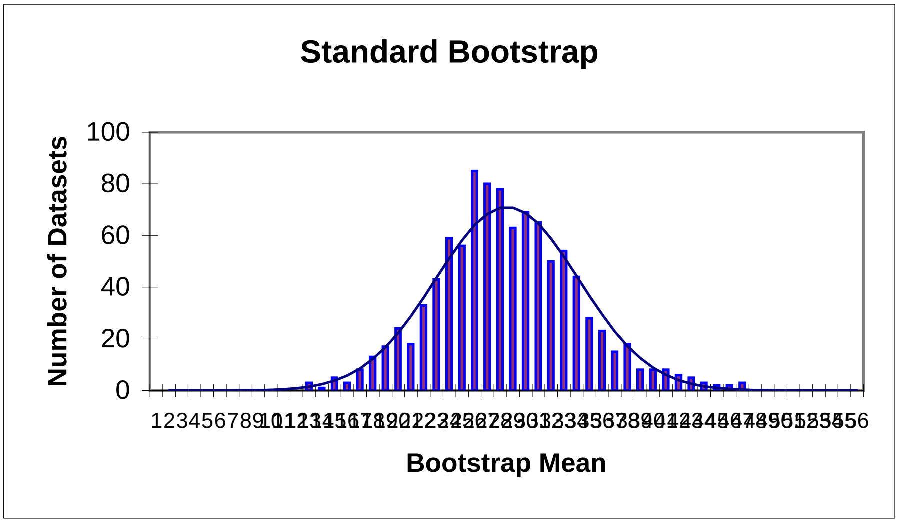
| | | | | | | |
|---|---|---|---|---|---|---|
| **Bootstrap Results (Raw Data)** | | | | | | |
| Standard Bootstrap | Mean | 1.32E+06 | 90% UCL | 1.52E+06 | 95% UCL | 1.57E+06 |
| Skewness | 2.88E-01 | | Kurtosis | 3.39E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 1.54E+06 | 95% UCL | | | 1.62E+06 |
| Skewness | -6.83E-01 | | Kurtosis | 4.57E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Hall's t Bootstrap | 90% UCL | 1.54E+06 | 95% UCL | | | 1.61E+06 |
| Skewness | ######## | | Kurtosis | 5.78E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |

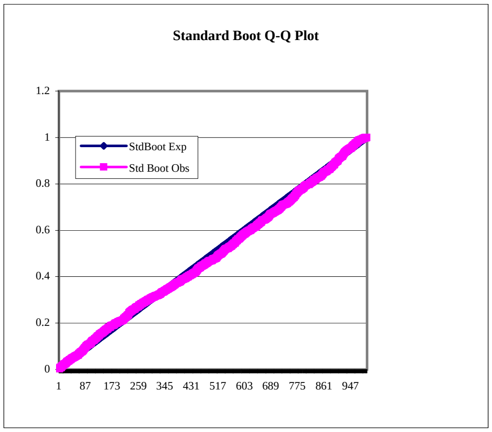


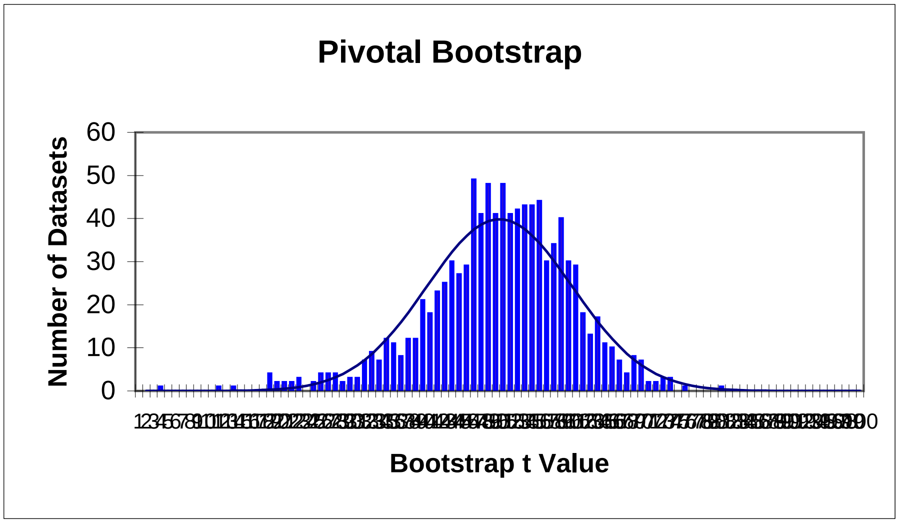
2 = Using the Jackknife

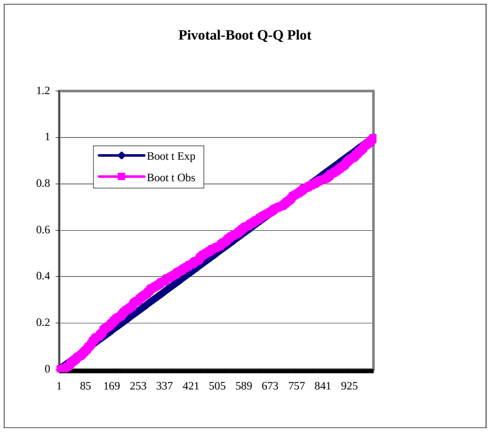
MVUE=Minimum Variance Unbiased Estimator
UCL=Upper Confidence Interval

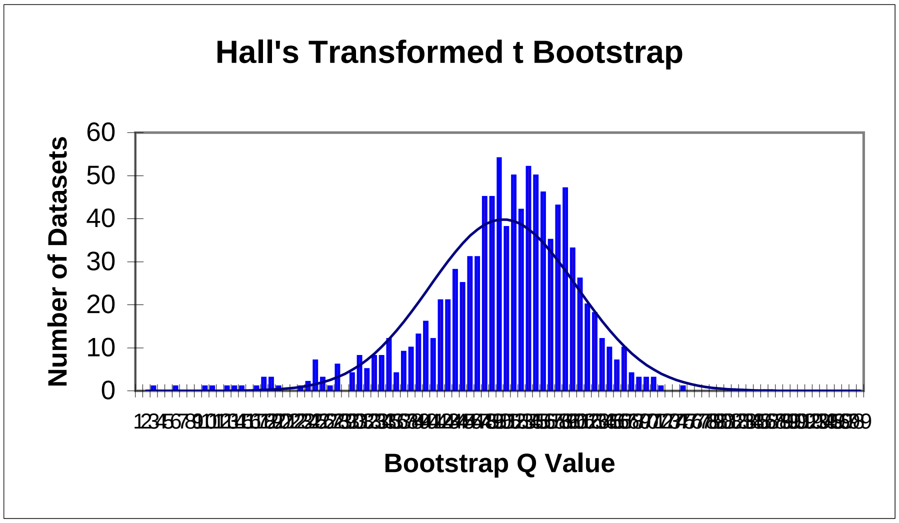
## BOOTSTRAP RESULTS FOR OCTANOL-WATER PARTITIONING COEFFCIENTS FOR TETRACHLOROBIPHENYLS OBTAINED FROM EISLER AND BELISLE (1996)

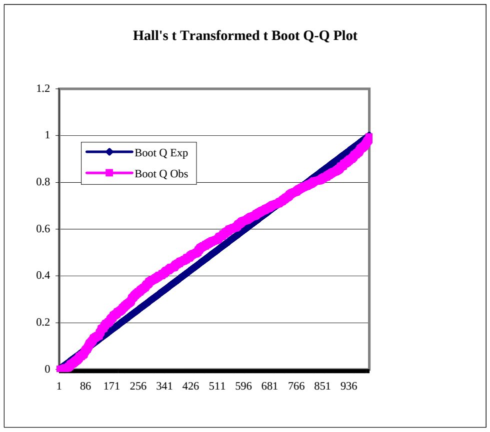


# STATISTICAL ANALYSIS OF OCTANOL-WATER PARTITIONING COEFFICIENTS OBTAINED FROM EISLER AND BELISLE (1996)

## Pentachlorobiphenyls

The data are best described as log-normally distributed and there were a sufficient number of detected values to perform statistical analysis. The CV is > 100%

| Congener | Value | $Log_{10}Kow$ |
|---|---|---|
| 82 | 1386756 | 6.142 |
| 83 | 1849269 | 6.267 |
| 84 | 1099006 | 6.041 |
| 85 | 4083194 | 6.611 |
| 86 | 1599558 | 6.204 |
| 87 | 2349633 | 6.371 |
| 88 | 32809529 | 7.516 |
| 89 | 1193988 | 6.077 |
| 90 | 2328091 | 6.367 |
| 91 | 1370882 | 6.137 |
| 92 | 2275097 | 6.357 |
| 93 | 1114295 | 6.047 |
| 94 | 1370882 | 6.137 |
| 95 | 1370882 | 6.137 |
| 96 | 521195 | 5.717 |
| 97 | 4688134 | 6.671 |
| 98 | 1370882 | 6.137 |
| 99 | 16255488 | 7.211 |
| 100 | 1725838 | 6.237 |
| 101 | 11776060 | 7.071 |
| 102 | 1468926 | 6.167 |
| 103 | 1686553 | 6.227 |
| 104 | 656145 | 5.817 |
| 105 | 4539416 | 6.657 |
| 106 | 4436086 | 6.647 |
| 107 | 5211947 | 6.717 |
| 108 | 5211947 | 6.717 |
| 109 | 3069022 | 6.487 |
| 110 | 3404082 | 6.532 |
| 111 | 5847901 | 6.767 |
| 112 | 2864178 | 6.457 |
| 113 | 3523709 | 6.547 |
| 114 | 4539416 | 6.657 |
| 115 | 3140509 | 6.497 |
| 116 | 2013724 | 6.304 |
| 117 | 2930893 | 6.467 |
| 118 | 13212956 | 7.121 |
| 119 | 3863670 | 6.587 |
| 120 | 6266139 | 6.797 |
| 121 | 4436086 | 6.647 |
| 122 | 4436086 | 6.647 |
| 123 | 5584702 | 6.747 |
| 124 | 5457579 | 6.737 |
| 125 | 3288516 | 6.517 |
| 126 | 7888601 | 6.897 |
| 127 | 9057326 | 6.957 |

| | | | | |
|---|---|---|---|---|
| Recommended Mean | MVUE of the log-mean | 4400776 | $Log_{10}$ | 6.644 |
| Recommended UCL | UCL based on Jackknifed MVUE | 5544897 | $Log_{10}$ | 6.744 |

| | | | | | |
|---|---|---|---|---|---|
| **Raw Data Results** | | | | | |
| Number of Values | | 46 | | | |
| Maximum Value | | 3.28E+07 | Minimum Value | | 5.21E+05 |
| **Normal (Non-transformed) Results** | | | | | |
| Normal Mean | | 4.58E+06 | Mean Standard Error | | 7.91E+05 |
| Standard Deviation | | 5.37E+06 | Coefficient of Variance (%) | | 117% |
| Dataset Skewness | Fail | 3.47E+00 | Dataset Kurtosis | Fail | 1.74E+01 |
| Tested for Normality | | W-Test | NormalityResult (a = 0.05) | | Fail |
| Critical Value | | 9.45E-01 | Calculated Value for dataset | | 6.19E-01 |
| 90% UCL using t-statistic | | 5.61E+06 | 95% UCL using -t-statistic | | 5.91E+06 |
| **Natural Log-Transformed Results** | | | | | |
| MVUE of the log-mean | | 4.40E+06 | Standard error of the log-me | | 6.14E+05 |
| Standard Deviation | | 8.39E-01 | Coefficient of Variance (%) | | 6% |
| Dataset Skewness | Pass | 3.45E-01 | Dataset Kurtosis | Pass | 3.11E+00 |
| Tested for Normality | | W-Test | Normality Result (a = 0.05) | | Pass |
| Critical Value | | 9.45E-01 | Calculated Value for dataset | | 9.79E-01 |
| Anderson Darling (AD) $A^2$ | | 3.48E-01 | AD Probability | Pass | 8.99E-01 |
| 90% UCL of the MVUE | | 5.46E+06 | 95% UCL of the MVUE | | 5.82E+06 |
| **Jackknife Results** | | | | | |
| Jackknifed Mean | | 4.58E+06 | Jackknifed Standard Error | | 7.91E+05 |
| 90% UCL of the mean | | 5.61E+06 | 95% UCL of the mean | | 5.91E+06 |
| 90% UCL of the MVUE[2] | | 5.28E+06 | 95% UCL of the MVUE[2] | | 5.54E+06 |

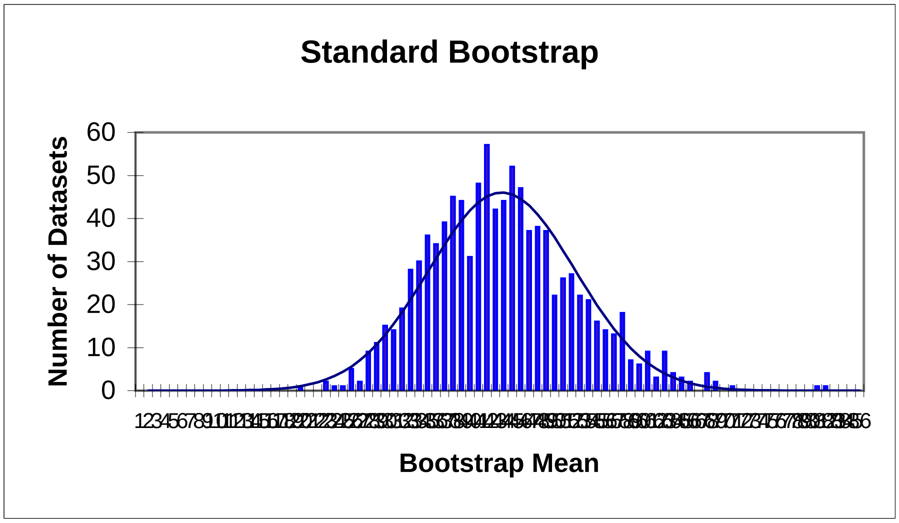
| | | | | | | |
|---|---|---|---|---|---|---|
| **Bootstrap Results (Raw Data)** | | | | | | |
| Standard Bootstrap | Mean | 4.57E+06 | 90% UCL | 5.58E+06 | 95% UCL | 5.87E+06 |
| Skewness | 4.76E-01 | | Kurtosis | 3.43E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 6.39E+06 | 95% UCL | 7.10E+06 | | |
| Skewness | -1.6E+00 | | Kurtosis | 7.30E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Hall's t Bootstrap | 90% UCL | 6.52E+06 | 95% UCL | 7.20E+06 | | |
| Skewness | -2.6E+00 | | Kurtosis | 1.58E+01 | | |
| Quantile fit is poor do not use Bootstrap Results | | | | | | |

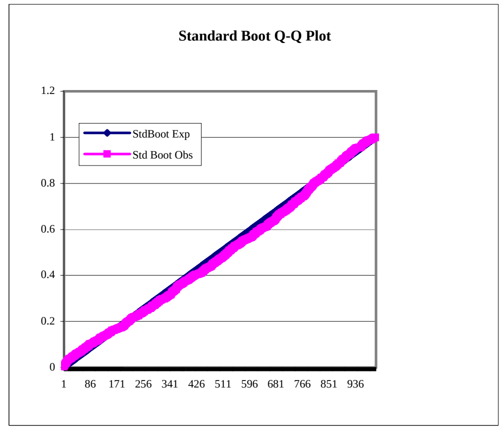


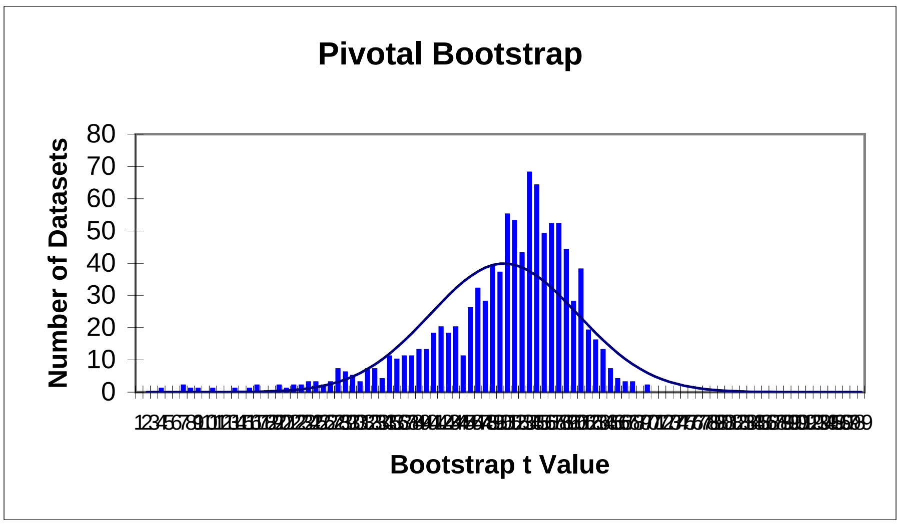
2 = Using the Jackknife

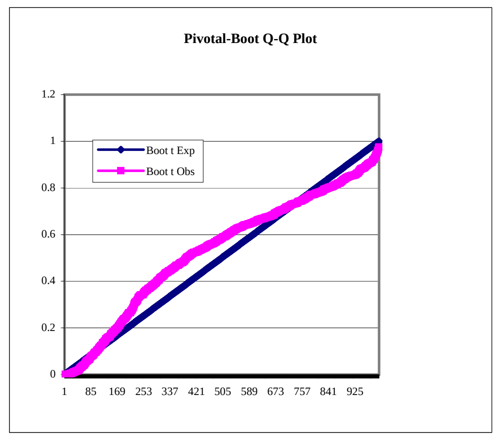
MVUE=Minimum Variance Unbiased Estimator
UCL=Upper Confidence Interval

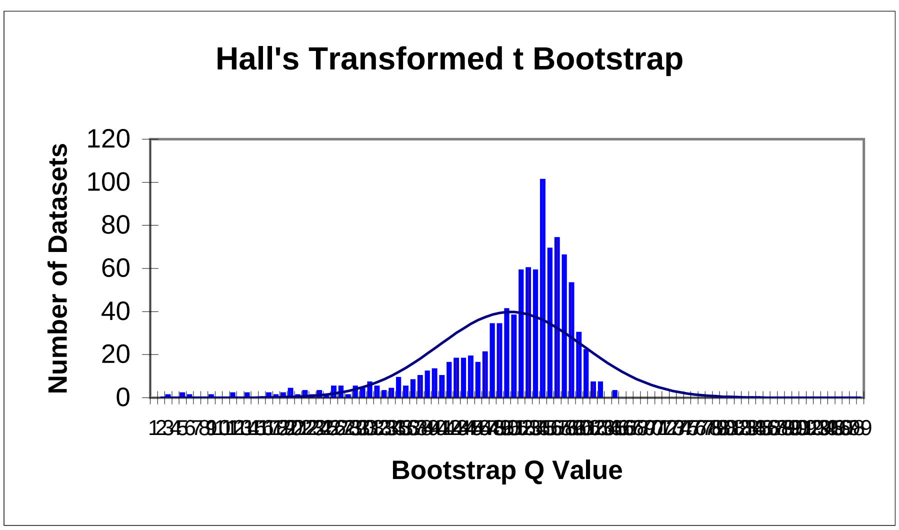
## BOOTSTRAP RESULTS FOR OCTANOL-WATER PARTITIONING COEFFCIENTS FOR PENTACHLOROBIPHENYLS OBTAINED FROM EISLER AND BELISLE (1996)

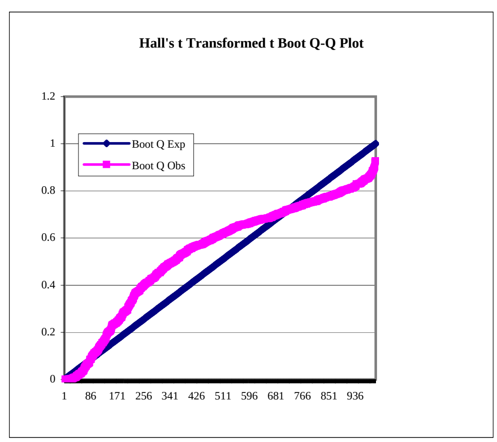


# STATISTICAL ANALYSIS OF OCTANOL-WATER PARTITIONING COEFFICIENTS OBTAINED FROM EISLER AND BELISLE (1996)

## Hexachlorobiphenyls

The data are best described as log-normally distributed and there were a sufficient number of detected values to perform statistical analysis. The CV is less than 100%

| | | | | |
|---|---|---|---|---|
| Recommended Mean | MVUE of the log-mean | 13630937 | $Log_{10}$ | 7.135 |
| Recommended UCL | UCL based on H-statistic | 18596711 | $Log_{10}$ | 7.269 |

| Congener | Value | $Log_{10}Kow$ |
|---|---|---|
| 128 | 9141132 | 6.961 |
| 129 | 20941125 | 7.321 |
| 130 | 24603676 | 7.391 |
| 131 | 3863670 | 6.587 |
| 132 | 3863670 | 6.587 |
| 133 | 7362071 | 6.867 |
| 134 | 20137242 | 7.304 |
| 135 | 14157938 | 7.151 |
| 136 | 3243396 | 6.511 |
| 137 | 51404365 | 7.711 |
| 138 | 27605779 | 7.441 |
| 139 | 4753352 | 6.677 |
| 140 | 4753352 | 6.677 |
| 141 | 39084090 | 7.592 |
| 142 | 3288516 | 6.517 |
| 143 | 4045759 | 6.607 |
| 144 | 4753352 | 6.677 |
| 145 | 1807174 | 6.257 |
| 146 | 7888601 | 6.897 |
| 147 | 4436086 | 6.647 |
| 148 | 5457579 | 6.737 |
| 149 | 19098533 | 7.281 |
| 150 | 2123244 | 6.327 |
| 151 | 4436086 | 6.647 |
| 152 | 1686553 | 6.227 |
| 153 | 56363766 | 7.751 |
| 154 | 5847901 | 6.767 |
| 155 | 13273945 | 7.123 |
| 156 | 15381546 | 7.187 |
| 157 | 15381546 | 7.187 |
| 158 | 10641430 | 7.027 |
| 159 | 17660378 | 7.247 |
| 160 | 8649679 | 6.937 |
| 161 | 12217997 | 7.087 |
| 162 | 17660378 | 7.247 |
| 163 | 9931160 | 6.997 |
| 164 | 10641430 | 7.027 |
| 165 | 11402498 | 7.057 |
| 166 | 8649679 | 6.937 |
| 167 | 18923436 | 7.277 |
| 168 | 13091819 | 7.117 |
| 169 | 26730064 | 7.427 |

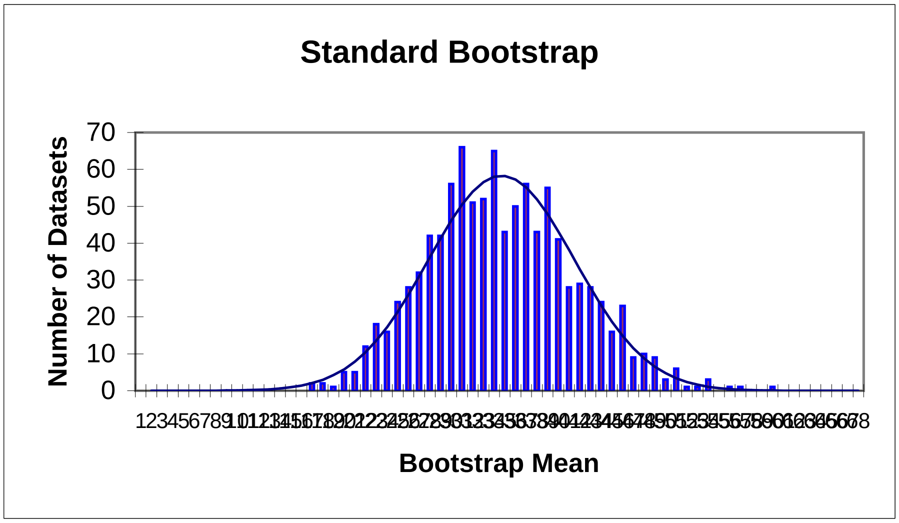
| Raw Data Results | | | | |
|---|---|---|---|---|
| Number of Values | 42 | | | |
| Maximum Value | 5.64E+07 | Minimum Value | | 1.69E+06 |
| **Normal (Non-transformed) Results** | | | | |
| Normal Mean | 1.35E+07 | Mean Standard Error | | 1.90E+06 |
| Standard Deviation | 1.23E+07 | Coefficient of Variance (%) | | 91% |
| Dataset Skewness | Fail 1.83E+00 | Dataset Kurtosis | Fail | 6.35E+00 |
| Tested for Normality | W-Test | NormalityResult (a = 0.05) | | Fail |
| Critical Value | 9.42E-01 | Calculated Value for dataset | | 7.91E-01 |
| 90% UCL using t-statistic | 1.60E+07 | 95% UCL using -t-statistic | | 1.67E+07 |
| **Natural Log-Transformed Results** | | | | |
| MVUE of the log-mean | 1.36E+07 | Standard error of the log-me | | 2.07E+06 |
| Standard Deviation | 8.68E-01 | Coefficient of Variance (%) | | 5% |
| Dataset Skewness | Pass -2.00E-02 | Dataset Kurtosis | Pass | 2.29E+00 |
| Tested for Normality | W-Test | Normality Result (a = 0.05) | | Pass |
| Critical Value | 9.42E-01 | Calculated Value for dataset | | 9.76E-01 |
| Anderson Darling (AD) $A^2$ | 2.41E-01 | AD Probability | Pass | 9.75E-01 |
| 90% UCL of the MVUE | 1.73E+07 | 95% UCL of the MVUE | | 1.86E+07 |
| **Jackknife Results** | | | | |
| Jackknifed Mean | 1.35E+07 | Jackknifed Standard Error | | 1.90E+06 |
| 90% UCL of the mean | 1.60E+07 | 95% UCL of the mean | | 1.67E+07 |
| 90% UCL of the MVUE[2] | 1.62E+07 | 95% UCL of the MVUE[2] | | 1.70E+07 |

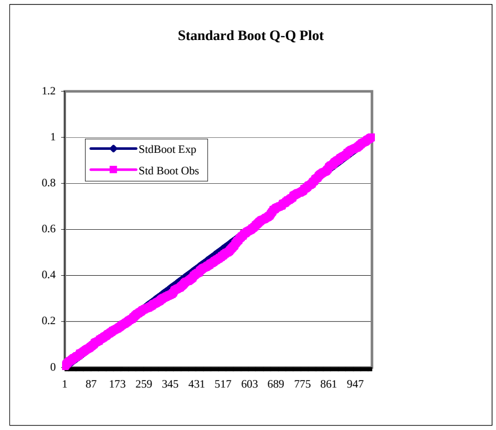
| Bootstrap Results (Raw Data) | | | | | | |
|---|---|---|---|---|---|---|
| Standard Bootstrap | Mean | 1.35E+07 | 90% UCL | 1.59E+07 | 95% UCL | 1.65E+07 |
| Skewness | 2.54E-01 | | Kurtosis | 2.89E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 1.66E+07 | 95% UCL | | | 1.76E+07 |
| Skewness | -8.04E-01 | | Kurtosis | 4.27E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Hall's t Bootstrap | 90% UCL | 1.65E+07 | 95% UCL | | | 1.82E+07 |
| Skewness | -1.3E+00 | | Kurtosis | 6.13E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |

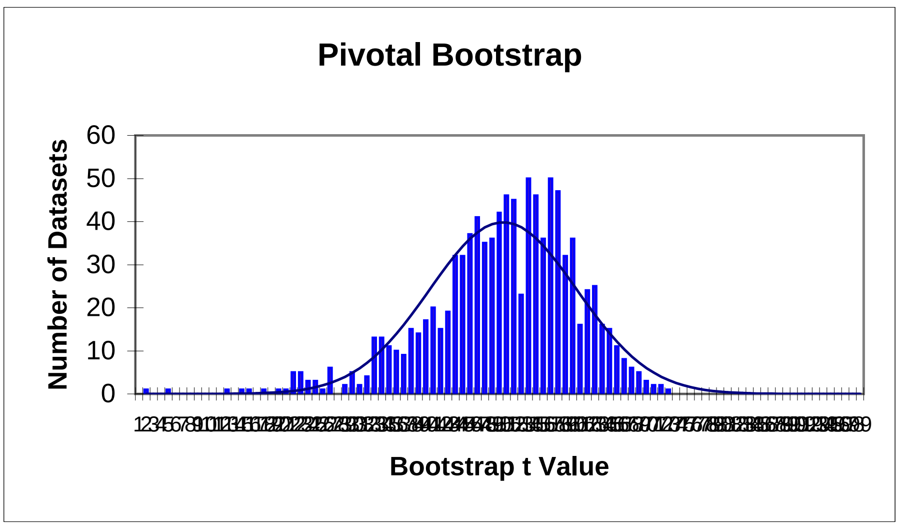


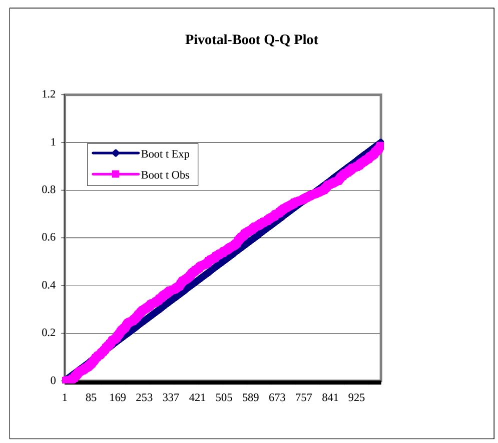
MVUE=Minimum Variance Unbiased Estimator
2 = Using the Jackknife
UCL=Upper Confidence Interval

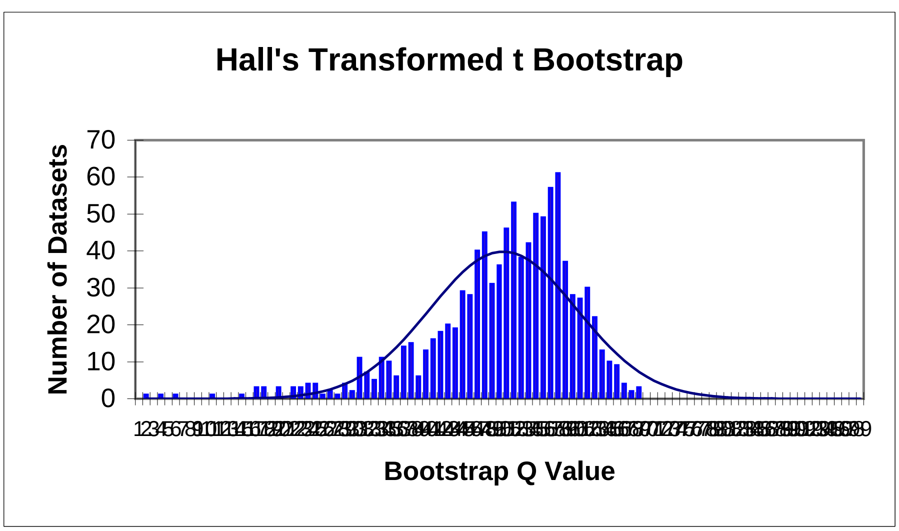
# BOOTSTRAP RESULTS FOR OCTANOL-WATER PARTITIONING COEFFCIENTS FOR HEXACHLOROBIPHENYLS OBTAINED FROM EISLER AND BELISLE (1996)

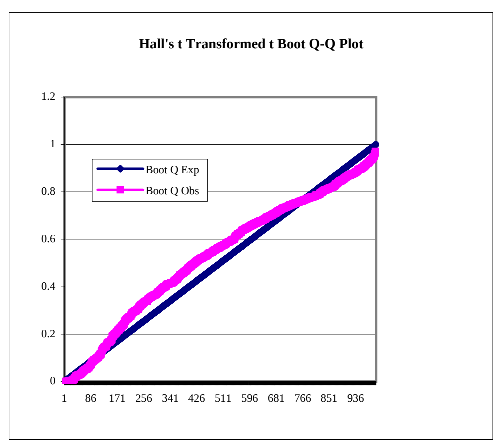


# STATISTICAL ANALYSIS OF OCTANOL-WATER PARTITIONING COEFFICIENTS OBTAINED FROM EISLER AND BELISLE (1996)

## Heptachlorobiphenyls

The data are best described as log-normally distributed and there were a sufficient number of detected values to perform statistical analysis. The CV is less than 100%

| Congener | Value | $Log_{10}Kow$ |
|---|---|---|
| 170 | 18923436 | 7.277 |
| 171 | 5058247 | 6.704 |
| 172 | 21727012 | 7.337 |
| 173 | 10641430 | 7.027 |
| 174 | 13091819 | 7.117 |
| 175 | 15031420 | 7.177 |
| 176 | 5847901 | 6.767 |
| 177 | 12217997 | 7.087 |
| 178 | 14028137 | 7.147 |
| 179 | 5457579 | 6.737 |
| 180 | 23280913 | 7.367 |
| 181 | 13091819 | 7.117 |
| 182 | 16106456 | 7.207 |
| 183 | 16106456 | 7.207 |
| 184 | 7194490 | 6.857 |
| 185 | 85703785 | 7.933 |
| 186 | 4977371 | 6.697 |
| 187 | 15031420 | 7.177 |
| 188 | 6714289 | 6.827 |
| 189 | 52119471 | 7.717 |
| 190 | 29308932 | 7.467 |
| 191 | 36057864 | 7.557 |
| 192 | 33651157 | 7.527 |
| 193 | 33651157 | 7.527 |

| | | | | |
|---|---|---|---|---|
| Recommended Mean | MVUE of the log-mean | 20323408 | $Log_{10}$ | 7.308 |
| Recommended UCL | UCL based on H-statistic | 29257630 | $Log_{10}$ | 7.466 |

**Raw Data Results**

| | | | | | |
|---|---|---|---|---|---|
| Number of Values | | 24 | | | |
| Maximum Value | | 8.57E+07 | Minimum Value | | 4.98E+06 |

**Normal (Non-transformed) Results**

| | | | | | |
|---|---|---|---|---|---|
| Normal Mean | | 2.06E+07 | Mean Standard Error | | 3.72E+06 |
| Standard Deviation | | 1.82E+07 | Coefficient of Variance (%) | | 88% |
| Dataset Skewness | Fail | 2.02E+00 | Dataset Kurtosis | Fail | 7.33E+00 |
| Tested for Normality | | W-Test | NormalityResult (a = 0.05) | | Fail |
| Critical Value | | 9.16E-01 | Calculated Value for dataset | | 7.58E-01 |
| 90% UCL using t-statistic | | 2.55E+07 | 95% UCL using -t-statistic | | 2.70E+07 |

**Natural Log-Transformed Results**

| | | | | | |
|---|---|---|---|---|---|
| MVUE of the log-mean | | 2.03E+07 | Standard error of the log-me | | 3.41E+06 |
| Standard Deviation | | 7.57E-01 | Coefficient of Variance (%) | | 5% |
| Dataset Skewness | Pass | 2.56E-01 | Dataset Kurtosis | Pass | 2.33E+00 |
| Tested for Normality | | W-Test | Normality Result (a = 0.05) | | Pass |
| Critical Value | | 9.16E-01 | Calculated Value for dataset | | 9.62E-01 |
| Anderson Darling (AD) $A^2$ | | 2.91E-01 | AD Probability | Pass | 9.45E-01 |
| 90% UCL of the MVUE | | 2.68E+07 | 95% UCL of the MVUE | | 2.93E+07 |

**Jackknife Results**

| | | | |
|---|---|---|---|
| Jackknifed Mean | 2.06E+07 | Jackknifed Standard Error | 3.72E+06 |
| 90% UCL of the mean | 2.55E+07 | 95% UCL of the mean | 2.70E+07 |
| 90% UCL of the MVUE[2] | 2.51E+07 | 95% UCL of the MVUE[2] | 2.65E+07 |

**Bootstrap Results (Raw Data)**

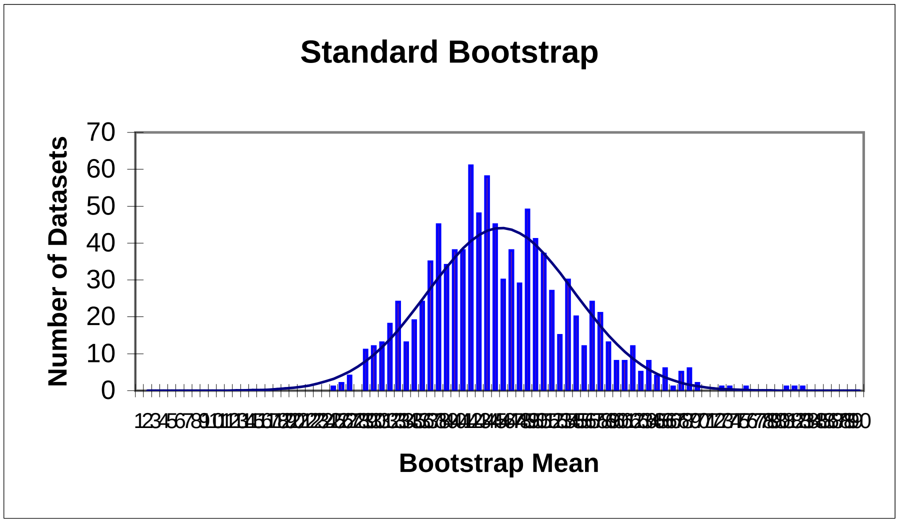
| | | | | | | |
|---|---|---|---|---|---|---|
| Standard Bootstrap | Mean | 2.05E+07 | 90% UCL | 2.52E+07 | 95% UCL | 2.66E+07 |
| Skewness | 5.50E-01 | | Kurtosis | 3.48E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 2.87E+07 | 95% UCL | | 3.19E+07 | |
| Skewness | -1.2E+00 | | Kurtosis | 5.69E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Hall's t Bootstrap | 90% UCL | 2.92E+07 | 95% UCL | | 3.25E+07 | |
| Skewness | -1.8E+00 | | Kurtosis | 7.95E+00 | | |
| Quantile fit is poor do not use Bootstrap Results | | | | | | |

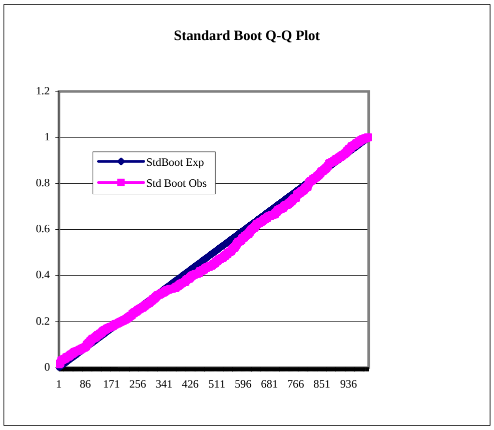


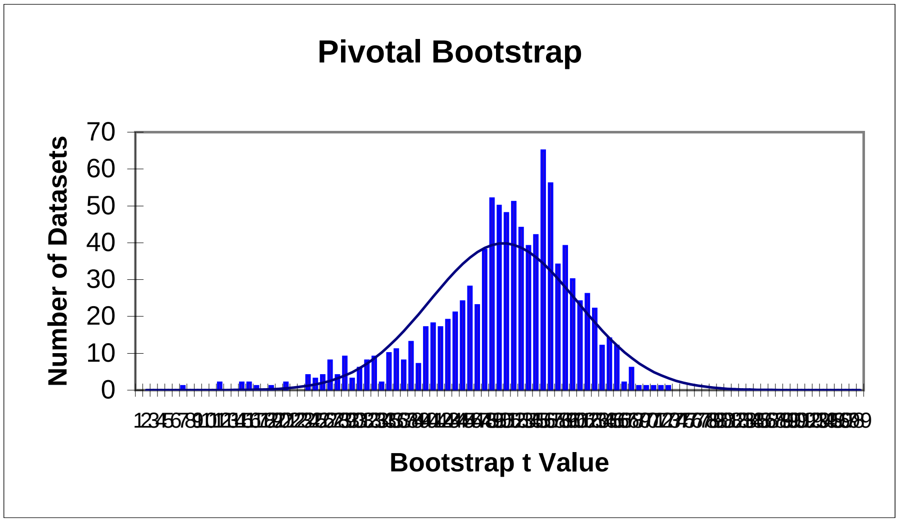
2 = Using the Jackknife

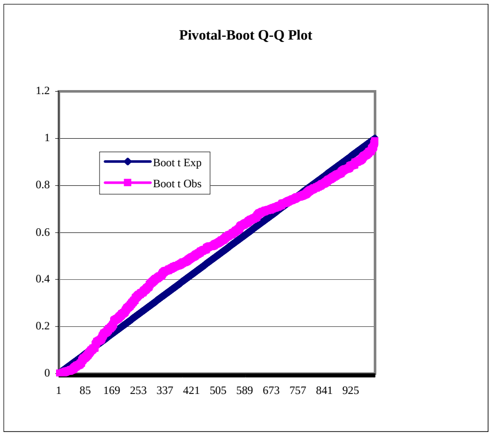
MVUE=Minimum Variance Unbiased Estimator
UCL=Upper Confidence Interval

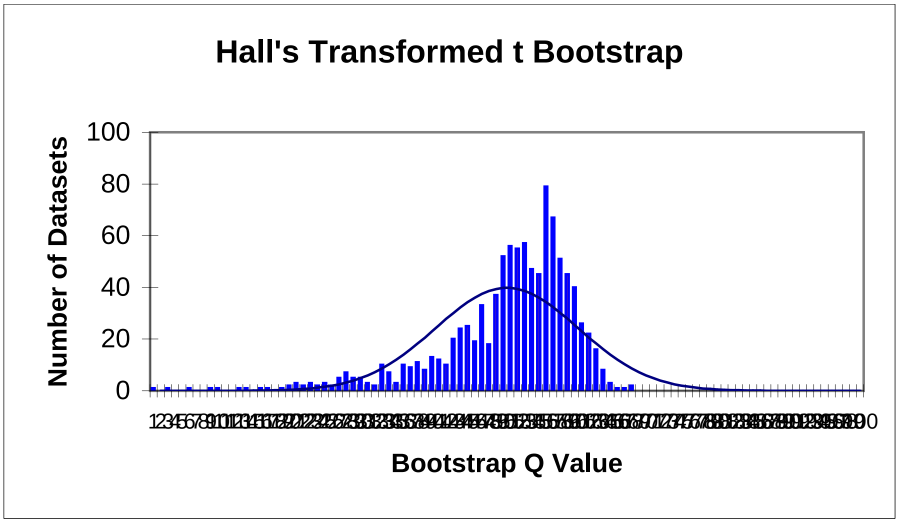
**BOOTSTRAP RESULTS FOR OCTANOL-WATER PARTITIONING COEFFCIENTS FOR HEPTACHLOROBIPHENYLS OBTAINED FROM EISLER AND BELISLE (1996)**

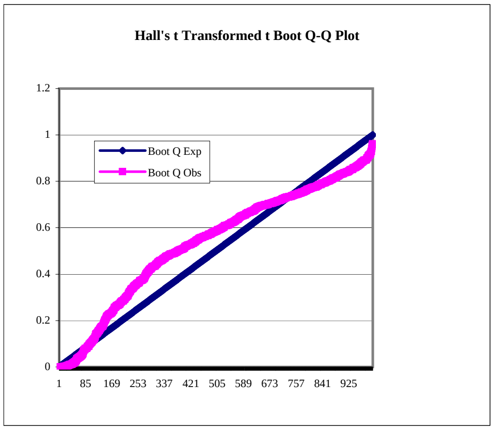


# STATISTICAL ANALYSIS OF OCTANOL-WATER PARTITIONING COEFFICIENTS OBTAINED FROM EISLER AND BELISLE (1996)

## Octachlorobiphenyls

There is a sufficient number of values for statistical analysis - the data were found to be non-normally distributed and the number of samples is below 15

| Congener | Value | $Log_{10}Kow$ |
|---|---|---|
| 194 | 481947798 | 8.683 |
| 195 | 36897760 | 7.567 |
| 196 | 45394162 | 7.657 |
| 197 | 20276827 | 7.307 |
| 198 | 42364297 | 7.627 |
| 199 | 16106456 | 7.207 |
| 200 | 18923436 | 7.277 |
| 201 | 42364297 | 7.627 |
| 202 | 264850014 | 8.423 |
| 203 | 45394162 | 7.657 |
| 204 | 20276827 | 7.307 |
| 205 | 101624869 | 8.007 |

| | | | | |
|---|---|---|---|---|
| Recommended Mean | Jackknife Mean | 94701742 | $Log_{10}$ | 7.976 |
| Recommended UCL | Jackknifed UCL | 167287874 | $Log_{10}$ | 8.223 |

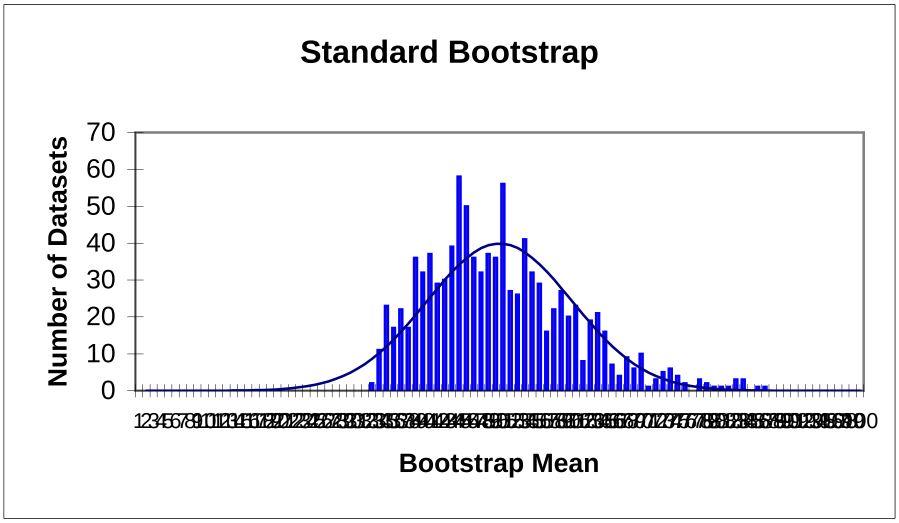
| | | | | | |
|---|---|---|---|---|---|
| **Raw Data Results** | | | | | |
| Number of Values | | 12 | | | |
| Maximum Value | | 4.82E+08 | Minimum Value | | 1.61E+07 |
| **Normal (Non-transformed) Results** | | | | | |
| Normal Mean | | 9.47E+07 | Mean Standard Error | | 4.04E+07 |
| Standard Deviation | | 1.40E+08 | Coefficient of Variance (%) | | 148% |
| Dataset Skewness | Fail | 1.84E+00 | Dataset Kurtosis | Pass | 5.10E+00 |
| Tested for Normality | | W-Test | NormalityResult (a = 0.05) | | Fail |
| Critical Value | | 8.59E-01 | Calculated Value for dataset | | 6.03E-01 |
| 90% UCL using t-statistic | | 1.50E+08 | 95% UCL using -t-statistic | | 1.67E+08 |
| **Natural Log-Transformed Results** | | | | | |
| MVUE of the log-mean | | 8.17E+07 | Standard error of the log-me | | 2.70E+07 |
| Standard Deviation | | 1.06E+00 | Coefficient of Variance (%) | | 6% |
| Dataset Skewness | Pass | 9.04E-01 | Dataset Kurtosis | Pass | 2.52E+00 |
| Tested for Normality | | W-Test | Normality Result (a = 0.05) | | Fail |
| Critical Value | | 8.59E-01 | Calculated Value for dataset | | 8.56E-01 |
| Anderson Darling (AD) $A^2$ | | 7.38E-01 | AD Probability | Pass | 5.27E-01 |
| 90% UCL of the MVUE | | 1.74E+08 | 95% UCL of the MVUE | | 2.31E+08 |
| **Jackknife Results** | | | | | |
| Jackknifed Mean | | 9.47E+07 | Jackknifed Standard Error | | 4.04E+07 |
| 90% UCL of the mean | | 1.50E+08 | 95% UCL of the mean | | 1.67E+08 |
| 90% UCL of the MVUE[2] | | 1.26E+08 | 95% UCL of the MVUE[2] | | 1.42E+08 |
| **Bootstrap Results (Raw Data)** | | | | | |
| Standard Bootstrap | Mean | 9.48E+07 | 90% UCL 1.46E+08 | 95% UCL | 1.60E+08 |
| Skewness | 7.41E-01 | | Kurtosis 3.45E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 2.95E+08 | 95% UCL | | 4.52E+08 |
| Skewness | -3.4E+00 | | Kurtosis 1.52E+01 | | |
| Quantile fit is poor do not use Bootstrap Results | | | | | |
| Hall's t Bootstrap | 90% UCL | 2.92E+08 | 95% UCL | | 3.58E+08 |
| Skewness | -4.8E+00 | | Kurtosis 3.49E+01 | | |
| Quantile fit is poor do not use Bootstrap Results | | | | | |

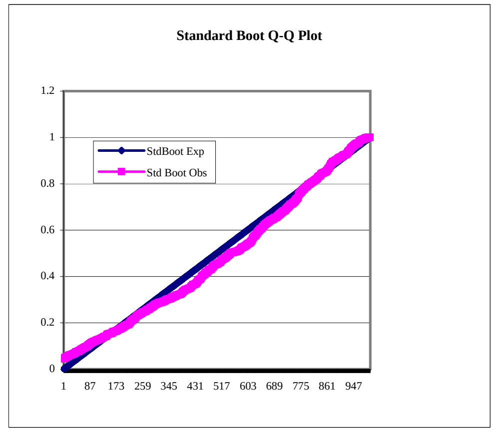


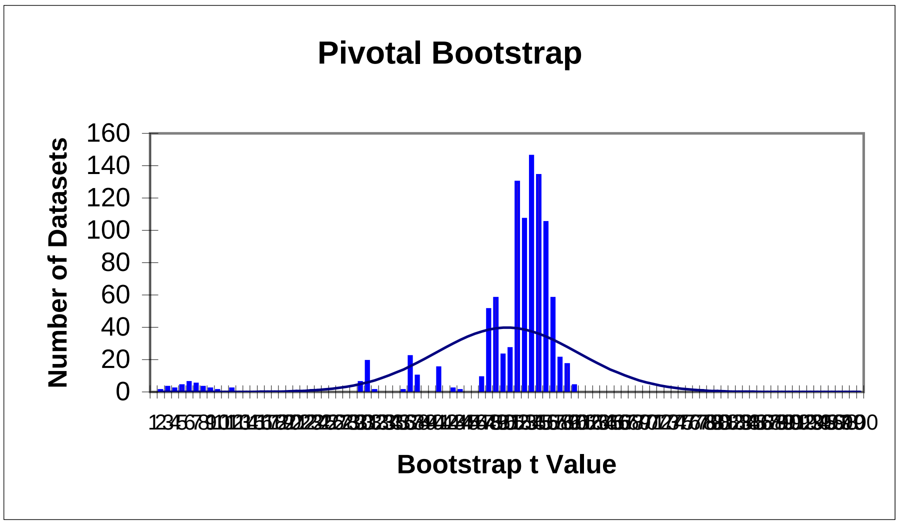
2 = Using the Jackknife

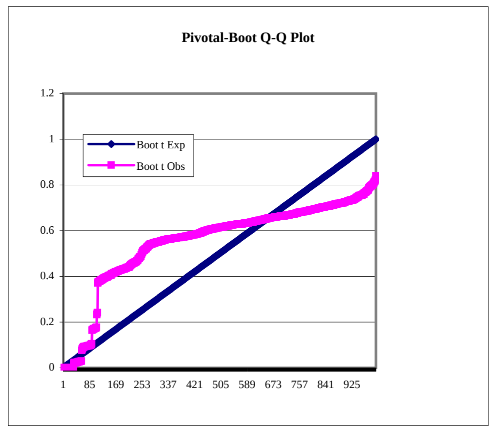
MVUE=Minimum Variance Unbiased Estimator
UCL=Upper Confidence Interval

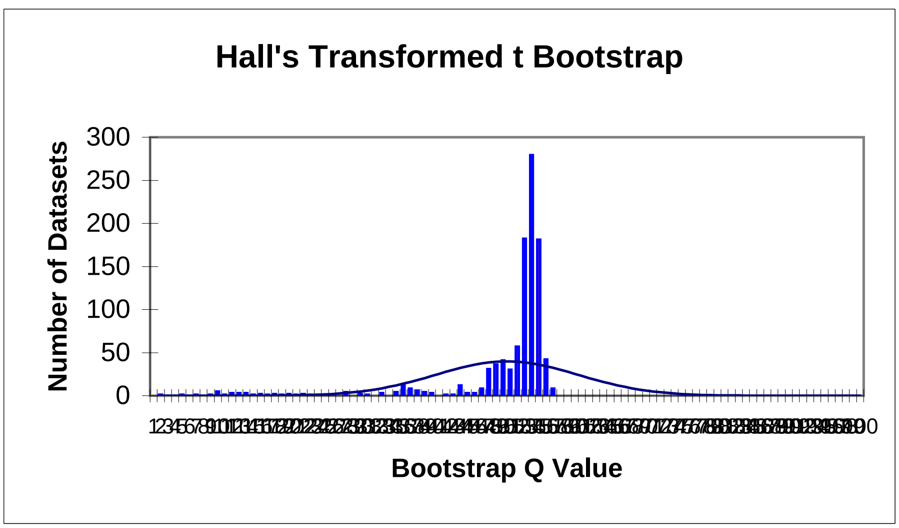
# BOOTSTRAP RESULTS FOR OCTANOL-WATER PARTITIONING COEFFCIENTS FOR OCTACHLOROBIPHENYLS OBTAINED FROM EISLER AND BELISLE (1996)

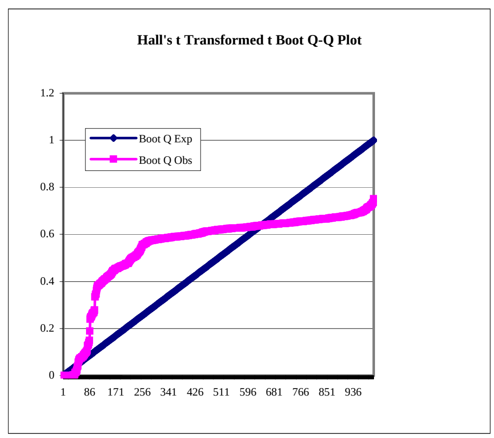


## SOLUBILITY, $K_{oc}$, AND $K_{ow}$ OF SEVERAL PCBs

| Compound | Solubility (ppb) | log S | $K_{oc}$ | log $K_{oc}$ |
|---|---|---|---|---|
| Monochlorobiphenyls | | | | |
| 2- | 5,900 | 3.77 | 2,951 | 3.47 |
| 3- | 3,500 | 3.54 | 4,168 | 3.62 |
| 4- | 1,190 | 3.08 | 7,943 | 3.90 |
| Dichlorobiphenyls | | | | |
| 2,4- | 1,400 | 3.15 | 7,244 | 3.86 |
| 2,2'- | 1,500 | 3.18 | 6,918 | 3.84 |
| 2,4'- | 1,260 | 3.10 | 8,000 | 3.90 |
| 4,4'- | 80 | 1.90 | 42,658 | 4.63 |
| Trichlorobiphenyls | | | | |
| 2,4,4'- | 85 | 1.93 | 40,738 | 4.61 |
| 2',3,4- | 78 | 1.89 | 43,652 | 4.64 |
| Tetrachlorobiphenyls | | | | |
| 2,2',5,5'- | 36 | 1.56 | 47,000 | 4.67 |
| 2,2',3,3'- | 34 | 1.53 | 72,443 | 4.86 |
| 2,2',3,5'- | 170 | 2.23 | 26,915 | 4.43 |
| 2,2',4,4'- | 66 | 1.82 | 47,863 | 4.68 |
| 2,3',4,4'- | 58 | 1.76 | 52,480 | 4.72 |
| 2,3',4,5'- | 41 | 1.61 | 64,565 | 4.81 |
| 3,3',4,4'- | 180 | 2.26 | 25,633 | 4.41 |
| Pentachlorobiphenyls | | | | |
| 2,2',3,4,5'- | 22 | 1.34 | 95,324 | 4.98 |
| 2,2',4,5,5'- | 31 | 1.49 | 76,948 | 4.89 |
| Hexachlorobiphenyl | | | | |
| 2,4,5,2',4',5'- | 0.95 | -0.02 | 1,200,000 | 6.08 |

Source = Chou, S.F.J., and R.A. Griffin. 1986. Solubility and soil mobility of polychlorinated biphenyls. Chapter 5 IN PCBs in the Environment. J.S. Waid, Ed., CRC Press, Boca Ratob, FL.

# APPENDIX C

# CALCULATION OF HOMOLOG-SPECIFIC VAPOR PRESSURES

## VAPOR PRESSURE VALUES FROM OBERG (2001)

| PCB | Measured (mm Hg) | Homolog Group | Geomean for Homolog Group (mm Hg) | Vapor Pressure (Pa) |
|---|---|---|---|---|
| 1 | 1.38E-03 | Mono | 4.74E-03 | 6.32E-01 |
| 2 | 7.35E-03 | | | |
| 3 | 1.05E-02 | | | |
| 4 | 2.75E-03 | | | |
| 5 | m | | | |
| 6 | m | | | |
| 7 | 1.38E-03 | | | |
| 8 | 2.09E-03 | | | |
| 9 | 1.38E-03 | | | |
| 10 | m | | | |
| 11 | 6.49E-04 | | | |
| 12 | m | | | |
| 13 | m | | | |
| 14 | m | | | |
| 15 | 5.35E-04 | | | |
| 16 | m | | | |
| 17 | m | | | |
| 18 | 1.05E-03 | | | |
| 19 | m | | | |
| 20 | m | | | |
| 21 | m | | | |
| 22 | m | | | |
| 23 | m | | | |
| 24 | m | | | |
| 25 | m | | | |
| 26 | m | | | |
| 27 | m | | | |
| 28 | 1.95E-04 | | | |
| 29 | 9.75E-04 | | | |
| 30 | 7.16E-04 | | | |
| 31 | 4.00E-04 | | | |
| 32 | m | | | |
| 33 | 1.03E-04 | | | |
| 34 | m | | | |
| 35 | m | | | |
| 36 | m | | | |
| 37 | m | | | |
| 38 | m | | | |
| 39 | m | | | |
| 40 | 7.35E-05 | | | |
| 41 | m | | | |
| 42 | m | | | |
| 43 | m | | | |
| 44 | m | | | |
| 45 | m | | | |
| 46 | m | | | |
| 47 | 8.63E-05 | | | |
| 48 | m | | | |
| 49 | 8.48E-06 | | | |
| 50 | m | | | |
| 51 | m | | | |
| 52 | m | | | |
| 53 | 2.25E-05 | | | |

## VAPOR PRESSURE VALUES FROM OBERG (2001)

| PCB | Measured (mm Hg) | Homolog Group | Geomean for Homolog Group (mm Hg) | Vapor Pressure (Pa) |
|---|---|---|---|---|
| 54 | m | | | |
| 55 | m | | | |
| 56 | m | | | |
| 57 | m | | | |
| 58 | m | | | |
| 59 | m | | | |
| 60 | m | | | |
| 61 | 3.75E-05 | | | |
| 62 | m | | | |
| 63 | m | | | |
| 64 | m | | | |
| 65 | m | | | |
| 66 | 4.62E-05 | | | |
| 67 | m | | | |
| 68 | m | | | |
| 69 | m | | | |
| 70 | 4.08E-05 | | | |
| 71 | m | | | |
| 72 | m | | | |
| 73 | m | | | |
| 74 | m | | | |
| 75 | m | | | |
| 76 | m | | | |
| 77 | 1.64E-05 | | | |
| 78 | m | | | |
| 79 | m | | | |
| 80 | m | | | |
| 81 | m | | | |
| 82 | m | | | |
| 83 | m | | | |
| 84 | m | | | |
| 85 | m | | | |
| 86 | 6.97E-05 | | | |
| 87 | 1.70E-05 | | | |
| 88 | m | | | |
| 89 | m | | | |
| 90 | m | | | |
| 91 | m | | | |
| 92 | m | | | |
| 93 | m | | | |
| 94 | m | | | |
| 95 | m | | | |
| 96 | m | | | |
| 97 | m | | | |
| 98 | m | | | |
| 99 | 2.20E-05 | | | |
| 100 | m | | | |
| 101 | 2.52E-05 | | | |
| 102 | m | | | |
| 103 | m | | | |
| 104 | m | | | |
| 105 | 6.53E-06 | | | |
| 106 | m | | | |

## VAPOR PRESSURE VALUES FROM OBERG (2001)

| PCB | Measured (mm Hg) | Homolog Group | Geomean for Homolog Group (mm Hg) | Vapor Pressure (Pa) |
|---|---|---|---|---|
| 107 | m | | | |
| 108 | m | | | |
| 109 | m | | | |
| 110 | m | | | |
| 111 | m | | | |
| 112 | m | | | |
| 113 | m | | | |
| 114 | m | | | |
| 115 | m | | | |
| 116 | m | | | |
| 117 | m | | | |
| 118 | 8.97E-06 | | | |
| 119 | m | | | |
| 120 | m | | | |
| 121 | m | | | |
| 122 | m | | | |
| 123 | m | | | |
| 124 | m | | | |
| 125 | m | | | |
| 126 | m | | | |
| 127 | m | | | |
| 128 | 2.56E-06 | | | |
| 129 | m | | | |
| 130 | m | | | |
| 131 | m | | | |
| 132 | m | | | |
| 133 | m | | | |
| 134 | 1.09E-06 | | | |
| 135 | m | | | |
| 136 | m | | | |
| 137 | m | | | |
| 138 | 3.79E-06 | | | |
| 139 | m | | | |
| 140 | m | | | |
| 141 | m | | | |
| 142 | m | | | |
| 143 | m | | | |
| 144 | m | | | |
| 145 | m | | | |
| 146 | m | | | |
| 147 | m | | | |
| 148 | m | | | |
| 149 | 8.43E-06 | | | |
| 150 | m | | | |
| 151 | 2.29E-06 | | | |
| 152 | m | | | |
| 153 | 3.43E-06 | | | |
| 154 | m | | | |
| 155 | 1.20E-05 | | | |
| 156 | 1.61E-06 | | | |
| 157 | m | | | |
| 158 | m | | | |
| 159 | m | | | |

## VAPOR PRESSURE VALUES FROM OBERG (2001)

| PCB | Measured (mm Hg) | Homolog Group | Geomean for Homolog Group (mm Hg) | Vapor Pressure (Pa) |
|---|---|---|---|---|
| 160 | m | | | |
| 161 | m | | | |
| 162 | m | | | |
| 163 | m | | | |
| 164 | m | | | |
| 165 | m | | | |
| 166 | m | | | |
| 167 | m | | | |
| 168 | m | | | |
| 169 | m | | | |
| 170 | 6.28E-07 | Hepta | 1.92E-06 | 2.56E-04 |
| 171 | 1.40E-06 | | | |
| 172 | m | | | |
| 173 | m | | | |
| 174 | m | | | |
| 175 | m | | | |
| 176 | m | | | |
| 177 | m | | | |
| 178 | m | | | |
| 179 | m | | | |
| 180 | 9.77E-07 | | | |
| 181 | m | | | |
| 182 | m | | | |
| 183 | m | | | |
| 184 | m | | | |
| 185 | m | | | |
| 186 | m | | | |
| 187 | m | | | |
| 188 | m | | | |
| 189 | m | | | |
| 190 | m | | | |
| 191 | m | | | |
| 192 | m | | | |
| 193 | m | | | |
| 194 | m | Octa | 6.48E-07 | 8.65E-05 |
| 195 | m | | | |
| 196 | m | | | |
| 197 | m | | | |
| 198 | m | | | |
| 199 | m | | | |
| 200 | m | | | |
| 201 | m | | | |
| 202 | 3.93E-06 | | | |
| 203 | m | | | |
| 204 | m | | | |
| 205 | m | | | |
| 206 | m | Nona | 2.07E-07 | 2.77E-05 |
| 207 | m | | | |
| 208 | m | | | |
| 209 | 1.06E-07 | Deca | 1.06E-07 | 1.41E-05 |

# PCB VAPOR PRESSURES OBTAINED FROM THE SCIENTIFIC LITERATURE

| | | | | | | |
|---|---|---|---|---|---|---|
| **Dichlorobiphenyls** | | | | | | |
| 4 | 0.1844115 | 1.52E-01 | 0.4235385 | 0.33538575 | | |
| 7 | 0.18137175 | 0.17529225 | 0.21176925 | | | |
| 9 | 0.1965705 | 0.23203425 | | | | |
| 11 | 0.033538575 | 0.06464535 | 9.22E-02 | | | |
| 12 | 0.00073562 | 0.053195625 | 0.078526875 | | | |
| 15 | 0.00328293 | 0.050763825 | 7.50E-02 | | | |
| **Trichlorobiphenylas** | | | | | | |
| 18 | 0.0761964 | 3.55E-02 | 0.0903819 | 0.076703025 | | |
| 26 | 0.032322675 | 1.82E-02 | 0.0352611 | 0.041239275 | | |
| 28 | 0.014489475 | 1.52E-02 | 0.027661725 | 0.033538575 | | |
| 30 | 0.0644427 | 0.09463755 | 0.11044425 | | | |
| **Tetrachlorobiphenyls** | | | | | | |
| 40 | 0.00109431 | 4.56E-03 | 1.11E-02 | 0.008805143 | | |
| 52 | 0.0129696 | 9.02E-02 | 1.93E-02 | 0.01844115 | | |
| 53 | 0.006707715 | 1.11E-02 | 0.035565075 | 0.026648475 | | |
| 54 | 0.00226968 | 6.59E-02 | 0.056640675 | | | |
| 77 | 1.82E-05 | 0.001398285 | 0.002117693 | | 5.87E-05 | |
| **Pentachlorobiphenyls** | | | | | | |
| 101 | 5.27E-04 | 1.42E-03 | 0.003576773 | 0.003586905 | | |
| 104 | 0.00433671 | 0.00433671 | | | | |
| **Hexachlorobiphenyls** | | | | | | |
| 128 | 2.94E-06 | 9.82853E-05 | 0.000358691 | 0.000366797 | | |
| 138 | | | | | 5.33E-04 | |
| 153 | 3.24E-05 | 2.53E-04 | 0.006626655 | 0.007001558 | 5.07E-05 | 1.20E-04 |
| 155 | 0.000480281 | 0.004427903 | | | | |
| 169 | | | | | 5.36E-05 | |

First four columns are from Fielder (2001) and the last two are from ATSDR (1995)
All vapor pressures are in Pascals (Pa)

# STATISTICAL ANALYSIS OF VAPOR PRESSURES OBTAINED FROM THE SCIENTIFIC LITERATURE

## Dichlorobiphenyl

The data are best described as normally distributed and there were a sufficient number of values to perform a statistical analysis.

*Vapor presure is in Pascals (Pa)*

| | Value |
|---|---|
| 1 | 0.1844115 |
| 2 | 0.1813718 |
| 3 | 0.1965705 |
| 4 | 0.0335386 |
| 5 | 0.0007356 |
| 6 | 0.0032829 |
| 7 | 0.1519875 |
| 8 | 0.1752923 |
| 9 | 0.2320343 |
| 10 | 0.0646454 |
| 11 | 0.0531956 |
| 12 | 0.0507638 |
| 13 | 0.4235385 |
| 14 | 0.2117693 |
| 15 | 0.0922058 |
| 16 | 0.0785269 |
| 17 | 0.0749805 |
| 18 | 0.3353858 |

| | | |
|---|---|---|
| Recommended Mean | Normal Mean | 1 |
| Recommended UCL | UCL based on t-statistic | 0.188130706 |

| | | | | | |
|---|---|---|---|---|---|
| **Raw Data Results** | | | | | |
| Number of Values | | 18 | | | |
| Maximum Value | | 4.24E-01 | Minimum Value | | 7.36E-04 |
| **Normal (Non-transformed) Results** | | | | | |
| Normal Mean | | 1.41E-01 | Mean Standard Error | | 2.69E-02 |
| Standard Deviation | | 1.14E-01 | Coefficient of Variance (%) | | 81% |
| Dataset Skewness | Pass | 8.24E-01 | Dataset Kurtosis | Pass | 2.94E+00 |
| Tested for Normality | | W-Test | NormalityResult (a = 0.05) | | Pass |
| Critical Value | | 8.97E-01 | Calculated Value for dataset | | 9.14E-01 |
| 90% UCL using t-statistic | | 1.77E-01 | 95% UCL using -t-statistic | | 1.88E-01 |
| **Natural Log-Transformed Results** | | | | | |
| MVUE of the log-mean | | 2.41E-01 | Standard error of the log-me | | 1.08E-01 |
| Standard Deviation | | 1.60E+00 | Coefficient of Variance (%) | | -62% |
| Dataset Skewness | Fail | -1.6E+00 | Dataset Kurtosis | Pass | 4.98E+00 |
| Tested for Normality | | W-Test | Normality Result (a = 0.05) | | Fail |
| Critical Value | | 8.97E-01 | Calculated Value for dataset | | 7.87E-01 |
| Anderson Darling (AD) $A^2$ | | 1.39E+00 | AD Probability | Fail | 2.06E-01 |
| 90% UCL of the MVUE | | 7.59E-01 | 95% UCL of the MVUE | | 1.12E+00 |
| **Jackknife Results** | | | | | |
| Jackknifed Mean | | 1.41E-01 | Jackknifed Standard Error | | 2.69E-02 |
| 90% UCL of the mean | | 1.77E-01 | 95% UCL of the mean | | 1.88E-01 |
| 90% UCL of the MVUE[2] | | 3.68E-01 | 95% UCL of the MVUE[2] | | 4.01E-01 |

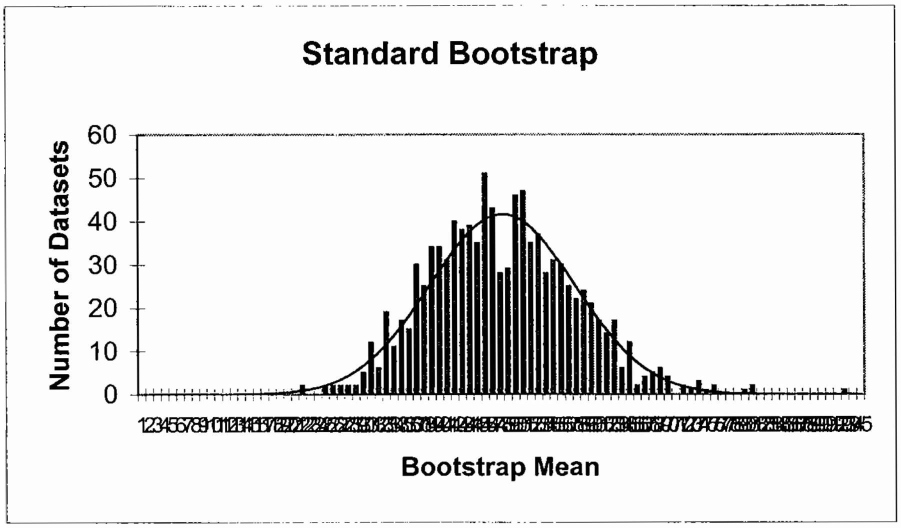
| | | | | | | |
|---|---|---|---|---|---|---|
| **Bootstrap Results (Raw Data)** | | | | | | |
| Standard Bootstrap | Mean | 1.40E-01 | 90% UCL | 1.75E-01 | 95% UCL | 1.84E-01 |
| Skewness | 3.52E-01 | | Kurtosis | 3.41E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 1.88E-01 | 95% UCL | | | 2.03E-01 |
| Skewness | -5.96E-01 | | Kurtosis | 4.46E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Hall's t Bootstrap | 90% UCL | 1.83E-01 | 95% UCL | | | 1.97E-01 |
| Skewness | -1.5E+00 | | Kurtosis | 9.86E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |

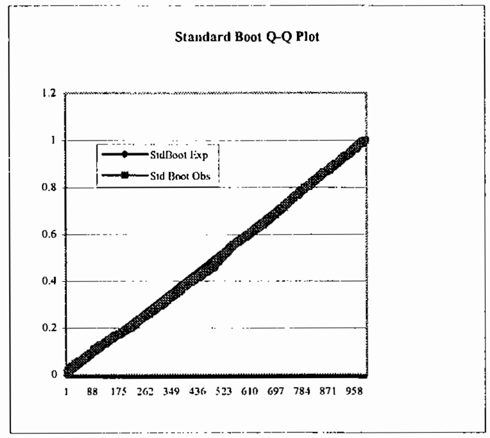
2 = Using the Jackknife

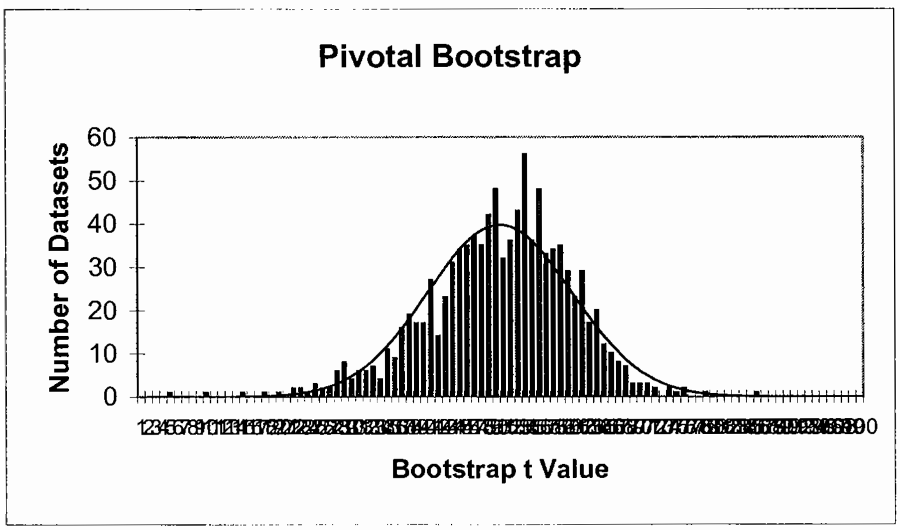
MVUE=Minimum Variance Unbiased Estimator

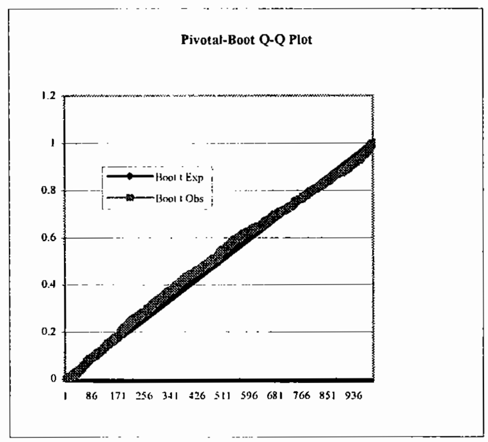
UCL=Upper Confidence Interval

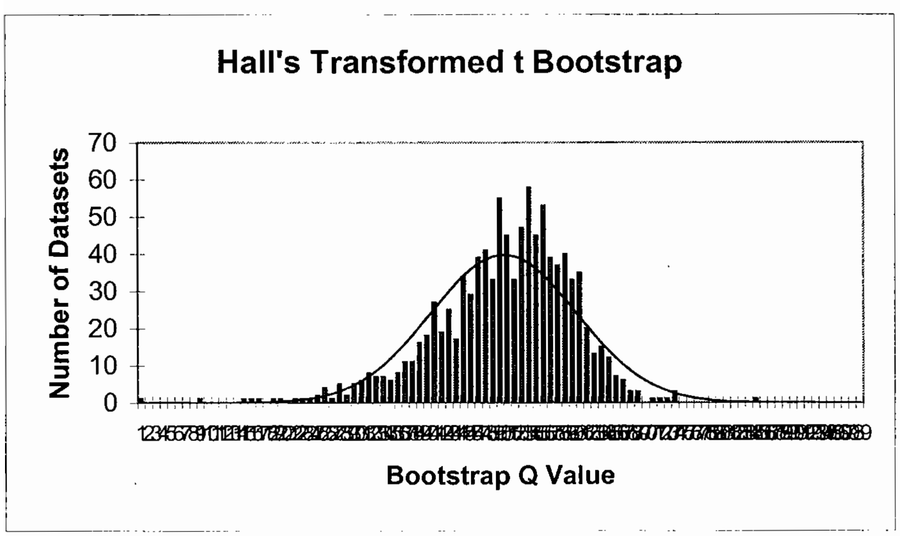
# BOOTSTRAP RESULTS FOR VAPOR PRESSURES FOR DICHLOROBIPHENYLS OBTAINED FROM THE SCIENTIFIC LITERATURE

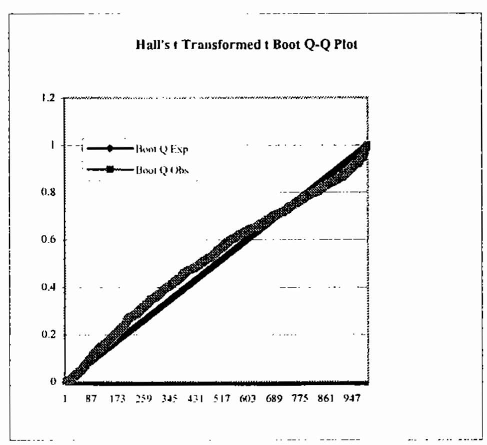


# STATISTICAL ANALYSIS OF VAPOR PRESSURES OBTAINED FROM THE SCIENTIFIC LITERATURE

## Trichlorobiphenyl

The data are best described as normally distributed and there were a sufficient number of detected values to perform a statistical analysis. Use the normal mean and t-statistic derived UCLs as EPCs

*Vapor presure is in Pascals (Pa)*

| | Value |
|---|---|
| 1 | 0.0761964 |
| 2 | 0.0323227 |
| 3 | 0.0144895 |
| 4 | 0.0644427 |
| 5 | 0.0354638 |
| 6 | 0.0182385 |
| 7 | 0.0151988 |
| 8 | 0.0946376 |
| 9 | 0.0903819 |
| 10 | 0.0352611 |
| 11 | 0.0276617 |
| 12 | 0.1104443 |
| 13 | 0.076703 |
| 14 | 0.0412393 |
| 15 | 0.0335386 |

| | | |
|---|---|---|
| Recommended Mean | Normal Mean | 1 |
| Recommended UCL | UCL based on t-statistic | 0.065429299 |

| | | | | | |
|---|---|---|---|---|---|
| **Raw Data Results** | | | | | |
| Number of Values | | 15 | | | |
| Maximum Value | | 1.10E-01 | Minimum Value | | 1.45E-02 |
| **Normal (Non-transformed) Results** | | | | | |
| Normal Mean | | 5.11E-02 | Mean Standard Error | | 8.15E-03 |
| Standard Deviation | | 3.16E-02 | Coefficient of Variance (%) | | 62% |
| Dataset Skewness | Pass | 4.74E-01 | Dataset Kurtosis | Fail | 1.65E+00 |
| Tested for Normality | | W-Test | NormalityResult (a = 0.05) | | Pass |
| Critical Value | | 8.81E-01 | Calculated Value for dataset | | 8.97E-01 |
| 90% UCL using t-statistic | | 6.20E-02 | 95% UCL using -t-statistic | | 6.54E-02 |
| **Natural Log-Transformed Results** | | | | | |
| MVUE of the log-mean | | 5.16E-02 | Standard error of the log-me | | 9.39E-03 |
| Standard Deviation | | 6.71E-01 | Coefficient of Variance (%) | | -21% |
| Dataset Skewness | Pass | -1.19E-01 | Dataset Kurtosis | Fail | 1.59E+00 |
| Tested for Normality | | W-Test | Normality Result (a = 0.05) | | Pass |
| Critical Value | | 8.81E-01 | Calculated Value for dataset | | 9.31E-01 |
| Anderson Darling (AD) $A^2$ | | 3.92E-01 | AD Probability | Pass | 8.58E-01 |
| 90% UCL of the MVUE | | 7.08E-02 | 95% UCL of the MVUE | | 7.89E-02 |
| **Jackknife Results** | | | | | |
| Jackknifed Mean | | 5.11E-02 | Jackknifed Standard Error | | 8.15E-03 |
| 90% UCL of the mean | | 6.20E-02 | 95% UCL of the mean | | 6.54E-02 |
| 90% UCL of the MVUE[2] | | 6.36E-02 | 95% UCL of the MVUE[2] | | 6.73E-02 |

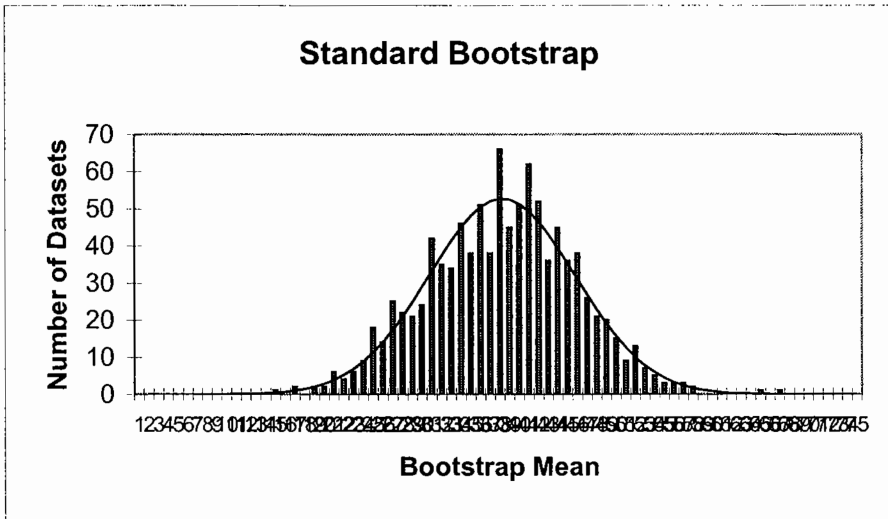
| | | | | | | |
|---|---|---|---|---|---|---|
| **Bootstrap Results (Raw Data)** | | | | | | |
| Standard Bootstrap | Mean | 5.13E-02 | 90% UCL | 6.12E-02 | 95% UCL | 6.41E-02 |
| Skewness | -9.45E-03 | | Kurtosis | 2.96E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 6.38E-02 | 95% UCL | 6.77E-02 | | |
| Skewness | -7.97E-01 | | Kurtosis | 5.64E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Hall's t Bootstrap | 90% UCL | 6.38E-02 | 95% UCL | 6.71E-02 | | |
| Skewness | -1.9E+00 | | Kurtosis | 1.36E+01 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |

2 = Using the Jackknife

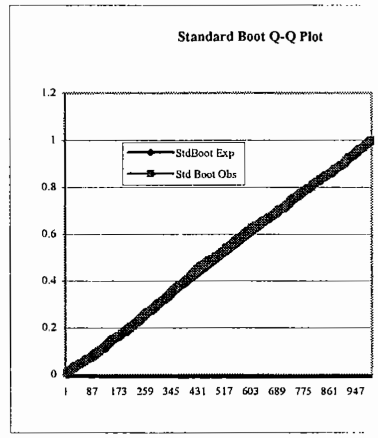
MVUE=Minimum Variance Unbiased Estimator

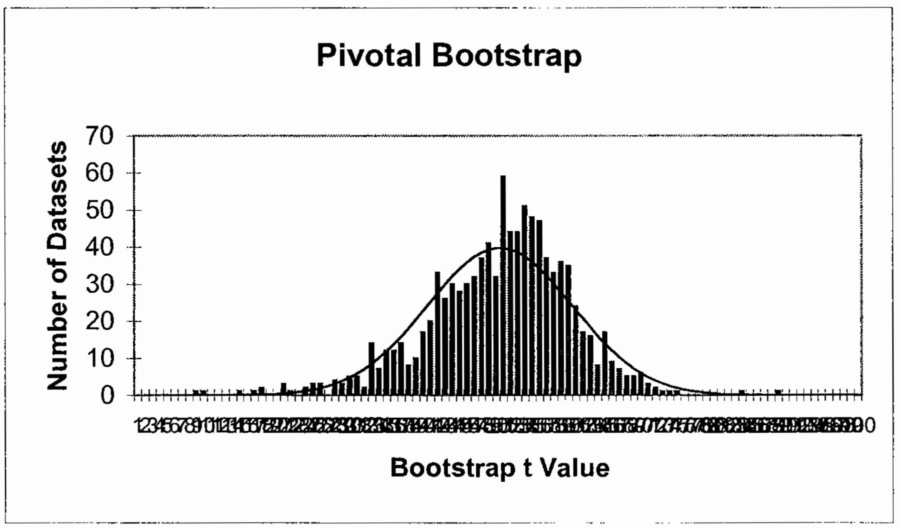
UCL=Upper Confidence Interval

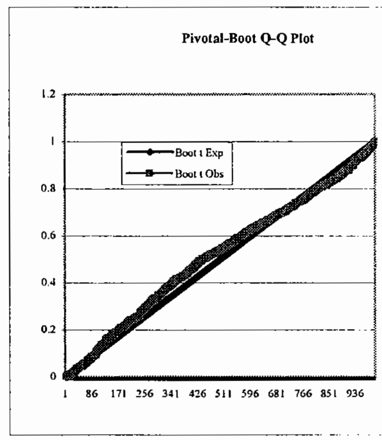
# BOOTSTRAP RESULTS FOR VAPOR PRESSURES FOR TRICHLOROBIPHENYLS OBTAINED FROM THE SCIENTIFIC LITERATURE

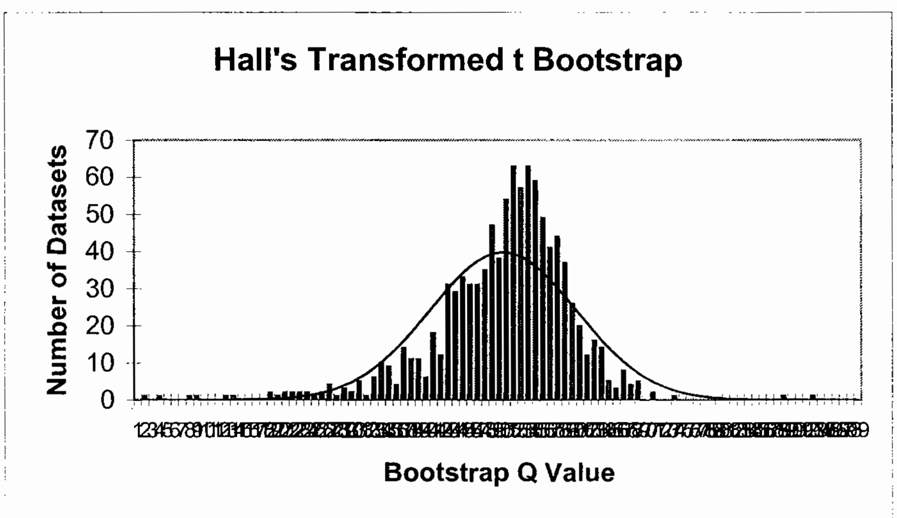


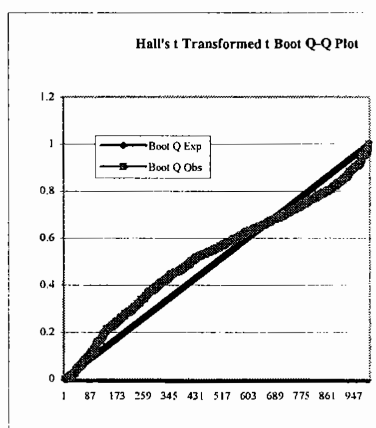

1



# STATISTICAL ANALYSIS OF VAPOR PRESSURES OBTAINED FROM THE SCIENTIFIC LITERATURE

## Tetrachlorobiphenyl

There is a sufficient number of values for statistical analysis - the data were found to be non-normal with high skewness, however, the Hall's transformed t bootstrap failed to normalize the dataset

*Vapor presure is in Pascals (Pa)*

| | Value |
|---|---|
| 1 | 0.0010943 |
| 2 | 0.0129696 |
| 3 | 0.0067077 |
| 4 | 0.0022697 |
| 5 | 1.824E-05 |
| 6 | 0.0045596 |
| 7 | 0.0901793 |
| 8 | 0.0111458 |
| 9 | 0.0658613 |
| 10 | 0.0013983 |
| 11 | 0.0111458 |
| 12 | 0.0192518 |
| 13 | 0.0355651 |
| 14 | 0.0566407 |
| 15 | 0.0021177 |
| 16 | 0.0088051 |
| 17 | 0.0184412 |
| 18 | 0.0266485 |

| | | |
|---|---|---|
| Recommended Mean | Bootstrap Mean | 1 |
| Recommended UCL | Standard Bootstrap UCL | 0.030500704 |

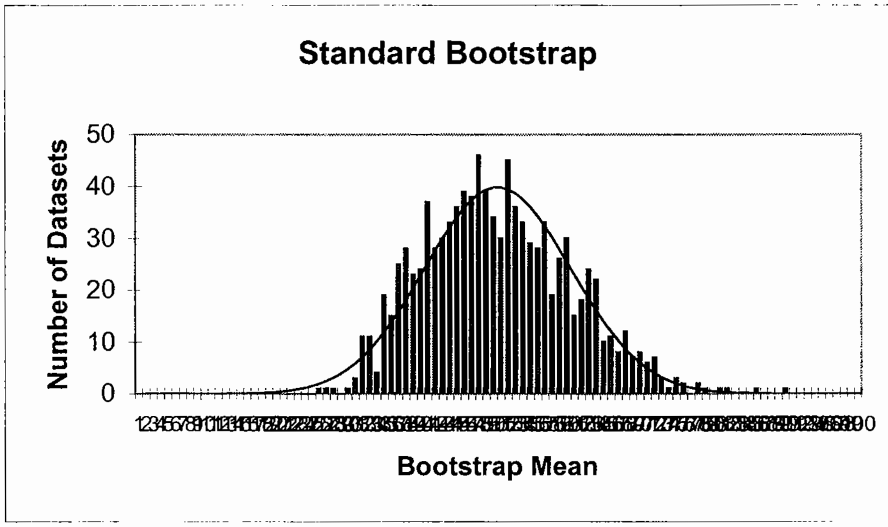
| | | | |
|---|---|---|---|
| **Raw Data Results** | | | |
| Number of Values | 18 | | |
| Maximum Value | 9.02E-02 | Minimum Value | 1.82E-05 |
| **Normal (Non-transformed) Results** | | | |
| Normal Mean | 2.08E-02 | Mean Standard Error | 6.03E-03 |
| Standard Deviation | 2.56E-02 | Coefficient of Variance (%) | 123% |
| Dataset Skewness | Fail 1.41E+00 | Dataset Kurtosis | Pass 3.86E+00 |
| Tested for Normality | W-Test | NormalityResult (a = 0.05) | Fail |
| Critical Value | 8.97E-01 | Calculated Value for dataset | 7.74E-01 |
| 90% UCL using t-statistic | 2.89E-02 | 95% UCL using -t-statistic | 3.13E-02 |
| **Natural Log-Transformed Results** | | | |
| MVUE of the log-mean | 4.23E-02 | Standard error of the log-me | 2.39E-02 |
| Standard Deviation | 1.99E+00 | Coefficient of Variance (%) | -41% |
| Dataset Skewness | Fail -1.4E+00 | Dataset Kurtosis | Pass 5.06E+00 |
| Tested for Normality | W-Test | Normality Result (a = 0.05) | Fail |
| Critical Value | 8.97E-01 | Calculated Value for dataset | 8.73E-01 |
| Anderson Darling (AD) $A^2$ | 6.10E-01 | AD Probability | Pass 6.37E-01 |
| 90% UCL of the MVUE | 2.44E-01 | 95% UCL of the MVUE | 4.36E-01 |
| **Jackknife Results** | | | |
| Jackknifed Mean | 2.08E-02 | Jackknifed Standard Error | 6.03E-03 |
| 90% UCL of the mean | 2.89E-02 | 95% UCL of the mean | 3.13E-02 |
| 90% UCL of the MVUE[2] | 7.69E-02 | 95% UCL of the MVUE[2] | 8.69E-02 |

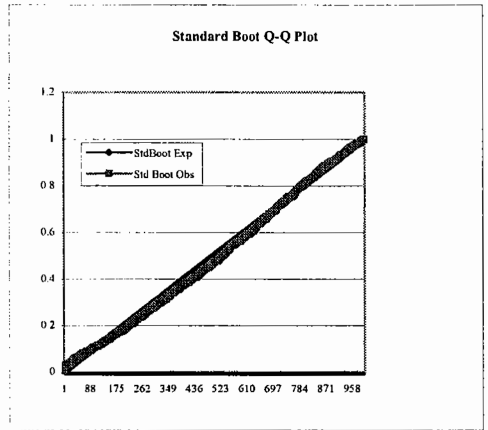
| | | | | | | |
|---|---|---|---|---|---|---|
| **Bootstrap Results (Raw Data)** | | | | | | |
| Standard Bootstrap | Mean | 2.08E-02 | 90% UCL | 2.84E-02 | 95% UCL | 3.05E-02 |
| Skewness | 3.78E-01 | | Kurtosis | 2.92E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 3.27E-02 | 95% UCL | 3.73E-02 | | |
| Skewness | -2.0E+00 | | Kurtosis | 1.33E+01 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Hall's t Bootstrap | 90% UCL | 3.37E-02 | 95% UCL | 3.57E-02 | | |
| Skewness | -3.4E+00 | | Kurtosis | 2.53E+01 | | |
| Quantile fit is poor do not use Bootstrap Results | | | | | | |

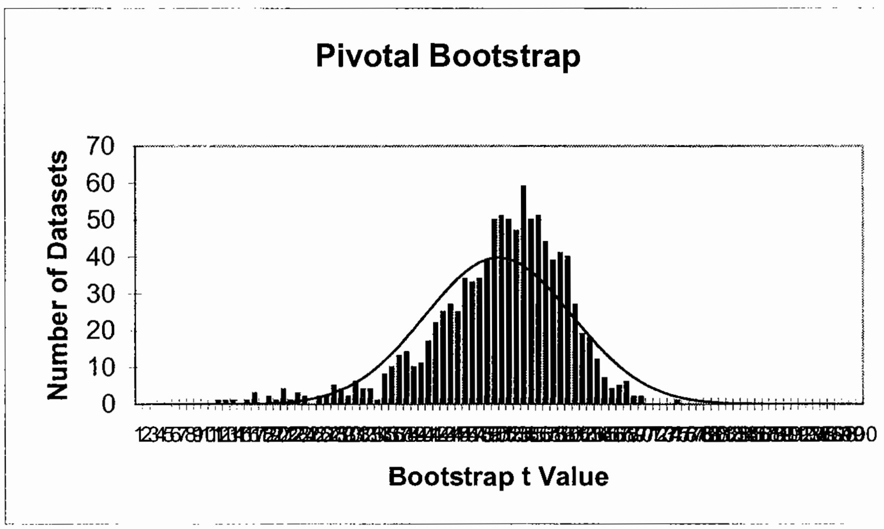
2 = Using the Jackknife
MVUE=Minimum Variance Unbiased Estimator
UCL=Upper Confidence Interval

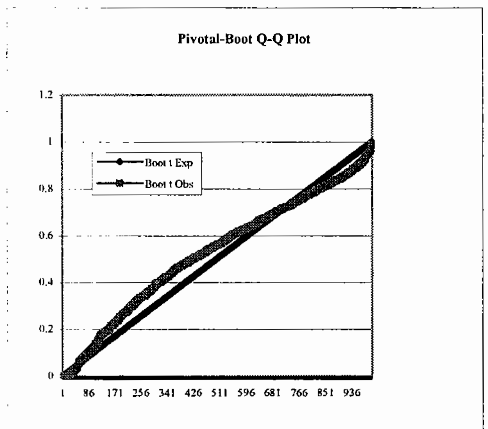
# BOOTSTRAP RESULTS FOR VAPOR PRESSURES FOR TETRACHLOROBIPHENYLS OBTAINED FROM THE SCIENTIFIC LITERATURE (Including suspected outlier)

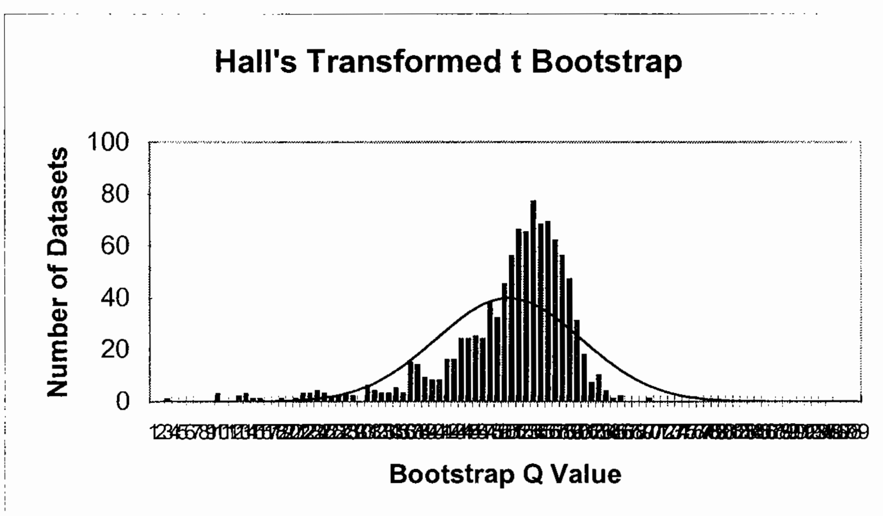
1

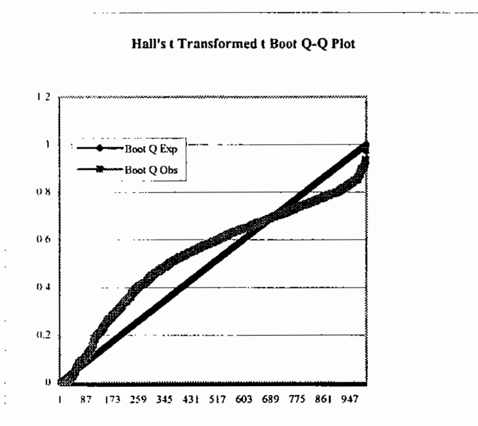


# STATISTICAL ANALYSIS OF VAPOR PRESSURES OBTAINED FROM THE SCIENTIFIC LITERATURE

## Pentachlorobiphenyl

The data are best described as normally distributed and there were a sufficient number of detected values to perform a statistical analysis.

*Vapor presure is in Pascals (Pa)*

| | Value |
|---|---|
| 1 | 0.0005269 |
| 2 | 0.0043367 |
| 3 | 0.0014186 |
| 4 | 0.0043367 |
| 5 | 0.0035768 |
| 6 | 0.0035869 |

| | | |
|---|---|---|
| Recommended Mean | Normal Mean | 1 |
| Recommended UCL | UCL based on t-statistic | 0.004283067 |

| | | | | | |
|---|---|---|---|---|---|
| **Raw Data Results** | | | | | |
| Number of Values | | 6 | | | |
| Maximum Value | | 4.34E-03 | Minimum Value | | 5.27E-04 |
| **Normal (Non-transformed) Results** | | | | | |
| Normal Mean | | 2.96E-03 | Mean Standard Error | | 6.55E-04 |
| Standard Deviation | | 1.60E-03 | Coefficient of Variance (%) | | 54% |
| Dataset Skewness | Pass | -5.06E-01 | Dataset Kurtosis | Fail | 1.22E+00 |
| Tested for Normality | | W-Test | NormalityResult (a = 0.05) | | Pass |
| Critical Value | | 7.88E-01 | Calculated Value for dataset | | 8.31E-01 |
| 90% UCL using t-statistic | | 3.93E-03 | 95% UCL using -t-statistic | | 4.28E-03 |
| **Natural Log-Transformed Results** | | | | | |
| MVUE of the log-mean | | 3.17E-03 | Standard error of the log-me | | 1.09E-03 |
| Standard Deviation | | 8.48E-01 | Coefficient of Variance (%) | | -14% |
| Dataset Skewness | Pass | -8.16E-01 | Dataset Kurtosis | Pass | 1.79E+00 |
| Tested for Normality | | W-Test | Normality Result (a = 0.05) | | Fail |
| Critical Value | | 7.88E-01 | Calculated Value for dataset | | 7.75E-01 |
| Anderson Darling (AD) $A^2$ | | 6.77E-01 | AD Probability | Pass | 5.78E-01 |
| 90% UCL of the MVUE | | 7.99E-03 | 95% UCL of the MVUE | | 1.20E-02 |
| **Jackknife Results** | | | | | |
| Jackknifed Mean | | 2.96E-03 | Jackknifed Standard Error | | 6.55E-04 |
| 90% UCL of the mean | | 3.93E-03 | 95% UCL of the mean | | 4.28E-03 |
| 90% UCL of the MVUE[2] | | 4.31E-03 | 95% UCL of the MVUE[2] | | 4.67E-03 |

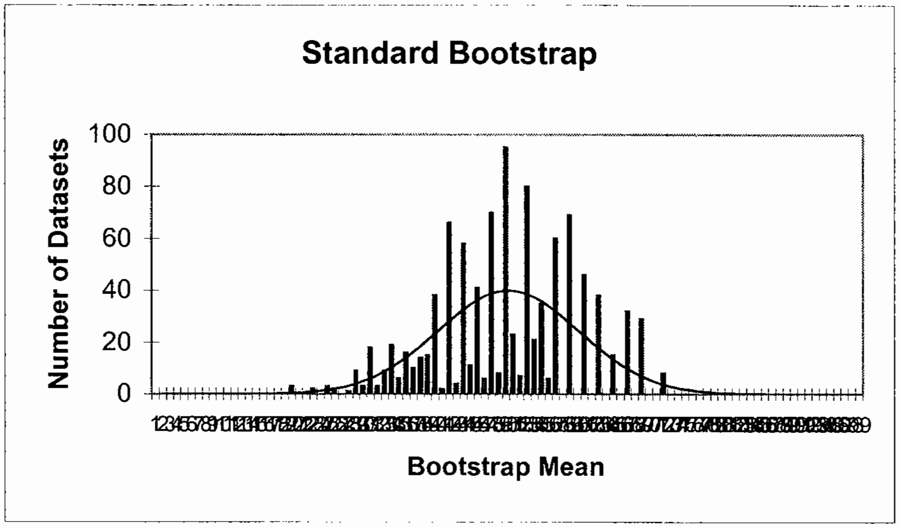
| | | | | | | |
|---|---|---|---|---|---|---|
| **Bootstrap Results (Raw Data)** | | | | | | |
| Standard Bootstrap | Mean | 2.96E-03 | 90% UCL | 3.71E-03 | 95% UCL | 3.92E-03 |
| Skewness | -1.45E-01 | | Kurtosis | 2.71E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 3.83E-03 | 95% UCL | | | 4.05E-03 |
| Skewness | 2.13E+01 | | Kurtosis | 4.68E+02 | | |
| Quantile fit is poor do not use Bootstrap Results | | | | | | |
| Hall's t Bootstrap | 90% UCL | 3.73E-03 | 95% UCL | | | 4.05E-03 |
| Skewness | 1.69E+01 | | Kurtosis | 3.29E+02 | | |
| Quantile fit is poor do not use Bootstrap Results | | | | | | |

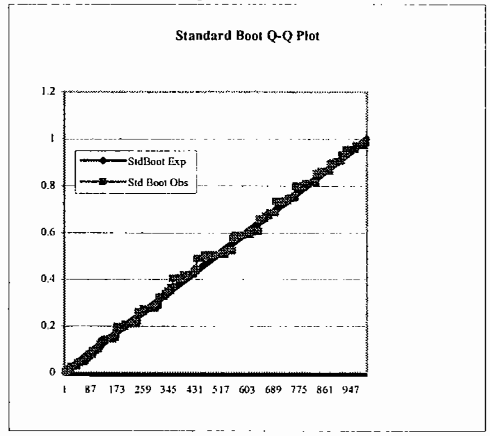
2 = Using the Jackknife

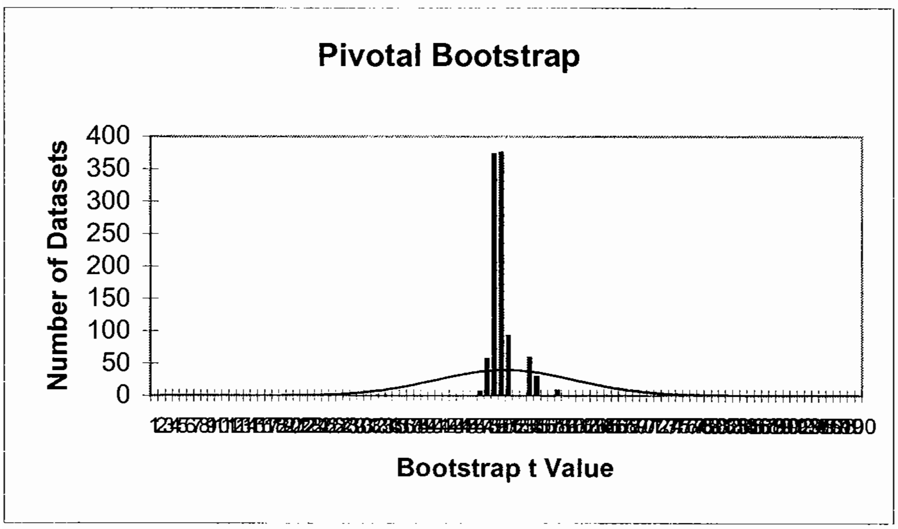
MVUE=Minimum Variance Unbiased Estimator

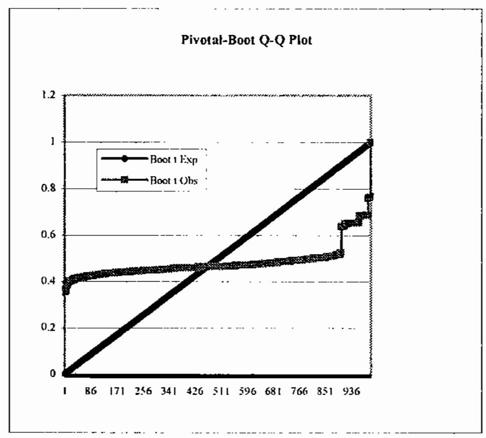
UCL=Upper Confidence Interval

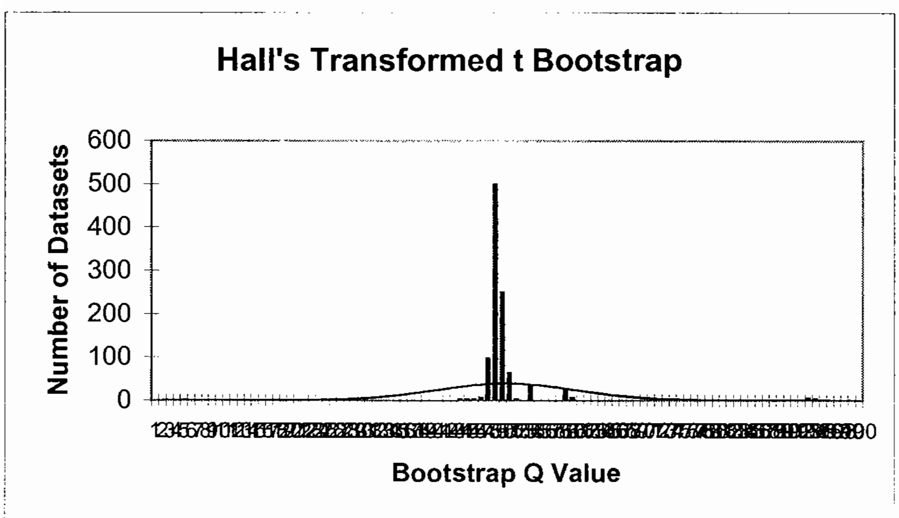
# BOOTSTRAP RESULTS FOR VAPOR PRESSURES FOR PENTACHLOROBIPHENYLS OBTAINED FROM THE SCIENTIFIC LITERATURE

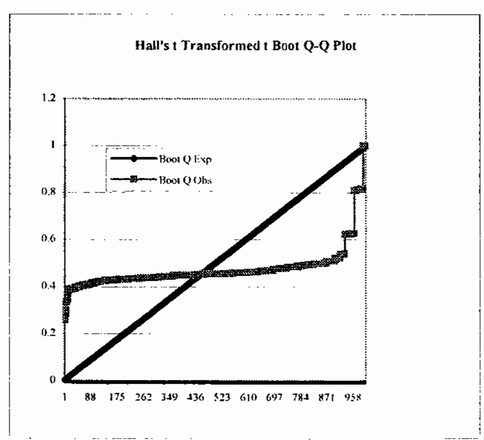


# STATISTICAL ANALYSIS OF VAPOR PRESSURES OBTAINED FROM THE SCIENTIFIC LITERATURE

## Hexachlorobiphenyl

The data are best described as log-normally distributed and there were a sufficient number of detected values to perform statistical analysis. The CV is > 100%

*Vapor presure is in Pascals (Pa)*

| | Value |
|---|---|
| 1 | 2.938E-06 |
| 2 | 3.242E-05 |
| 3 | 0.0004803 |
| 4 | 9.829E-05 |
| 5 | 0.0002533 |
| 6 | 0.0044279 |
| 7 | 0.0003587 |
| 8 | 0.0066267 |
| 9 | 0.0003668 |
| 10 | 0.0070016 |

| | | |
|---|---|---|
| Recommended Mean | MVUE of the log-mean | 1 |
| Recommended UCL | UCL based on Jackknifed MVUE | 0.009196063 |

**Raw Data Results**

| | | | | | |
|---|---|---|---|---|---|
| Number of Values | | 10 | | | |
| Maximum Value | | 7.00E-03 | Minimum Value | | 2.94E-06 |

**Normal (Non-transformed) Results**

| | | | | | |
|---|---|---|---|---|---|
| Normal Mean | | 1.96E-03 | Mean Standard Error | | 9.10E-04 |
| Standard Deviation | | 2.88E-03 | Coefficient of Variance (%) | | 146% |
| Dataset Skewness | Pass | 8.66E-01 | Dataset Kurtosis | Pass | 1.78E+00 |
| Tested for Normality | | W-Test | NormalityResult (a = 0.05) | | Fail |
| Critical Value | | 8.42E-01 | Calculated Value for dataset | | 6.85E-01 |
| 90% UCL using t-statistic | | 3.22E-03 | 95% UCL using -t-statistic | | 3.63E-03 |

**Natural Log-Transformed Results**

| | | | | | |
|---|---|---|---|---|---|
| MVUE of the log-mean | | 3.43E-03 | Standard error of the log-me | | 2.61E-03 |
| Standard Deviation | | 2.46E+00 | Coefficient of Variance (%) | | -31% |
| Dataset Skewness | Pass | -3.89E-01 | Dataset Kurtosis | Pass | 2.07E+00 |
| Tested for Normality | | W-Test | Normality Result (a = 0.05) | | Pass |
| Critical Value | | 8.42E-01 | Calculated Value for dataset | | 9.29E-01 |
| Anderson Darling (AD) $A^2$ | | 3.31E-01 | AD Probability | Pass | 9.14E-01 |
| 90% UCL of the MVUE | | 2.78E-01 | 95% UCL of the MVUE | | 1.52E+00 |

**Jackknife Results**

| | | | |
|---|---|---|---|
| Jackknifed Mean | 1.96E-03 | Jackknifed Standard Error | 9.10E-04 |
| 90% UCL of the mean | 3.22E-03 | 95% UCL of the mean | 3.63E-03 |
| 90% UCL of the MVUE[2] | 7.89E-03 | 95% UCL of the MVUE[2] | 9.20E-03 |

**Bootstrap Results (Raw Data)**

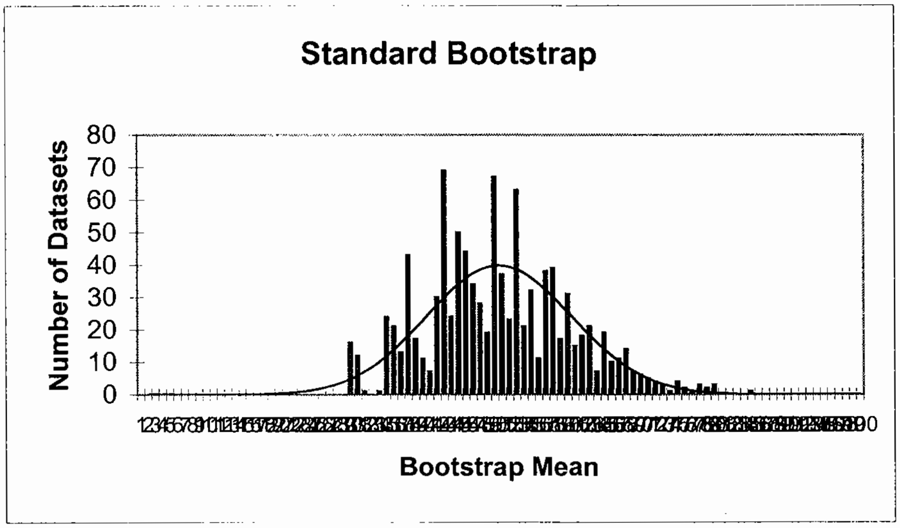
| | | | | | | |
|---|---|---|---|---|---|---|
| Standard Bootstrap | Mean | 1.99E-03 | 90% UCL | 3.12E-03 | 95% UCL | 3.44E-03 |
| Skewness | 3.30E-01 | | Kurtosis | 2.89E+00 | | |
| Quantile fit is good - Bootstrap Output is Normal or nearly so | | | | | | |
| Pivitol (t) Bootstrap | 90% UCL | 3.56E-03 | 95% UCL | 4.98E-03 | | |
| Skewness | -5.4E+00 | | Kurtosis | 3.16E+01 | | |
| Quantile fit is poor do not use Bootstrap Results | | | | | | |
| Hall's t Bootstrap | 90% UCL | 3.55E-03 | 95% UCL | 4.97E-03 | | |
| Skewness | -1.0E+01 | | Kurtosis | 1.28E+02 | | |
| Quantile fit is poor do not use Bootstrap Results | | | | | | |

2 = Using the Jackknife

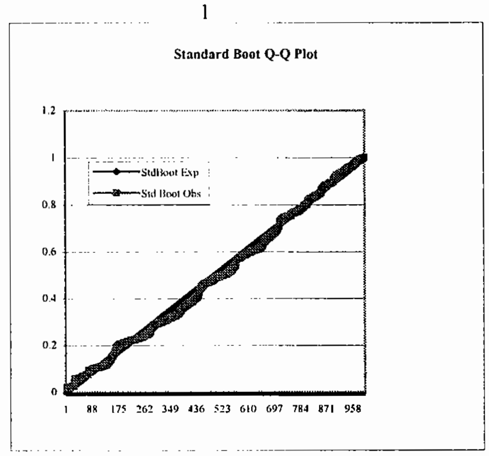
MVUE=Minimum Variance Unbiased Estimator

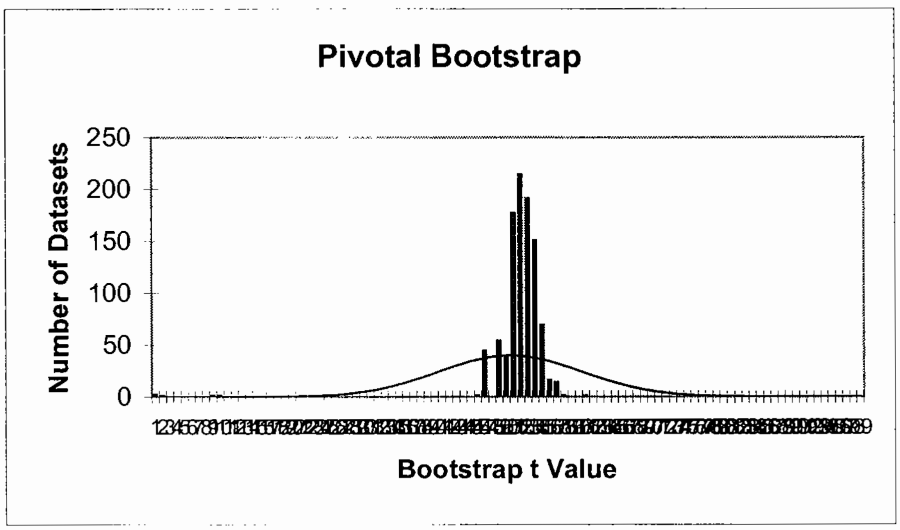
UCL=Upper Confidence Interval

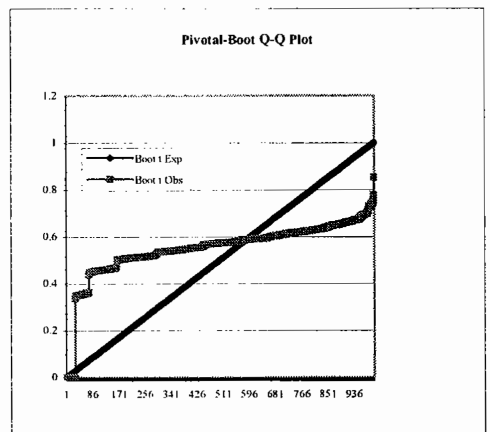
# BOOTSTRAP RESULTS FOR VAPOR PRESSURES FOR HEXACHLOROBIPHENYLS OBTAINED FROM THE SCIENTIFIC LITERATURE

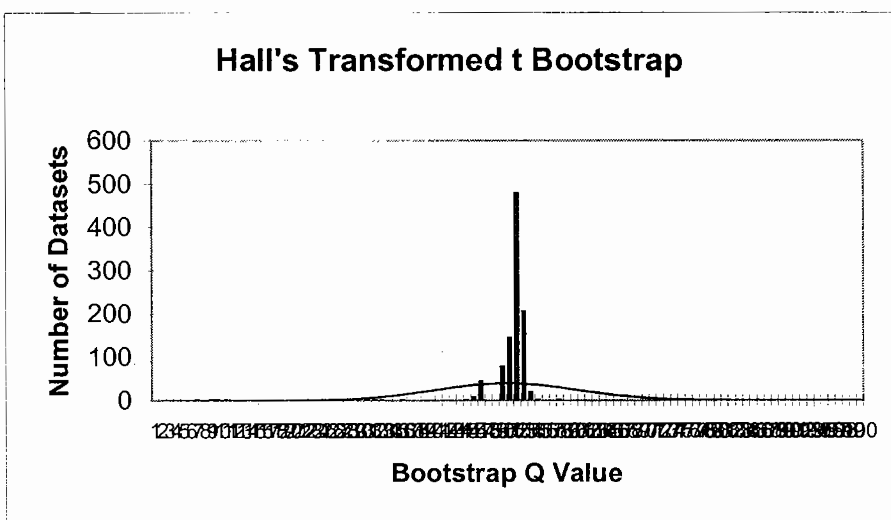


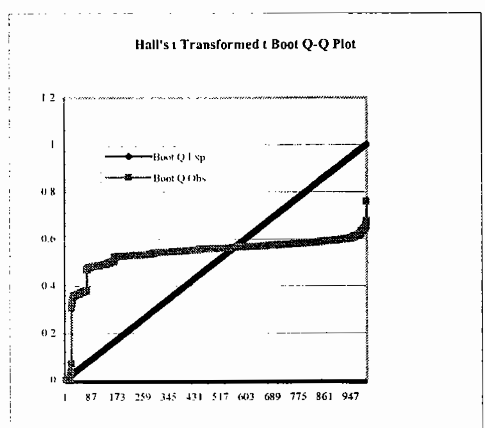

1



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# Prediction of physical properties for PCB congeners from molecular descriptors

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**Keywords: Polychlorinated biphenyls, QSPR, principal components regression, PLS modeling.**

## Abstract

A methodology is described to model quantitative structure-property relationships that can accept significant contamination with "bad data". This approach is used to model and predict the vapor pressures, the water solubilities, the octanol-water partitioning coefficients and the Henry's laws coefficients for all 209 congeners of polychlorinated biphenyls (PCB). The model predictions seem to provide a reliable summary and extension of the currently available database on these compounds.

## Introduction

The physical properties for organic chemical compounds are important in determining their distribution and fate in the environment[1]. Examples of such properties are the vapor pressure, the water solubility, the octanol-water partition coefficient and the Henry's law coefficient. Experimental measurements of these properties have become easier with the introduction of new methods, e.g. determination of octanol-water partitioning using gas chromatography, but the number of compounds under consideration still makes it necessary to also use models for estimation.

Polychlorinated biphenyls (PCB) are a group of 209 different congeners that have attracted much attention as environmental pollutants. On May 22 2001, 127 governments adopted the

Stockholm Convention on Persistent Organic Pollutants. PCBs were among the chemicals initially selected for elimination from production and use[2]. Production of PCB has been banned in the industrialized world since many years, but large quantities still remain in the environment[3]. It is therefore still of utmost importance to estimate and monitor their fate in the environment and the biological food chains. The physical properties of the PCBs can also be used as input in calculating relationships to biological activity[4], or to other physical properties[5]. Measured physical properties have been reported for 20-60% of the PCB congeners[6].

The molecular structure holds the key to predicting the physical properties, and it is easy to recognize the trends within a homologous group such as the PCBs[7,8]. The literature contains many estimation methods, and well known are the additive group and bond contribution methods[9,10,11,12,13,14]. These methods are fairly robust and can be applied to a wide variety of organic molecules. A robust and general method will however by definition lack some accuracy and precision when considering local phenomena, such as the properties within a specific compound group.

Topological, geometrical and electronic descriptors can give more in-depth descriptions of the molecules and serve as a basis for developing predictive models with an improved accuracy and precision[15,16,17]. The purpose of this investigation is to develop multivariate calibration models and predict the vapor pressure, the water solubility, the octanol-water partitioning, and the Henry's law constant for all 209 PCB congeners. We will also explore the possibilities of using these models to validate available experimental data.

## Experimental

Experimentally determined values for the physical properties were obtained from the PhysProp Database (Syracuse Research Corporation, Syracuse, NY, USA)[6]. Vapor pressures were reported for 42 congeners, water solubilities for 122 congeners, octanol-water partitioning coefficients for 92 congeners, and Henry's law constants for 91 congeners. The data in the PhysProp Database are collected from a large number of investigators, so we can assume that there is variation both within and between the various laboratories and investigators.

With the purpose of validating the methodology we also have included a set of experimental data with an expected high accuracy and precision in the form of retention times in gas chromatography using different columns and separation conditions. Retention time data were obtained from the manufacturers data sheets[18,19,20].

The chemical structure of each congener was sketched on a PC using the software HyperChem (HyperCube, Inc., Gainesville, Florida, USA). Each compound was modeled using the force-field routine MM+, an extension by HyperCube of the standard MM2 force field[21]. The molecular structures were then used as input for the generation of 853 descriptors with the software Dragon (Milano Chemometrics and QSAR Research Group, University of Milano-Bicocca, Milano, Italy), listed in the enclosed text file varfile.txt. Todeschini and Consonni have reviewed these molecular descriptors[22].

The multivariate analysis and calibration was carried out with the software Unscrambler (CAMO ASA, Oslo, Norway), Matlab (MathWorks, Inc., Natick, MA, USA) and Progress (Rousseeuw & Leroy, 1987). Principal component analysis (PCA), principal component regression (PCR), PLS-regression (PLSR) and least median of squares regression (LMSR) were used as the modeling methods. Martens and Næs have reviewed PCA, PCR and PLSR[23]. Rousseeuw and Leroy have reviewed LMSR and other methods for robust regression and outlier detection[24].

## Results and discussion

Here we use the numbering system for PCB congeners currently assigned by Ballschmiter and the International Union of Pure and Applied Chemistry[25].

447 descriptors with constant values for all congeners were excluded from the data analysis. The raw data hence consist of 406 descriptor variables (varlist.txt) and the seven dependent

response variables. The raw data is listed in the enclosed tab separated text file rawdat.txt (the first row lists the column headings, each following row corresponds to a congener and each column to a variable). All descriptor variables were autoscaled to zero mean and unit variance. The three dependent retention-times variables were also autoscaled, while the four dependent physical property variables were log-transformed prior to data analysis and modeling.

The descriptor data were initially modeled using principal component analysis (PCA). A five-component model explained 65% of the variance in the calibration data and 59% of the variance in ten randomly selected cross-validation segments. The first two score vectors are shown in figure 1. All five score vectors are listed in the enclosed tab separated text file scores.txt.

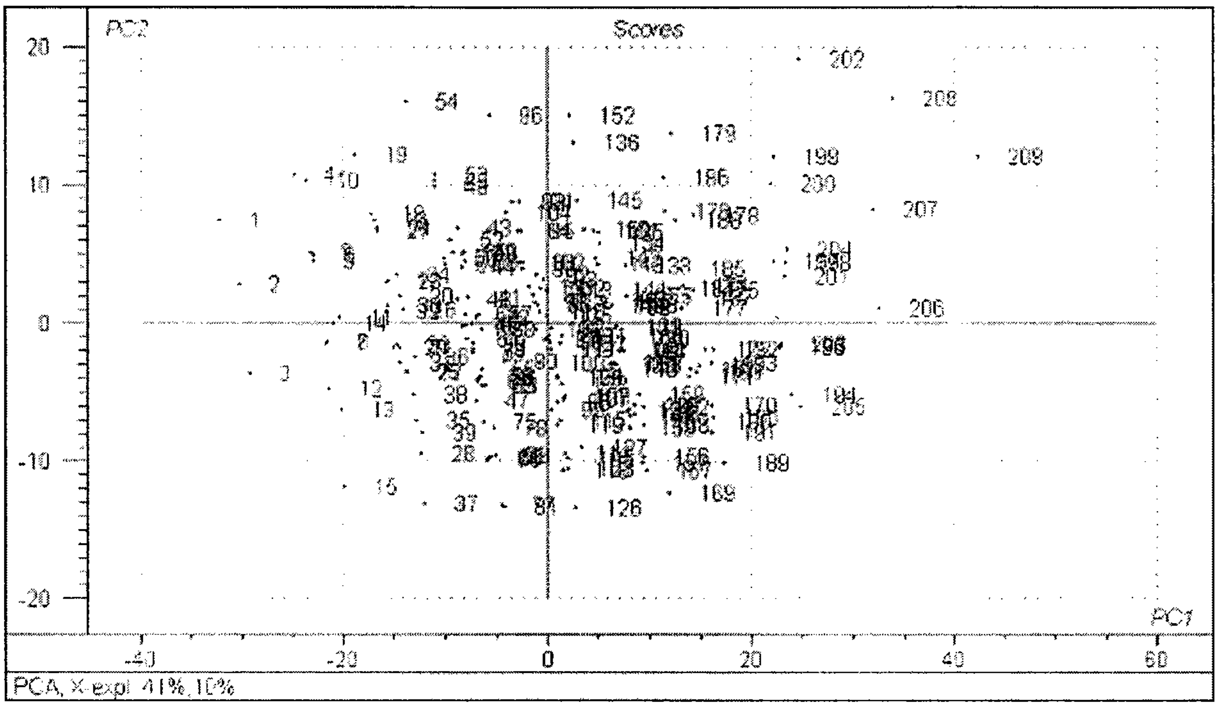



*Figure 1*
*Scores for the two first principal components (IUPAC-numbers shown for each congener).*

The position of the congeners on the score plot relates to the chemical structures. The congener groups line up from left to the right with increasing number of chlorine atoms. In a similar manner the vertical distribution reflect the substitution pattern, with non-ortho chlorinated biphenyls ("co-planar") at the bottom and those with tri- and tetra-ortho substitution at the top. The ortho-substitution pattern directly influences the energy barrier of rotation and it is also correlated to the biological activities of these compounds[26].

The first five principal components were used as independent variables for LMSR. Such a semi-robust regression model was estimated for each of the dependent physical property variables and subsequently used to identify outliers in the dependent variables. An object was declared an outlier if the standardized residual was larger than 2.5. PCR and PLSR can also be extended to become robust both with regard to independent and dependent variables[27,28], but this would not serve any purpose in the present investigation.

As a second step, a reweighted PCR could be run by assigning zero weight, or some value on a scale between zero and one, to the outlying objects. Instead we have proceeded with a reweighted PLSR were each outlying object was assigned zero weight, i.e. removed from the computation of the regression model. The PLSR1 procedure was used to obtain models with optimal accuracy and precision. A further step to get parsimonious models was to assign zero weight to descriptor variables with minor influence in the PLS1-regression. These variables were selected on the criteria that the weighted regression coefficients were approximately less than half of the maximum values when all variables were included.

**Vapor pressure**

Experimental measurements were available for 42 congeners. Outlying objects were identified using the robust PCR procedure described above. 34 objects (objlist1.txt) and 260 descriptor variables (varlist1.txt) were assigned non-zero weight in the successive PLSR1-regression. The calibration model was validated using a test set of 12 randomly selected objects (testset1.txt). The number of latent variables to keep in the PLS-model was estimated to one, yielding a model with a coefficient of determination $R^2$ for the test set of 0.972. The standard error of prediction SEP, estimated from the test set, was 0.21 (log mm

Hg). Figure 2 show predicted versus measured results for all 42 congeners, with the eight outlying objects marked as filled rectangles.

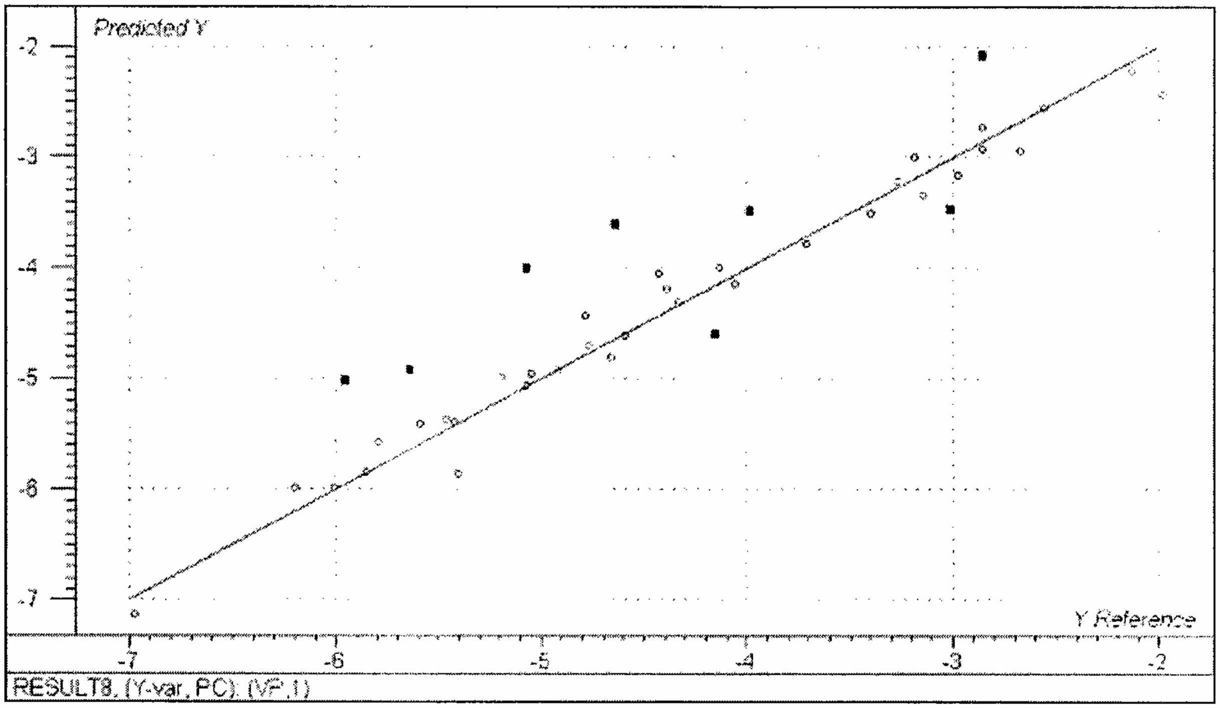



*Figure 2*
*Predicted vs. measured vapor pressure (log mm Hg), 42 PCB congeners.*

The antilogarithms of the measured and the predicted vapor pressures at 25° C (mm Hg) for all congeners, and the accompanying residuals, are listed in the enclosed tab separated text file vp.txt.

**Water solubility**

Experimental measurements were available for 122 congeners. Outlying objects were identified using the robust PCR procedure described above. 119 objects (objlist2.txt) and 275 descriptor variables (varlist2.txt) were assigned non-zero weight in the successive PLSR1-regression. The calibration model was validated using a test set of 47 randomly selected objects (testset2.txt). The number of latent variables to keep in the PLS-model was estimated to one, yielding a model with a coefficient of determination $R^2$ for the test set of 0.941. The standard error of prediction SEP, estimated from the test set, was 0.33 (log mg/l). Figure 3 show predicted versus measured results for all 122 congeners, with the three outlying objects marked as filled rectangles.

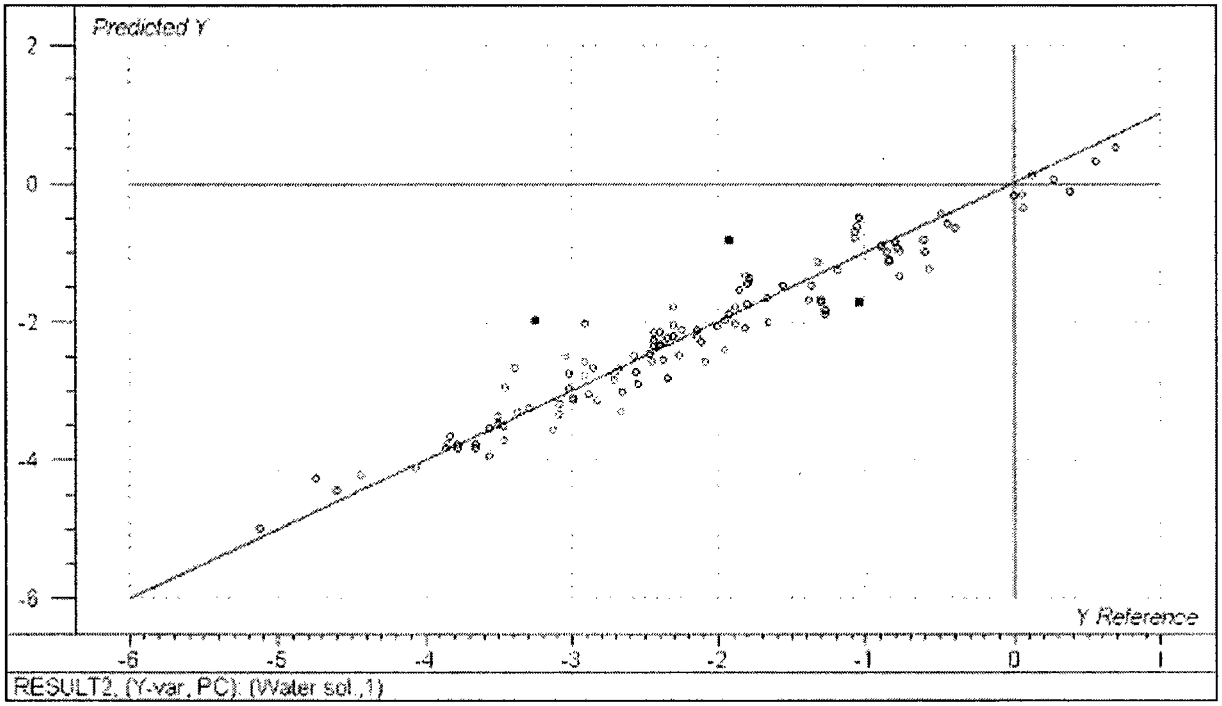



*Figure 3*
*Predicted vs. measured water solubility (log mg/l), 122 PCB congeners.*

The antilogarithms of the measured and the predicted water solubilities at 25° C (mg/l) for all congeners, and the accompanying residuals, are listed in the enclosed tab separated text file water.txt.

**Partitioning coefficient octanol-water**

Experimental measurements were available for 92 congeners. Outlying objects were identified using the robust PCR procedure described above. 87 objects (objlist3.txt) and 227 descriptor variables (varlist3.txt) were assigned non-zero weight in the successive PLSR1-regression. The calibration model was validated using a test set of 34 randomly selected objects (testset3.txt). The number of latent variables to keep in the PLS-model was estimated to one, yielding a model with a coefficient of determination $R^2$ for the test set of 0.983. The standard error of prediction SEP, estimated from the test set, was 0.15 (log P). Figure 4 show predicted versus measured results for all 92 congeners, with the five outlying objects marked as filled rectangles.

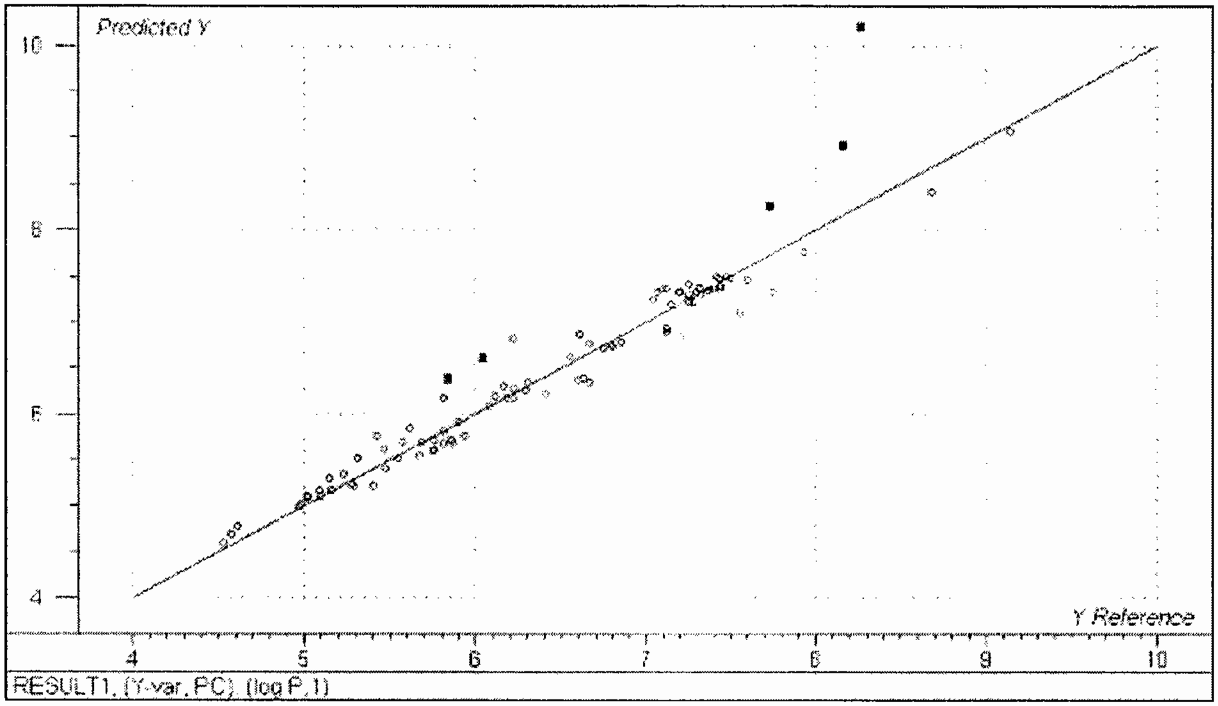



*Figure 4*
*Predicted vs. measured partitioning coefficient octanol-water (log P), 92 PCB congeners.*

The logarithms of the measured and the predicted partitioning coefficients octanol-water (log P) for all congeners, and the accompanying residuals, are listed in the enclosed tab separated text file logp.txt.

**Henry's law constant**

Experimental measurements were available for 91 congeners. Outlying objects were identified using the robust PCR procedure described above. 79 objects (objlist4.txt) and 145 descriptor variables (varlist4.txt) were assigned non-zero weight in the successive PLSR1-regression. The calibration model was validated using a test set of 31 randomly selected objects (testset4.txt). The number of latent variables to keep in the PLS-model was estimated to two, yielding a model with a coefficient of determination $R^2$ for the test set of 0.960. The standard error of prediction SEP, estimated from the test set, was 0.086 (log atm-$m^3$/mol). Figure 5 show predicted versus measured results for all 91 congeners, with the twelve outlying objects marked as filled rectangles.

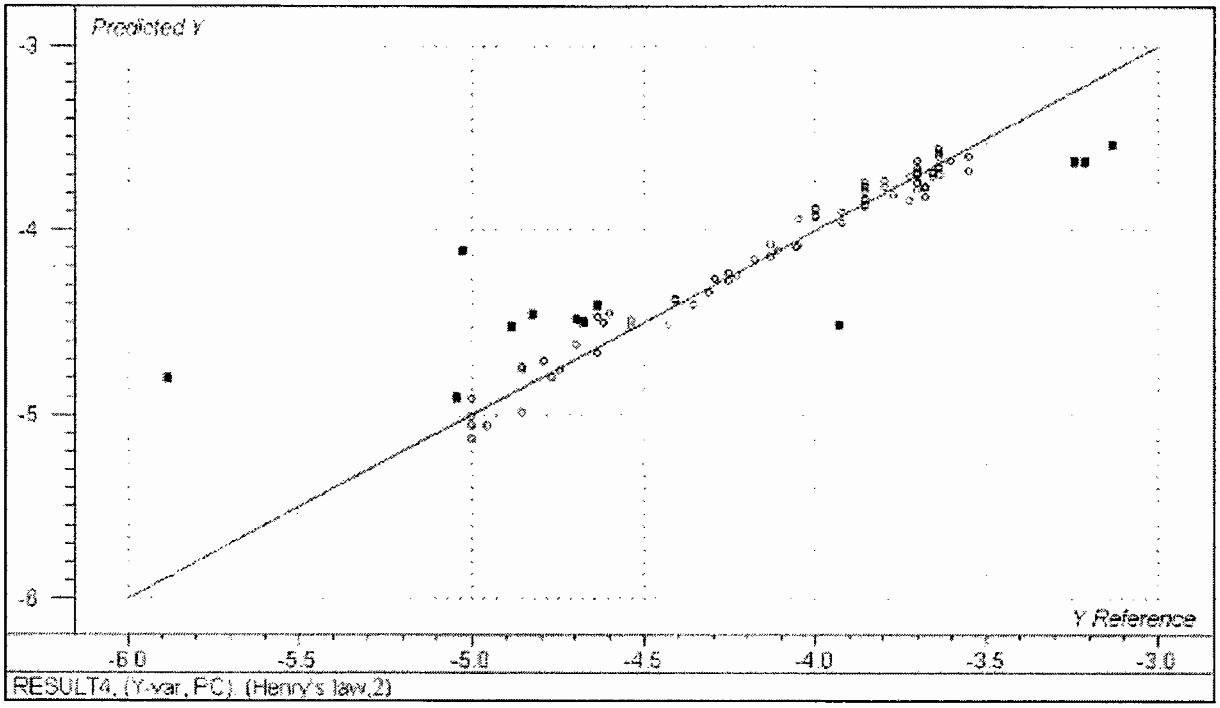



*Figure 5*

*Predicted vs. measured Henry's law constant (log atm-$m^3$/mol), 91 PCB congeners.*

The antilogarithms of the measured and the predicted Henry's law constants at 25° C (atm-$m^3$/mol) for all congeners, and the accompanying residuals, are listed in the enclosed tab separated text file henry.txt.

**Retention times in gas chromatography**

As an additional validation of this approach to establish quantitative structure property relationships (QSPR) for PCB congeners we have also tried to model the retention times obtained from gas chromatographic separation on three different columns: Rtx-CLP, SPB-Octyl and HT8.

Experimental measurements were available for 207-209 congeners. The retention times on all three columns showed a high correlation in between. 209 objects and 201 descriptor variables were assigned non-zero weight in PLSR2-regression. The calibration model was validated using a test set of 82 randomly selected objects. The number of latent variables to keep in the PLS-model was estimated to two, yielding a model with coefficients of determination $R^2$, for the test set, between 0.979 and 0.989. The standard error of prediction SEP, estimated from the test set, was 0.086-1.17 (min). Figure 6 show predicted versus measured results for 207 congeners separated on the HT8 column.

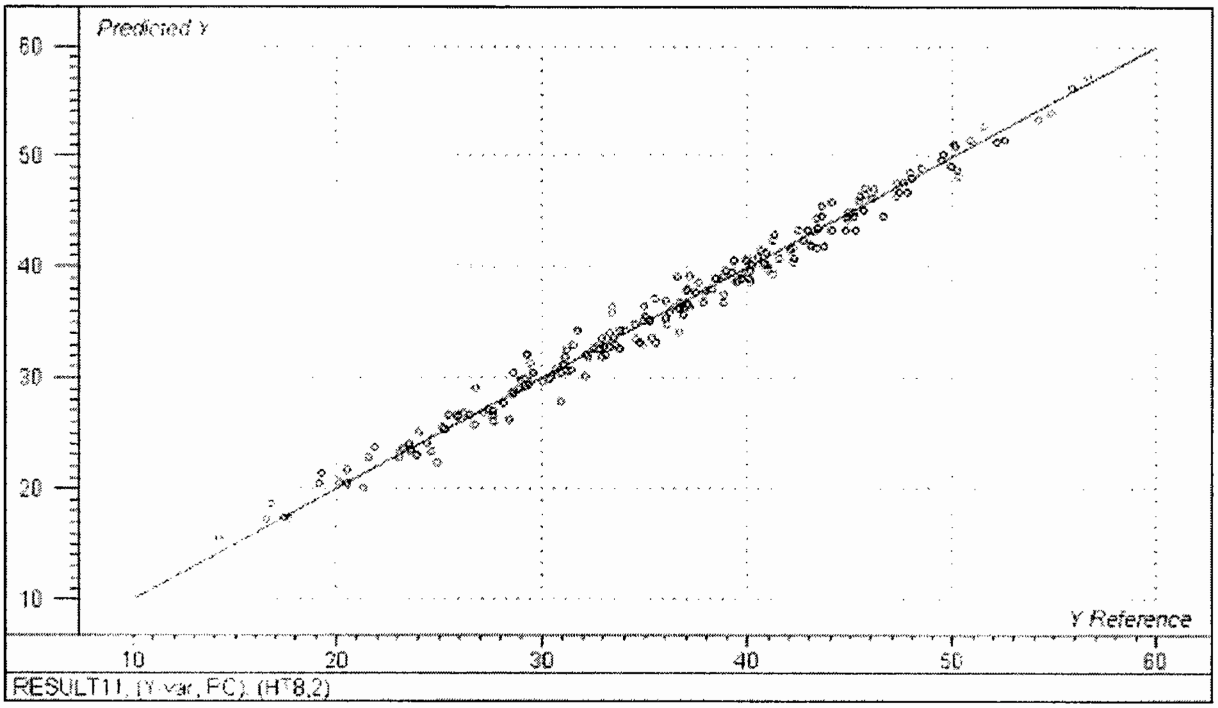



*Figure 6*
*Predicted vs. measured retention times (min), 207 PCB congeners on a HT8 column.*

The four physical properties were best described by constitutional and topological descriptors, molecular walk counts, WHIM and GETAWAY descriptors. The retention times correlated with descriptors from all groups

The results presented above shows that it is possible to obtain a good fit and low prediction errors using multivariate calibration models for physical properties, and retention times on gas chromatography columns, based solely on computationally derived descriptors. Experimental data with the smallest expected experimental errors were also the easiest to model, i.e. the retention times.

Deviation between measured values and model predictions can be due either to model error or experimental error. The "experimental error" result from both intra- and inter-laboratory variation, and especially the last factor is important since different laboratories often have used different methodology. We feel that there are rather strong indications that the experimental error is the limiting factor for these structure-property modeling efforts, since the model fit improves both with a robust approach and with more reliable data. Others have reported a similar experience with some of the group contribution methods for estimation of the partitioning coefficient octanol-water[29].

The deviation between experimental measurements and model predictions are particularly pronounced for two objects with regard to the Henry's law constant. PCB #77 and #172 have predicted values of 1.0E-4 and 1.8E-5 atm-m3/mol. The reported experimentally determined values in the PhysProp database are 9.4E-6 respectively 1.3E-6 atm-$m^3$/mol. We therefore made a check with the original papers, where the reported data for PCB #77 and #172 actually are a magnitude higher 9.4E-5 and 1.3E-5 atm-$m^3$/mol[30,31]. The large deviations are obviously due to errors in the transfer between the published data and the PhysProp database.

Validation is a general problem when using data compiled from many different sources. The usual approach to this problem is to carefully re-evaluate all original data and investigations. However, in many cases this can prove to be difficult and at least very time consuming. Furthermore, experimental errors will often remain after this process. Another way of dealing with the problem is to use high-breakdown methods for data evaluation, i.e. robust methods for model building that can accept significant contamination with bad data. Least median of squares regression is an example of such a robust method, with a breakdown point of 50%. This method will work if we can expect at least 50% "good data", and this does seem as a conservative assumption in many practical situations.

How reliable are then the model predictions compared to the individual experimentally determined results? Each model interpolation is actually based on a substantial number of experiments performed in various laboratories. We are therefore inclined to put more faith in the model interpolations if a reported experimental value show up as an outlier with a high residual. It will be very interesting to see if repeated measurements on some of the congeners with the largest reported deviations will provide a more definitive answer to this.

## Conclusions

We have in this investigation reported estimations of some important basic physical parameters for all 209 congeners of polychlorinated biphenyls. These estimations were made from computationally derived descriptors using a robust approach to multivariate calibration. In a number of cases large deviations were detected from the reported experimentally determined values. Some of these could directly be assigned to typing errors. The most reliable measurements available, retention times from gas chromatography, were also the easiest to predict with accuracy and precision. The model predictions therefore seem to provide a reliable summary and extension of the currently available database on these compounds.

### Supplementary materials

- List of descriptor variables generated by the software Dragon as a text file.
- List of descriptor variables used in this study as a text file.
- Raw data file with descriptor and response variables as a tab separated text file.
- Score vectors from PCA as a tab separated text file.
- Text files with lists of objects (congeners), descriptor variables and test set for the vapor pressure PLS regression model.
- Measurements, predictions and residuals for vapor pressure (mm Hg) as a tab separated text file.
- Text files with lists of objects (congeners), descriptor variables and test set for the water solubility PLS regression model.
- Measurements, predictions and residuals for water solubility (mg/l) as a tab separated text file.

- Text files with lists of objects (congeners), descriptor variables and test set for the partitioning coefficient PLS regression model.
- Measurements, predictions and residuals for partitioning coefficient octanol-water (log P) as a tab separated text file.
- Text files with lists of objects (congeners), descriptor variables and test set for the Henry's law constant PLS regression model.
- Measurements, predictions and residuals for Henry's law constant (atm-$m^3$/mol) as a tab separated text file.



SWEDISH EnviroNet

# APPENDIX D

# FUGACITY EQUATION SUBSTITUTIONS

Individual fugacities for each compartment (as a bulk media) are described by the following equations:

(Air)

$$f_1 = \frac{D_{21} f_2}{D_{12} + DA_1} = \frac{D_{21} f_2}{DT_1} \text{ (no reaction in air)}$$

(Upper water column)

$$f_2 = \frac{D_{32} f_3 + D_{12} f_1}{D_{21} + D_{23} + D_{A2} + D_{R2}} = \frac{D_{32} f_3 + D_{12} f_1}{DT_2}$$

(Lower water column)

$$f_3 = \frac{D_{53} f_5 + D_{23} f_2 + D_{43} f_4}{D_{32} + D_{34} + D_{A3} + D_{R3}} = \frac{D_{53} f_5 + D_{23} f_2 + D_{43} f_4}{DT_3}$$

(Sediment Bed)

$$f_4 = \frac{D_{34} f_3}{D_{43} + D_{R4} + D_B} = \frac{D_{34} f_3}{DT_4}$$

(Vessel Interior)

$$f_5 = \frac{N_5}{D_{A5}}$$

Direct substitution to solve for $f_2$ as a function of $f_3$:

$$f_1 = \frac{D_{21} f_2}{DT_1}$$

$$DT_2 f_2 = D_{32} f_3 + D_{12} \times \frac{D_{21} f_2}{DT_1}$$

$$DT_2 f_2 - \frac{D_{12} D_{21} f_2}{DT_1} = D_{32} f_3$$

$$f_2 \left( DT_2 - \frac{D_{12} D_{21}}{DT_1} \right) = D_{32} f_3$$

$$f_2 = \frac{D_{32} f_3}{DT_2 - \frac{D_{12} D_{21}}{DT_1}}$$

Direct substitution to solve for $f_3$:

$$f_4 = \frac{D_{34} f_3}{DT_4}$$

$$DT_3 f_3 = D_{53} f_5 + \frac{D_{23} D_{32} f_3}{DT_2 - \frac{D_{12} D_{21}}{DT_1}} + \frac{D_{43} D_{34} f_3}{DT_4}$$

$$DT_3 f_3 = D_{53} f_5 + f_3 \left( \frac{D_{23} D_{32}}{DT_2 - \frac{D_{12} D_{21}}{DT_1}} + \frac{D_{43} D_{34}}{DT_4} \right)$$

$$DT_3 f_3 - D_{53} f_5 = f_3 \left( \frac{D_{23} D_{32}}{DT_2 - \frac{D_{12} D_{21}}{DT_1}} + \frac{D_{43} D_{34}}{DT_4} \right)$$

$$\frac{DT_3 f_3}{f_3} - \frac{D_{53} f_5}{f_3} = \frac{f_3}{f_3} \left( \frac{D_{23} D_{32}}{DT_2 - \frac{D_{12} D_{21}}{DT_1}} + \frac{D_{43} D_{34}}{DT_4} \right)$$

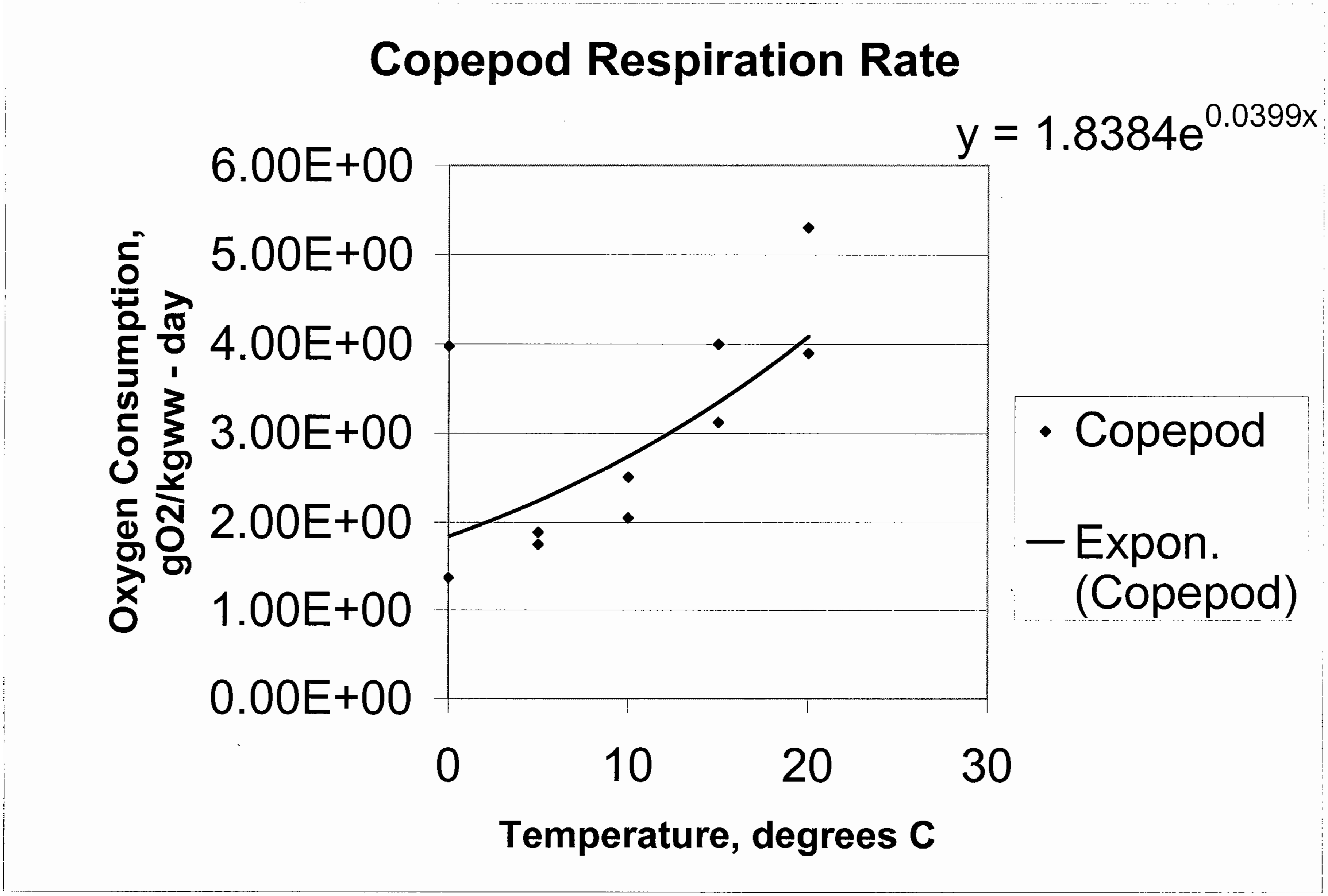
$$DT_3 - \frac{D_{23} D_{32}}{DT_2 - \frac{D_{12} D_{21}}{DT_1}} - \frac{D_{43} D_{34}}{DT_4} = \frac{D_{53} f_5}{f_3}$$

$$f_3 = \frac{D_{53} f_5}{DT_3 - \frac{D_{23} D_{32}}{DT_2 - \frac{D_{12} D_{21}}{DT_1}} - \frac{D_{43} D_{34}}{DT_4}}$$

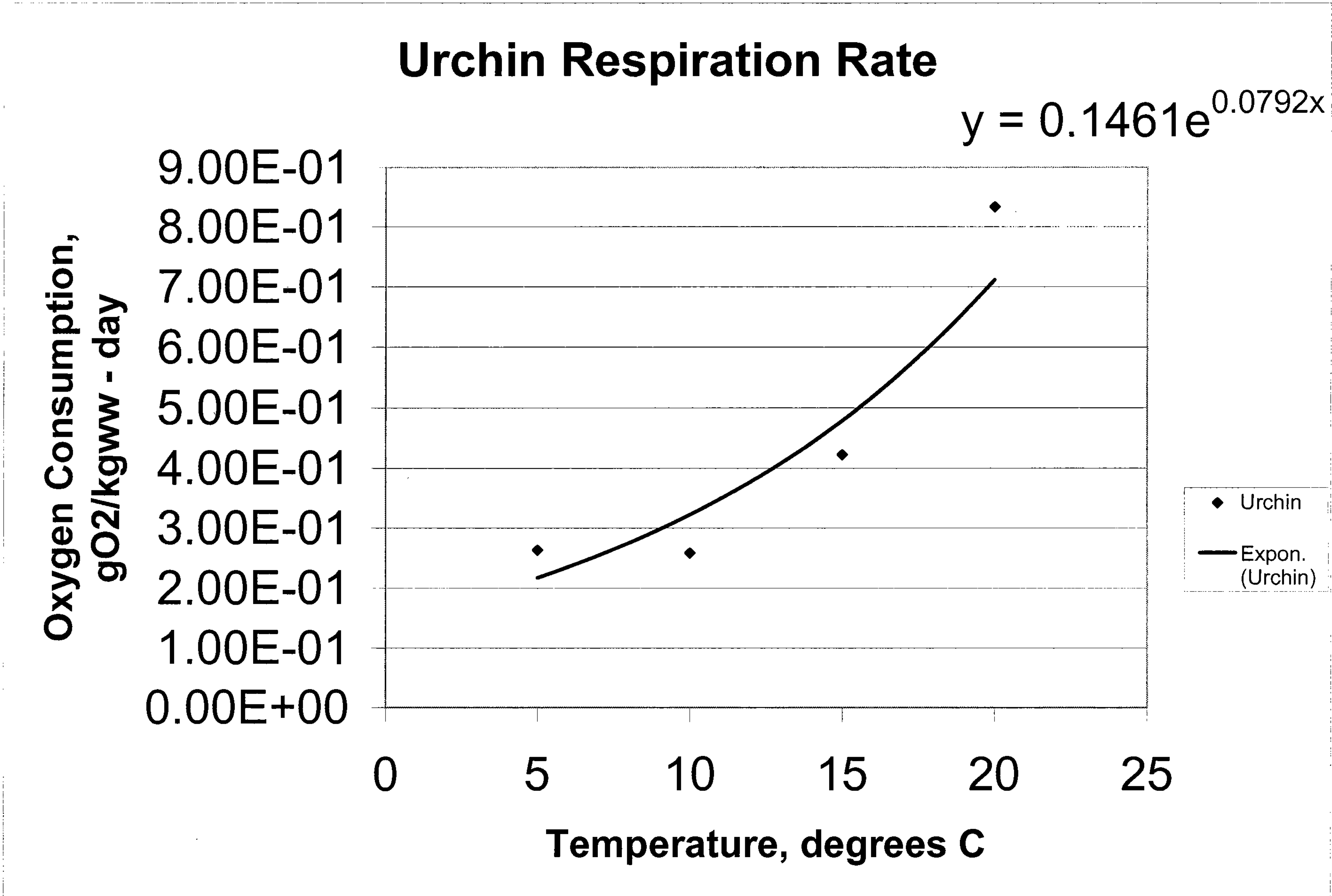
$$f_3 = \frac{D_{53} f_5}{DT_3 - \frac{D_{23} D_{32} DT_1}{DT_1 DT_2 - D_{12} D_{21}} - \frac{D_{34} D_{43}}{DT_4}}$$

# APPENDIX E

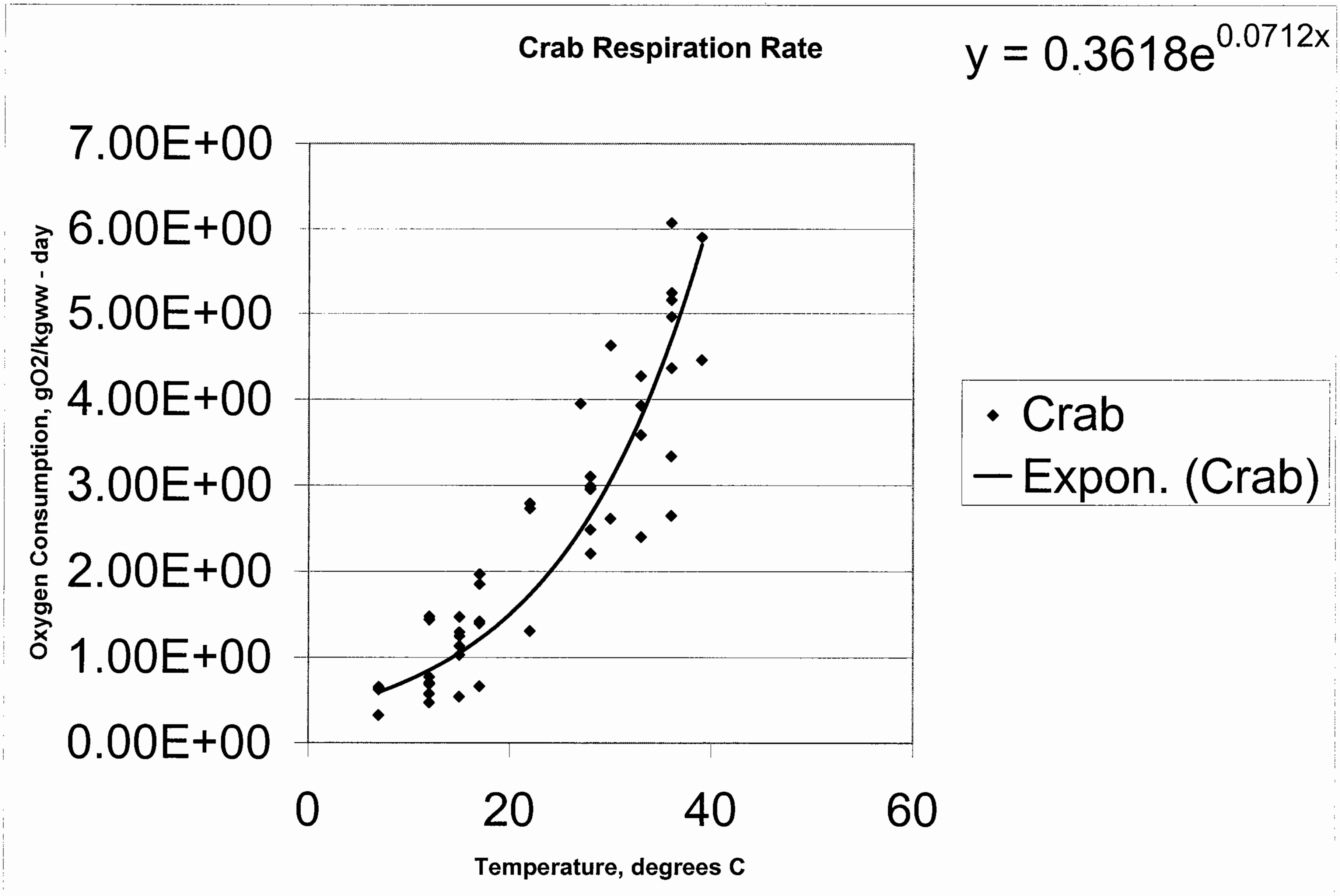
# ORGANISM RESPIRATION REGRESSIONS



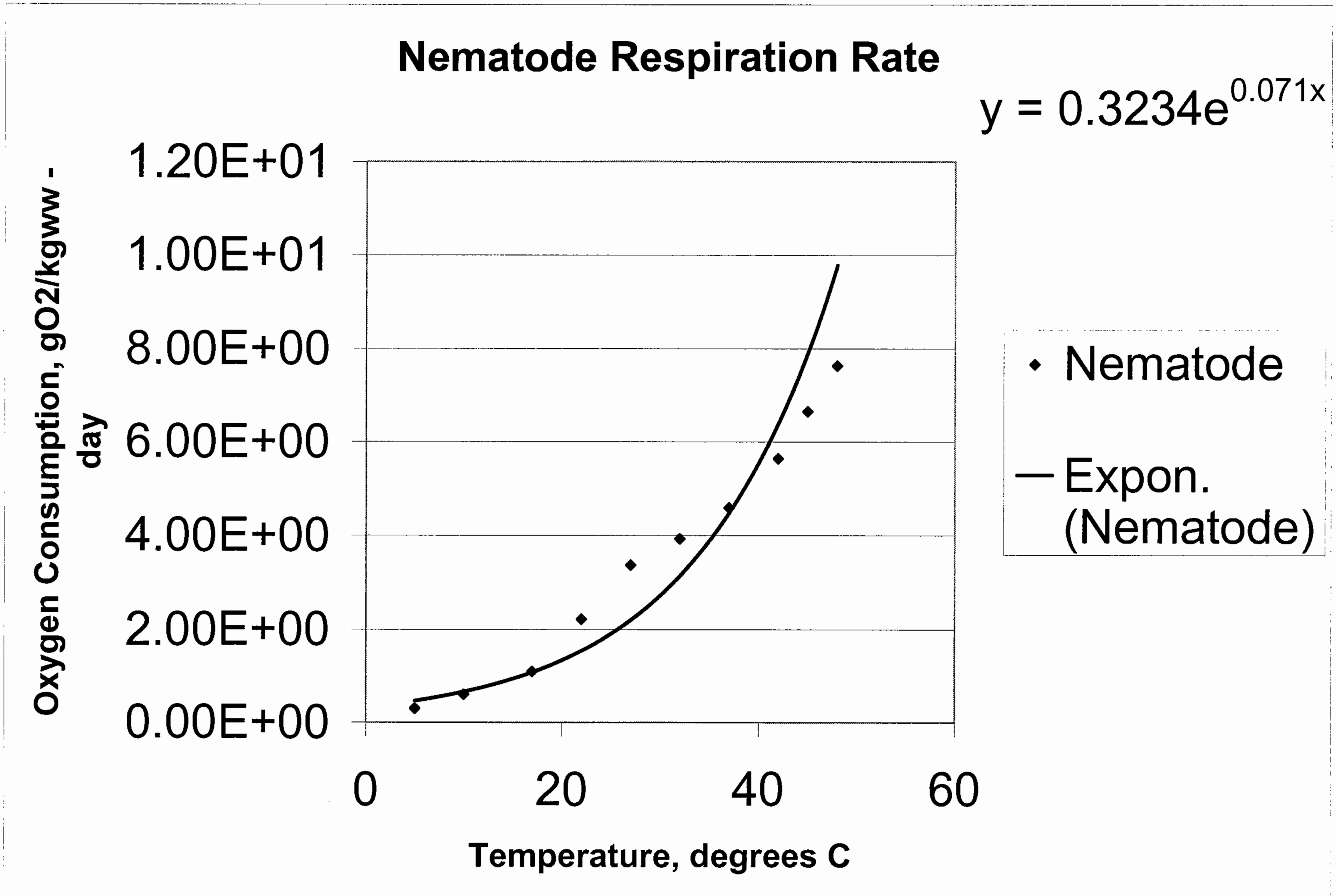
Copepod Respiration Rate
y = 1.8384e^0.0399x
6.00E+00
5.00E+00
4.00E+00
3.00E+00
2.00E+00
1.00E+00
0.00E+00
Oxygen Consumption, gO2/kgww - day
0
10
20
30
Temperature, degrees C
Copepod
Expon. (Copepod)



Urchin Respiration Rate
y = 0.1461e^0.0792x
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Oxygen Consumption, gO2/kgww - day
0
5
10
15
20
25
Temperature, degrees C
Urchin
Expon. (Urchin)



Crab Respiration Rate
y = 0.3618e^0.0712x
7.00E+00
6.00E+00
5.00E+00
4.00E+00
3.00E+00
2.00E+00
1.00E+00
0.00E+00
Oxygen Consumption, gO2/kgww - day
0
20
40
60
Temperature, degrees C
Crab
Expon. (Crab)


Nematode Respiration Rate
y = 0.3234e^0.071x
1.20E+01
1.00E+01
8.00E+00
6.00E+00
4.00E+00
2.00E+00
0.00E+00
Oxygen Consumption, gO2/kgww - day
0
20
40
60
Temperature, degrees C
Nematode
Expon. (Nematode)

# APPENDIX F

# ZONE OF INFLUENCE

This appendix is intended to provide additional details about the potential composition of a fish assembly that might be associated with the artificial reef ex-ORISKANY, and information of relevance to establishing spatial boundaries of that assemblage.

In plan view, the "footprint" of the ex-ORISKANY vessel is about 10,000 square meters ($m^2$), or a hectare (2.5 acres). Assuming that the vessel comes to rest in an upright attitude and minimally penetrates the substrate, most of the structure will extend about 30 meters (m) upward through the water column, with a portion (the "island") extending another 15 m (to within about 15 m of the sea surface). The vessel will provide about 27,800 $m^2$ (nearly 7 acres) of surface, which is likely to be perceived by marine organisms as the structural equivalent of "hard bottom" (Department of the Navy, 2004). There are scattered natural hard-bottom habitats in the general vicinity of the proposed site (i.e., within a few tens of kilometers [km]), but the main concentrations of such structures are at least 80 km to the southwest, and predominantly in deeper water (Thompson et al., 1999; Weaver et al., 2002). Thus the ex-ORISKANY will present an ecological novelty.

Inasmuch as fishers and aquatic ecologists have known for centuries that many fishes and other nektonic animals tend to congregate near submerged structures, both natural and artificial, (e.g., Walton, 1976; Moyle and Cech, 1982), it is reasonable to assume that from the potential "pool" of nektonic animals in the northeastern Gulf of Mexico there will be a subset that associates with the ex-ORISKANY. The issue becomes which kinds ("species"), to what degree (spatially and temporally), and in what densities nektonic assemblages will occur at the artificial reef. There are at least 300 kinds of fish, known or presumed to represent formally described (named) species, which have been recorded in waters overlying the northeastern Gulf of Mexico continental shelf between Longitudes 85° and 88° at depths from 15 to 70 m (~49 to ~230 feet). The foregoing statement is based on review of lists compiled from various sources, including Hoese and Moore (1998), Thompson et al. (1999), Weaver et al. (2002), Carpenter (2002), and others. At least some individual representatives of many of the aforementioned 300-plus fish species may spend various increments of time in a particular location such as that of the proposed site of the ex-ORISKANY.

The Gulf of Mexico Fishery Management Council (GMFMC, 2003) recognizes the following species as reef fish for purposes of its management planning:

| Common Name | Species |
|---|---|
| Gray triggerfish | *Balistes capriscus* |
| Greater amberjack | *Seriola dumerili* |
| Lesser amberjack | *Seriola fasciata* |
| Almaco jack | *Seriola rivoliana* |
| Banded rudderfish | *Seriola zonata* |
| Hogfish | *Lachnolaimus maximus* |
| Queen snapper* | *Etelis oculatus* |
| Mutton snapper** | *Lutjanus analis* |
| Schoolmaster snapper** | *Lutjanus apodus* |
| Blackfin snapper | *Lutjanus bucanella* |
| Red snapper | *Lutjanus campechanus* |
| Cubera snapper** | *Lutjanus cyanopterus* |
| Gray snapper | *Lutjanus griseus* |
| Dog snapper | *Lutjanus jocu* |
| Mahogany snapper** | *Lutjanus mahogoni* |
| Lane snapper | *Lutjanus synagris* |
| Silk snapper* | *Lutjanus vivanus* |
| Yellowtail snapper+ | *Ocyurus chrysurus* |
| Wenchman | *Pristipimoides aquilonaris* |
| Vermilion snapper++ | *Rhomboplites aurorubens* |
| Blueline tilefish | *Caulolatilis microps* |
| Tilefish* | *Lopholatilis chamaeleonticeps* |
| Rock hind | *Epinephelus adscensionis* |
| Speckled hind | *Epinephelus drummondhayi* |
| Yellowedge grouper* | *Epinephelus flavolimbatus* |
| Red hind | *Epinephelus guttatus* |
| Goliath grouper (formerly jewfish) | *Epinephelus itajara* |
| Red grouper | *Epinephelus morio* |
| Warsaw grouper | *Epinephelus nigritus* |
| Snowy grouper* | *Epinephelus niveatus* |
| Nassau grouper+ | *Epinephelus striatus* |
| Black grouper | *Mycteroperca bonaci* |
| Yellowmouth grouper | *Mycteroperca interstitialis* |
| Gag (or gag grouper) | *Mycteroperca microlepis* |
| Scamp | *Mycteroperca phenax* |
| Yellowfin grouper** | *Mycteroperca venenosa* |

* Adults may tend to avoid ex-ORISKANY because site is too shallow (GMFMC, 2003); Yellowedge grouper (*Epinephelus flavolimbatus*) and Snowy grouper (*Epinephelus niveatus*) were added to this group of fish per personal communication with Jon Dodrill, Florida FWCC, 01/05/05).

** Adults may tend to avoid ex-ORISKANY because site is too deep (GMFMC, 2003).

\+ Proposed site is outside normal geographic range (Carpenter, 2002).

++ Addition to the above GMFMC table per personal communication with J Dodrill, Florida FWCC, 01/05/05).

There is a good chance that adult individuals of species not footnoted (as "*" or "**") in the above list will eventually be recorded at the ex-ORISKANY site, and a few (e.g., gray triggerfish, red snapper, gag) are likely to become effectively "resident" and contribute significantly to local fishery landings. Many additional species will probably establish effective residence (as juveniles and adults), a few of which are not formally managed by the GMFMC as 'reef fish' (e.g., tomtate [*Haemulon aurolineatum*]) but are nevertheless exploited by fishers. Even so, the vast majority of the fishes that will spend most of their lives at the vessel are relatively small and/or of little or no interest to anglers. Examples of such "non-fishery" obligate reef fishes are wrasses, grunts, blennies, sandbasses, and gobies; these fish will be relevant to the ecological risk assessment (and as prey for some of the fishery species).

For purposes of the Prospective Risk Assessment Model (PRAM), only a few representatives of the 30 or so species likely to be associated with the vessel, and likely to be eaten by humans, are of special interest. That is, which among the fishery species are likely to have representatives that spend a substantial fraction of their lives (multiple years, in aggregate) in close proximity to the ex-ORISKANY?[1] Based on anticipated behavior, how many different types of fish are expected to have substantial affinity to the vessel?

[1] None of the fishery species likely to occur at the ex-ORISKANY spends its entire life in one location. These fishes often spawn in areas other than where they forage; and they all have planktonic larvae which in most cases "settle" in inshore areas where they spend a few to many months before moving offshore (Carpenter, 2002; GMFMC, 2003). Some of the larger fishes (e.g., most groupers) tend to migrate to progressively deeper water in the later years of their lives (Carpenter, 2002; GMFMC, 2003). Also, many of the larger predatory fishes may be removed by anglers within the first year or so after they first arrive at ex-ORISKANY (J. Dodrill, Florida FWCC, personal communication, 1/5/05). All of these realities are ignored by the PRAM (i.e., the model conservatively assumes that the fish remain consistently within the Zone of Influence [ZOI] throughout their lives).

There are two basic behavioral scenarios in the context of the PRAM. There are fishes that focus their foraging on vertical (or "suspended" horizontal) substrates, and thus would move up and down along the sides of ex-ORISKANY (e.g., gray triggerfish). This behavior entails gleaning or grazing on encrusting organisms and small animals living in or on the encrusted colonies (Beaver, 2004). The other basic behavior involves preying on plankton, smaller nekton (than the predator), and or benthic invertebrates associated with the sea bottom lateral to the vessel (e.g., red snapper). The second behavior involves substantial movement within the water column, at least while feeding (which is what most fish do when not resting or spawning [Moyle and Cech, 1982; Gerking, 1994). Practitioners of the second behavior may spend most of their time at various levels within the water column above the seafloor, and are traditionally referred to as *pelagic* (e.g., amberjacks), and some may spend most of their time very near or in contact with the natural bottom (called *demersal*; e.g., tilefish, some snappers and groupers). Still others may forage more or less equally in the water column and along the seafloor (e.g., some snappers and grunts).

To satisfy the requirements of PRAM to model PCB fate and transport in the abiotic media and to model trophic transfer of PCBs, it is necessary to identify the external boundary of at least one Zone of Influence (ZOI). However, in the context of evaluating human health risk associated with consumption of fish, it may be advantageous to consider using at least two different ZOIs to account for the above behavioral scenarios of fish. From the perspective of an aquatic ecologist this simply equates to identifying a realistic, albeit conservative, increment of space (distance) from the external surface of the ex-ORISKANY that would allow a fish to perform its behavior.

In the case of the gray triggerfish (*B. capriscus*) the estimate is relatively straight-forward. Because of its unusual mouth structure, a triggerfish is constrained to feed at a roughly perpendicular orientation relative to the surface on which it is grazing (Gerking, 1996). Since the typical adult *B. capriscus* is roughly 20 centimeters (cm) in total length (Hoese and Moore, 1998), one might suggest that the minimal, (most conservative) space, to allow at least some maneuverability is 0.5 m. However, a space as small as a fraction of a meter is unrealistic for use as a ZOI. This distance is only related to maneuverability for feeding, and does not account for other factors, such as opportunistic feeding behavior (Harper and McClellan, 1997). Triggerfish commonly feed on benthic invertebrates in the sediment bed adjacent to the reef, as well as encrusting organisms on the reef surface. Turpin (personal communication, 2005)[2] notes that reef-associated triggerfish commonly range more than10 m from the reef as part of their foraging behavior. This observation is consistent with information provided in Bortone et al. (1998) demonstrating a high level of predation of benthic organisms in the vicinity of artificial reefs, with maximum impacts on benthic biomass occurring between10 and 20 meters from the reef, as well as the observation that anglers regularly catch triggerfish several meters away from structures (personal experience and testimony of others). In addition to the above considerations, when determining which ZOI boundaries may be appropriate, one must also consider that within the PRAM, the ZOI also defines the volume into which PCBs released from the sunken vessel are received. PRAM uses an artificial construct of the sunken vessel, which assumes that all of the bulkheads of the vessel are porous, and do not retard the release of PCBs into the ZOI. To the extent that this does not accurately characterize the manner in which PCBs will be released from the vessel (i.e., PCBs may actually emanate from discrete apertures or "leakage" areas), an adequate distance around the sunken vessel should be assumed such that PCB release and distribution can occur. Therefore, a minimal distance of 15 meters is recommended to evaluate exposure to near-field foraging fishes such as triggerfish.

For the pelagic and demersal behavior scenarios the estimate is more complex. Ideally, one would have copious detailed observations of individually recognizable (or tagged) individuals representing at least a few anticipated fishery species. For the probable ex-ORISKANY examples mentioned above, there do not appear to be any such studies over short time periods at a local scale. There are some local-scale studies for fishes associated with natural reefs. In one example using acoustic telemetry, the Bermuda chub (*Kyphosus sectatrix*) was found to have elongate home ranges with lengths of 157-1259 meters and widths of 54-234 meters (Eristhee and Oxenford, 2001). That is, of the 11 tagged individuals tracked over a two-month period, there was one fish that limited its movement in one dimension to 54 meters. Regional-scale tagging studies are of little relevance to the immediate issue, because they generally tend to focus on questions about how far fish travel in the context of migration over extended periods. In such studies, many re-captures are recorded as occurring literally at the point of release (mainly early in the overall study) and the less frequent re-captures at remote locations are on the scale of tens or even hundreds of kilometers. Several such studies have been performed on red snappers in various parts of the

[2] Personal communication from Robert Turpin, Escambia County, Florida Marine Resources Division (01/05/05). Gray triggerfish associated with artificial reefs are opportunistic feeders that commonly feed on encrusting organisms on reefs and on benthic organisms in the vicinity of reefs. Based on personal observations on numerous artificial reef sites, gray triggerfish are commonly seen foraging on benthic organisms more than 10 meters from reef structures (often 40 meters or more).

Gulf of Mexico, some of which indicated a high rate of "fidelity" to the location of release, but virtually all of the cases had some records indicating movements on the scale of tens of (or more) kilometers (Fable, 1980; Szedlmayr and Shipp, 1994; Patterson et al., 2003; and others).

Recent development of multi-beam hydroacoustic technology has provided some valuable insights into the probable magnitude of local movements of pelagic and demersal artificial-reef associated fishes (Stanley, 1994; Stanley and Wilson, 1996, 1997, 1998, 2000a, b, 2003; Wilson et al., 2003). Some of the earlier of these studies merely indicated fish assemblage density discontinuities, thereby defining the boundaries of aggregations at the times of observations. More recently, the work has become much more sophisticated by deployments of stationary equipment that is capable of distinguishing the specific types of fish comprising a given aggregation. Studies have also captured data among a variety of submerged structure types (including petroleum platforms, artificial reefs, and natural hard-bottom habitats) and from different seasons.

The hydroacoustic studies have revealed two basic types of information of relevance to the ex-ORISKANY ZOI dimensions:

- Patterns of density magnitude vary substantially among seasons, indicating that at a fixed location at least some individuals are not always present.
- Spatial boundaries of aggregations (density discontinuities) are relatively similar at a given submerged structure, and they suggest localized short-term (on the scale of hours or less) movements within a range of tens of meters. Over a range of different structures, the span of distances to apparent aggregation 'boundaries' (relative to the structures) was about 12 to 50 m.

Using the results of one of the later studies at a petroleum platform in a bathymetric setting similar to that of the proposed ex-ORISKANY site, Stanley and Wilson (2003) estimated a 'near-field' area of influence of 18 meters. This distance was consistent with standard estimates derived from videographic surveys performed via remotely operated underwater vehicles (ROVs). It is also of interest to note that Bortone et al. (1998) found that demersal reef fish tended to measurably affect the composition and abundance of infaunal benthic communities out to distances as great as 80 m (see also Lindquist et al., 1994). However, in the Bortone et al. (1998) study the typical distance at which several benthic community metrics seemed to reflect a reversal in the pattern of disturbance was in the range of 10 to 20 m.

Based on the foregoing, it seems reasonable to suggest that the 'near-field' area of influence observed by Stanley and Wilson (2003) should provide a basis for a conservative estimate of the magnitude of the ZOI for the PRAM as applied to the ex-ORISKANY, whereas a distance of 50 to 80 meters, consistent with the disturbance patterns noted by Bortone et al. (1998) and Lindquist et al. (1994) should provide an upperbound estimate of the ZOI boundaries. This would apply particularly for the pelagic and demersal fishes that clearly would not obtain the bulk of their diets from the surface of the vessel itself.

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# APPENDIX G

# CLARIFICATIONS/ADDITIONS AND RESPONSES TO BIOLOGY TWG COMMENTS ON NAVY ENVIRONMENTAL HEALTH CENTER (NEHC) PROPOSED FOOD WEB DIET – WATER EXPOSURE MATRIX

# Clarifications/Additions and Responses to Biology TWG Comments on Navy Environmental Health Center (NEHC) Proposed Food Web Diet –Water Exposure Matrix

**January 9, 2005**

All clarifications/additions, revisions, and responses are provided below the commenter's statements.

**Dr. Wayne Munns Comments**:

As a result of today's [12-15-04] discussion, I am in basic agreement with the approach being taken to evaluate the progression of exposures to components of a reefed vessel food web. My sense is that it will address several of the issues raised during previous reviews of PRAM and the risk assessments. I appreciate the significant effort undertaken by the Navy to address these issues, and assuming that the response to the other review comments regarding PRAM is as aggressive, I believe that this next version of PRAM will be a highly credible and flexible tool to support decisions about the Oriskany and future vessels.

*Response: Thank you – comment noted.*

In addition to supporting the specific modifications to values suggested by Roland, Robert T. and Bob J., I'd like to emphasize what I believe to be some key considerations as we proceed with model documentation and analyses (with apologies in advance if these are obvious):

1) The reasoning behind the choices of analysis structure and specific values should be documented. To reiterate, I don't think this means an exhaustive review of existing literature and data. Rather, sufficient rationale should be provided to facilitate understanding of those choices. If a choice was based on intuitive logic (e.g., piscivores primarily eat fish), it's likely sufficient to state that. If based on precedent (e.g., the approaches mirrors that taken by other accepted models), say so and cite the relevant precedent(s). If based on existing information and data, simply cite the sources. If due to fundamental modeling constraints (zooplankton feeding on zooplankton would lead to infinite exposure), describe the limitation. Choices based on best professional judgment are a bit more problematic, in that the underlying considerations need some description and explanation, The important thing here is to explain the reasoning used to a level at which a reasonable person can understand that reasoning. I sensed that Mark and others understood this.

*Response: Comment noted. We have been working to address this in the documentation of the PRAM food web model construct. The matrix tables present findings from our review of literature, comments offered by the biology TWG members, and professional judgment.*

2) Within reason, the ramifications of those choices with respect to model output should be described. This consideration was behind my question to Mark about the sensitivities of model output to parameter choices. Obviously, exhaustive formal sensitivity analyses are the gold standard here, but such are not necessary (nor does time permit).

*Response: A sensitivity analysis was performed on an earlier version of the PRAM that revealed that biogenetic inputs and certain chemical inputs (e.g., Kow, Koc) were far more sensitive than dietary preferences. That analysis, however, was performed on a much simpler food chain than is currently incorporated into PRAM. With the revised foodweb in PRAM, we do agree that additional sensitivity analyses would be helpful to evaluate the potential significance of varying parameters. Given the time constraints, this effort could be considered, if so requested by the TWG, after the submission of our PRAM documentation deliverables.*

The answer Mark had provided to my question is a good start, but stopping there may risk questions about the appropriateness of parameter values chosen. Somewhere in between would be multiple (i.e., more than one) model (or sub-model) runs that can serve to bound model outputs. I suspect we might want to give this issue some additional thought.

*Response: We have discussed "bounding" results that may address this, using upper and lower limits of assumed values. Given the large number of variables (parameter values) required to model PCB release from the vessel, and subsequent transfer through the food web, it is unlikely that any meaningful bounding estimate could be provided. As such, we do not propose to provide bounding estimates. It is important to note that the parameter values chosen for inclusion in PRAM were based on the best available information, and have undergone review by the members of the biology Technical Working Group (TWG) in order to arrive at representative and defensible consensus values.*

3) As discussed by Bill and others, the documentation should be very clear about the degree of conservatism embodied within the choices. Although I might argue that assumptions and approaches in risk assessments, even screening-level RAs, should not be conservative, others hold a different perspective (usually for good reason). The decision-makers and stakeholders will want to understand the degree of conservatism assumed as it influences their confidence that they're not making a wrong decision.

*Response: Comment noted.*

I think we want all parties to the decision about the ex-ORISKANY to be able to stand behind the science supporting that decision. It's to everyone's advantage to have the communication of that science be transparent.

We did not reach consensus on whether or how to address the issue of risks to organisms with exposure pathways involving the interior of the ship. As some of us had suggested, both risk assessments [Human Health and Ecological] likely will need to address this issue in some fashion.

We had discussed (at least) three options for doing this: 1) incorporating additional reef components explicitly as environmental compartments (Bob J.'s "interior reef community"), 2) modifying PRAM to allow exposure of sessile filter feeders to vessel interior waters (as represented by unshading cell D10 in the water exposures matrix), or 3) acknowledging the lack of explicit analysis in a discussion of uncertainties. Absent hard information about utilization of the ship's interior by members of the reef community, which of these options is "best" is not apparent to me. However, an approach that combines options 2 and 3 seems reasonable and defendable. Allowing the potential for exposure to be non-negative brings its consideration into the analyses explicitly, and increases the flexibility of PRAM to accommodate various assumptions about the contribution of this exposure route if need arises. When associated with a discussion of the assumed value (zero or some low percentage) and attendant uncertainties in this value and its effects on model output, people may quibble about that value, but they can't charge that the pathway was ignored. To address one of Andrea's concerns, allowing some non-negative percentage of exposure to interior waters seems to be no different than assuming various percentages of exposure to other waters (or prey) to other receptors -- these percentages are intended to represent reasonable guesstimates of exposures averaged across individuals of each of the receptor populations. Thus, this approach is consistent with that taken throughout.

*Response: In order to make PRAM more flexible, we have unblocked cell D10 and have recommended a value of 0 percent, which reflects our position that a vessel interior community is unlikely, and if existent, would represent a negligible portion of the overall reef community biomass, and therefore unlikely to provide a significant portion of the overall diet to upper trophic level organisms. We believe this is consistent with comments made by Jon Dodrill and Robert Turpin (see, e.g., Robert Turpin's comments regarding his observance of a very strong inverse relationship between biological utilization and distance from the reefs "exterior"). Based on your comments and those of others to the effect that there may be a need to assign some non-negative percentage of exposure to internal waters, we are amenable to changing this value to some low percentage, if warranted.*

Second Round comments:

I believe that we need to put to rest the issue of an "interior (epifaunal) reef community" as quickly as possible. Although I continue to support the approach taken (i.e., unblocking that exposure pathway (Table 2, Cell D10) with a value near zero), my guess is that reasonable people will continue to hold to the belief that epifaunal organisms will utilize interior surfaces of the ship. Robert Turpin's comments not withstanding, we apparently lack the hard evidence to support selection of specific exposure values. I suspect that "professional judgment" will not win the day here, as professionals already seem to be in disagreement (by the way, I recommend that we put to bed the notion that sunlight for photosynthesis is needed to sustain interior organisms -- the determining factor is whether there is sufficient water movement into the ship's interior to transport: a) the pelagic larvae of epifaunal species, and b) organic matter and oxygen to sustain filter feeders). Confounding the issue has been our imprecision in defining the "interior." Is it possible to obtain quantitative information about utilization of reef interiors by epifaunal organisms to support selection of a specific exposure value? If not, we will need to relegate the issue to a discussion of uncertainties.

*Response: As discussed in the 6 Jan 05 biology TWG conference call, a compromise position has been achieved that reflects the differing requirements of the human health risk and ecological risk assessments. For purposes of the human health risk assessment, cell D10 (unblocked) will be set as 0% to reflect the consensus opinion that sessile filter feeders in interior ship compartments would represent a very minor/negligible source of PCBs to the higher trophic level organisms consumed by humans. For the ecological risk assessment, exposure to ecological receptor populations will be evaluated by comparing predicted abiotic (bulk water) PCB concentrations to ecological benchmark values.*

**Dr. Roland Ferry's Comments:**

I believe that the approach taken here is both reasonable and defendable. I think that Mark and his team did a nice job breaking out the relevant community compartments and estimating dietary preferences, particularly given the lack of specific information available.

*Response: Thank you – comment noted.*

I am in full agreement with Wayne's comments regarding documentation.

*Response: Comment noted. We have been working to address this in the documentation of the PRAM food web model construct. The documentation issue is clearly one that we need to address and we appreciate the expression of concern.*

Regarding the issue of exposures to the interior of the vessel I also believe it needs to be addressed since we are taking it on faith that interior spaces will have higher PCB concentrations and we know that some animals will reside and/or visit interior spaces. I'm not prepared to suggest how important this exposure will be in this case, perhaps not very, but it still remains. I also concur that it should be satisfactorily dealt with using a combination of inserting a value in cell D10 of the model and thoughtful discussion.

*Response: The cell for the matrix table (Table 2, Cell D10) is now unshaded to indicate there is a potentially complete (interior) exposure pathway for these organisms. The data users (ecological and human health risk assessors) will use the information provided to make their evaluation for the significance of this pathway.*

What follows are some specific suggestions and comments. These are educated guesses, no better than any others and I'm no "expert". If you come by better information or find other scientists who may be more credible, by all means use their suggestions.

Worksheet 1: Water Exposures

As we discussed, myself and others commented on the diel migration of zooplankton suggesting that water exposure of zooplankton should be split more evenly between the epilimnion and hypolimnion. Because planktivores and the piscivores that feed on them will follow the zooplankton (they are heavily preyed upon at night), their exposures should also be split more evenly between the epilimnion and hypolimnion.

*Response: We concur. The PRAM will be modified to reflect a 50:50 split for water exposures to the zooplankton community.*

Regarding the infaunal or macroinvertebrate community, as I stated, our collections in the northern Gulf show that the community will consist of from some 400-500 species. The majority of theses will be smaller motile invertebrates that move through the sediments. A smaller number of species will be larger bodied animals; some of them free living and some tube dwelling. Tube dwellers often line tubes with materials which may isolate them somewhat from pore water exposure. I can't say what species or groups will likely dominate in any site or sample. In terms of number of species and abundance (individuals) pore water exposure should be primary. In an area where tube dwellers are fairly abundant they may dominate in terms of biomass. In such a case hypolimnion exposure may be primary. If someone has some site specific information (perhaps Rob Turpin) about dominants at the reef site it could help set more reasonable exposure numbers. In lieu of better information one might be safe using a 50-50 split between pore water and hypolimnion.

*Response: Comment noted. Since other commenters (e.g., Dr. Johnston) provided a different opinion, we have developed a compromise position that we believe retains a degree of conservatism, as suggested by Dr. Johnston's and your suggestion. We agree that, as the macroinvertebrates employed within the PRAM are represented by burrowing worms , their exposure to pore water would be significant, and probably greater than 50%. However, we think it is unlikely that they would respire 100% pore water. Additionally, it is important to keep in mind that the PRAM is not modeling individual species but rather relevant guilds (i.e., infaunal benthos) such that the assumption that "all" infaunal benthos would respire only sediment pore water is probably inaccurate/unrealistic. Thus our recommendation is that the PRAM configuration should have the infaunal macroinvertebrates respiring 80% sediment pore water and 20% surface water.*

Worksheet 2: Dietary Preferences

My main comment here is in regard to the infaunal preference numbers. The infaunal species that are not predacious are generally classified as either deposit or suspension (filter) feeders. Deposit feeders are mainly feeding on the organic matter; zooplankton bodies, fecal pellets (mostly undigested phytoplankton) and detritus from other sources that settle on the seabed. Filter feeders are collecting organic particles from the upper few cm of overlying water. Only a fraction of the total species present ingest actual sediment, usually incidental. Because most of the organic matter consumed for suspension and deposit feeders is derived from algae (microbenthic algae and phytoplankton) and zooplankton, I'd give them about 40-40 with sediment 20%.

*Response: Comment noted. Since other commenters (e.g., Dr. Johnston) provided a different opinion, we have attempted to reconcile these opinions. Our current recommendation for the dietary fractions is: 50% sediment, 30% algae, and 20% zooplankton. While the actual dietary fractions of sediment remain high for the benthic macroinvertebrate guilds, it is recognized that there will be direct deposit feeding of algae and zooplankton. The rationale for the selection has been detailed in the PRAM documentation. Key to the consideration is the transfer(s) of PCBs from the sediment itself (representing a PCB" sink) into the detrital food web.*

Worksheet 3: Dietary Preference Projections

Planktivores: The progression seems to suggest that as more attached algae become present, it will become a larger % of the planktivore diet. I doubt that, as attached algae will not likely be fed on by this group. I'd spread those %'s among the SS, algae and zooplankton compartments.

*Response: The PRAM model construct for the food web, which is specifically designed to trace PCBs within the three communities, has been changed to reflect that the planktivores may not be the most relevant transport pathway for PCBs within the reef community (i.e., not the maximally exposed trophic level II guild). The representative guild selected for the PRAM, based on where maximum exposures concentration would occur, is the omnivorous invertebrate guild that scrapes attached algae and also consumes encrusted filter feeding organisms. The dietary fraction for this guild are 80% attached algae, and 20% encrusted organisms (sessile filter feeders). This is reflected in the revised table and discussed and defended within the PRAM documentation.*

Invertebrate forager: In this group I see crabs, urchins, sea slugs, etc., mainly walking and crawling animals, none of which will likely feed much on zooplankton, pelagic planktivores or other organisms free swimming in the water column. My guess is that early on benthic infauna and epifauna will comprise the bulk of the diet and later a larger % of the attached organisms on the vessel.

*Response: Comment noted. The diet has been adjusted to reflect a larger percentage of benthic macroinvertebrates. Please refer to the progression shown in the attached table.*

The last three groups (foragers and predators) have large initial %'s of their diet coming from benthic epifauna and benthic foragers – just where I'd expect it to come from, although I'd expect infauna to be more important to invertebrate foragers. However, they decrease to smaller %'s and finally go to zero values at day 712. I believe that any food source comprising 50-85% of their initial diet will remain important even as new sources become available. The %'s should decline somewhat, but probably won't go below say 30% of its starting value.

*Response: The attempt here was to arrive at the point, at 712 days, where these groups are separated into their respective resident communities. Although the reef vs. benthic* *foragers may be comprised of some of the same species, they are separated into distinct populations, those resident over the sediment or those on the reef once the reef has become fully established. This is described more completely in the final documentation along with the rationale, which is associated with maximizing exposure and evaluating relative risks between communities.*

**Dr. Jon Dodrill's Comments:**

1) We appreciate the effort that Mark, Bob and others have made to expand the trophic levels as well as feeding guilds within the categories. This expanded food web, though more difficult to incorporate into the model, I believe represents a more defensible approach than a simplistic food chain.

*Response: Thank you – comment noted.*

2) By choosing to be generic in each of your categories (example, Benthic Forager (TL-III_; Reef Predator (TL-IV)), but then assigning specific percentages for various food items consumed by the "generic" organisms, you have entered the realm of intuition, gestalt, or educated guessing. We all recognize that the pulse modeling sheet is the most subjective and probably the least defensible. I personally probably could not defend the reasons why these specific percentages were selected although I accept the fact that most seem intuitively reasonable. If someone were to ask me why at day 712 there are no pelagic planktivores in the reef predator's diet, I would be very hard pressed to defend that assessment.

*Response: We agree that any of the specific percentages are subjective and would be difficult to defend, given the paucity of information available regarding diet progression as an artificial reef develops. But it is intuitively clear that a diet progression must take place as reef organisms colonize the reef and communities are established. The proposed percentages simply represent an orderly progression of diet, as reef forage becomes available over time.*

*With respect to your comment regarding reef predator diet, and the possibility that some individual reef predator might someday consume a pelagic planktivore: yes, that is certainly a possibility. However, for modeling purposes one needs to characterize groups with common dietary characteristics such that the diets, and exposures associated with the diets, are representative of that guild. Hence, by definition, reef predators predominately eat reef-associated fish and not pelagic fish. Whereas, by definition, in the pelagic community, pelagic predators predominately eat pelagic fish. While mixing diets from the three communities may be a useful exercise in evaluating a specific fish species, it is not consistent with the goal of evaluating the potential exposure to a specific guild as a whole. It should be noted that the generic reef predator, as modeled in PRAM, will provide a more conservative estimate of potential PCB biouptake than a species, such as gag grouper, which also feeds on pelagic planktivores.*

For the Oriskany, we expect a dominant reef predator will be the gag grouper. Gag grouper feed heavily on schooling pelagic planktivores (scad, herring) when these planktivores are at artificial reef sites by the thousands, sometimes within days after a vessel is deployed

*Response: We recognize that the gag grouper is a species of particular interest, and that this species does not readily fit into the strict definition of a reef predator. Rather, we would place it in the pelagic predator guild, since its diet is primarily pelagic fish, and discuss the fact that gag grouper have a mixed diet.*

Dr. William Lindberg (University of Florida) reported that as much as 80 percent of the gag's diet during the summer off the Florida Big Bend are schooling planktivores and they pick them off in the water column. When, during winter, these planktivores leave, the gag's diet in the Florida Big Bend shifts to tomtate grunts, black sea bass, etc. So to say at year one or two that a reef predator does not feed on any pelagic planktivores is probably not defensible when one of the primary vertebrate reef predators expected on the Oriskany probably will still be feeding at least seasonally on pelagic planktivores. Similarly can we defend the example of a invertebrate forager feeding on a pelagic planktivore 15% of the time on day 1 and 10% on day 34? Again I personally couldn't. Does anyone have an example? Are we envisioning such invertebrate as Florida lobsters or slipper lobsters feeding on dead pelagic planktivores falling out of the water column because neither they nor a common octopus for example are going to be swimming up into the water column? Are you suggesting squid, yet squid wouldn't have as 35% of its diet attached algae. All I am saying, is, if one PRAM model objective is defensibility then you need to be ready to have some concrete examples relatable to this Oriskany project that at least fall somewhere in these dietary preference percentages proposed for these generic trophic levels. We need to be prepared to have a specific example(s) of real world organisms for each trophic level for which there is data to show that its dietary preferences as reported in the literature at least fall within the realm of common sense acceptability as relates to the percentages shown in these tables. I don't think "Professional Judgment by Consensus" trumps being able to have on hand (or better yet in the writeup) some specific references that at least support some of these very specific percents that are laid out here. –

*Response: Comments noted. In the PRAM write-up and the SHHRA we will discuss guilds with specific examples and relate them to the dietary preferences proposed for the generic trophic levels; where appropriate, we will discuss variances that may be significant in the context of characterizing representative species' exposures.*

3) What do these % dietary preferences represent: are they volumetric, by % weight, % number of prey organisms?

*Response: The percentage dietary preferences are related to the energy budgets in PRAM. That is, the important parameter is that the various percentages add up to 100% of the caloric intake for the organism. The percentages are based on a caloric content basis, where if 10% of the diet is zooplankton, based on the total caloric consumption of the predator, 10% of the animal's daily caloric intake comes from zooplankton. The mass of zooplankton consumed by the predator is based on the caloric content of the zooplankton and assimilation efficiency of zooplankton calories by the predator.*

4) Overall I agree with Roland Ferry's comments submitted.

*Response: Comment noted. Please see responses to Dr. Ferry's comments.*

5) I support the concept of utilizing a very conservative approach. However, intuitively I don't believe that the carrier will function as a theoretical framework of "cheesecloth" with respect to transport of PCBs. If that were the case, the U.S.S. Arizona, on the bottom in Pearl Harbor, now 63 years later, still wouldn't have 500,000 gallons of fuel on board, with only a fraction of it leaking out. The leaking may be a steady state rate, but unless that ship is pumped, someday there will be a much greater pulse of released oil.

In the Oriskany, I believe elevated levels of PCBs will build up in some of those hundreds of compartments on the Oriskany at lower levels below the flight deck where PCB containing bulkhead insulation and electrical cable remain. Personally, I don't see the ultimate steady state release achieved for the life of the wreck by year two.

At some point when there is a catastrophic hull failure (probably more than a half century from now) and interior water circulation abruptly increases there will be increased water movement with elevated PCB concentrations. If this hull is expected to behave like Swiss cheese, why did they have to run ventilation hoses down into the interior of the ship and check the air chemistry if there was steady air circulation?. Why would one expect to see unimpeded water circulation throughout the ship?. This is not a ship which to my knowledge is going to have gaping holes cut in the side (as was the case of the Yukon and other small Canadian DE's sunk as artificial reefs). The opened sea chests will be effectively sealed off again once the hull digs into the bottom immediately upon sinking. In short, I think you'll have a steady state situation in two years with the island, the hanger deck and the mezzanine deck and perhaps for some years thereafter for the ship as a whole as with the leaky oil Arizona.. But one day there will be some sort of storm induced catastrophic hull failure as has occurred with the smaller navy vessels on the east coast (though Oriskany hull integrity will fail at a much later date) and there will be another PCB pulse. I think you will need to address this issue in the write up in justifying your methodology.

*Response: Comments noted. We agree that modeling the vessel as "porous" is an artificial construct. We believe that it is a conservative approach to assume that the ship will leach PCBs continuously (i.e., with an assumption that there will be no PCB mass depletion over time), and that significant PCB releases into the environment will occur from the moment that the vessel is deployed on the sea floor (i.e. all PCB-containing solid materials will begin releasing PCBs right away, and there will be no barriers to the PCBs coming under the influence of an assumed internal water current which will facilitate transport of the PCBs to an external environment). We believe this is a conservative assumption from the standpoint of assessing exposure to the occupants of the reef. (Conversely, if an assumption were made that most of the PCBs would remain internal to the ship for many years, and not be released to the external environment, then the corollary would be that the reef occupants would only be exposed to very low levels of PCBs in the abiotic and biotic media for many years.)*

*Regarding the concern that PCBs could build up in internal, essentially sealed off compartments of the ship, and be released via a catastrophic failure: we have modeled this scenario in the context of SINKEX (although this document was not provided to EPA for review). What we found in that evaluation was that a single, large "pulse" release of PCBs into the environment did not equate to a significant human health risk, with respect to risk associated with human ingestion of fish. The analysis revealed that catastrophic release actually reduced the ultimate fish tissue concentrations in top predators as the PCBs were advected away from the vessel too quickly for the system to adsorb them. A slow constant release, because of the slow dynamics associated with the accumulation and trophic transfers of PCBs, will result in higher concentrations.*

*Regarding the comment that it may take longer than two years to reach a steady-state leach rate and/or steady-state condition in the reef: The "constant" PCB (homolog-specific) leach rates used in PRAM were based on the leachate studies conducted by SSC-SD. In these experiments, specific materials were immersed in sea water, and the leach rates recorded as a function of time in immersion. After initial periods where the leach rates increased to a maximum (taking days or weeks), the leach rates decreased over time, reaching or approaching an asymptotic value. These curves were used to derive an appropriate "steady-state" or "constant" leach rate for each PCB homolog group. The experimental period was approximately two years. By that time, all homolog rates had reached or approached asymptotic values. With regard to the two-period period assumed in PRAM (to reach a steady-state condition), this was based on an assumption that it would take several months, to more than a year, for the reef to mature into a viable reef, where all the occupants of the reef would be present. The rationale for the two year time frame is associated with the development of a complete and functional food web for the reef.*

6) The model has to be able to be communicated to and made understandable and defensible to the non modeler, who nevertheless still has some common sense.

*Response: We appreciate your comments, and will strive to make the description of the model understandable and defensible.*

7) I agree with Robert Turpin, that one will never see reef fish or foraging macroinvertebrates in the labyrinth of compartments and passageways in the lower levels of this ship in complete darkness, with little or no current activity. Bacterial colonies probably. Time spent by a school of red snapper technically inside the ship on the bridge just inside where all the windows have been removed along with most of the bulkhead insulation and the wire cable would present a different interior exposure scenario than these lower level compartments with all bulkhead insulation and all wiring remaining. However, I do understand the modeling challenges Mark has to deal with and that certain assumptions have to be made. They just need to be pointed out and explained.

*Response: We concur with your comments. Thank you for your appreciation of the challenges.*

**CAPT Robert Turpin's comments:**

It is my understanding that the "communities" in the trophic matrix represent a summation of exposure. For example, if all the organisms are exposed for 50% of the time, OR if 50% of the organisms are exposed 100% of the time, the resultant should be the same. If I misunderstand, please correct me. However, if I am correct, then it is most appropriate and representative to assign some small percentage of the reef epifauna to interior water exposure.

*Response: We agree that, in the general sense, such trade-offs can be made, so long as the values are clearly explained and understood by all. Please note our responses to Wayne Munns' comments above.*

From thousands of dives, many on artificial reefs, many of which my sole purpose was extracting fish and invertebrates for scientific and/or culinary objectives, I have observed a very strong inverse relationship between biological utilization and distance from the reefs "exterior". My videography should be sufficient to demonstrate, but will be more than happy to collect samples, better yet accompany anyone to any of my underwater vessels that feels the need to verify. It is my strong preference that we do not invent a community to satisfy the need to accurately model the small percentage of epifauna that will inhabit the "first" interior compartments. When viewing the ship from a volumetric perspective (and I think the "Virtual Oriskany" model can do this), it should be easy to calculate and compare the volumes of the "true" interior of the ship as well as the "inside of the outside" (that first compartment that can sustain life (food and dissolved oxygen; light for the photosynthetic organisms).

*Response: We appreciate your knowledge and experience with regards to reef habitat, and defer to your knowledge with respect to observing that a very strong inverse relationship exists between biological utilization and distance from the reefs "exterior".*

Second Round Comments:

Table 1

1) Title of the 4th column should be changed (from "sediment") to Detritus or POM (Particulate Organic Matter) to identify the materials that contain biological energy.

*Response: As discussed in the 6 Jan 05 biology TWG conference call, the term "sediment" refers to any material within the sediment bed that supplies the biological energy input. The column header will be footnoted to indicate that detritus or POM is the primary source of this energy input.*

2) Title of 5th column should be changed from Algae to Phytoplankton.

*Response: We agree that the term "phytoplankton" more accurately describes the primary producer (algal) population in the water column. The requested change will be made.*

3) Reef "Vertebrate Predator (TL-IV)" and Reef "Vertebrate Forager (TL-III)" diets should reflect some percentage of energy taken from the surrounding benthos. This is clearly represented by many papers on reef trophodynamics. As we agreed on Conf. Call, a value of 25% (spread across Infaunal Benthos & Epifaunal Benthos for Vert. Forager; spread across Infaunal Benthos, Epifaunal Benthos, and Benthic Forager for Reef Predator). Reductions of other columns should be proportional.

*Response: As discussed in the 6 Jan 05 biology TWG conference call, because of the opportunistic nature of their feeding behaviors, Vertebrate Reef Predators (TL-IV) and Vertebrate Reef Foragers (TL-III) undoubtedly obtain a significant portion of their diet from the benthic community. The Vertebrate Reef Forager (TL-III) and Vertebrate Reef Predator (TL-IV) food intake values in Table 1 will be revised as suggested.*

4) (For the record) I think that sessile filter feeders would consume a ratio of phyto-:zoo-plankton more evenly than 80:20.

*Response: Response noted. As discussed in the 6 Jan 05 biology TWG, the proposed dietary breakdown is intended to demonstrate PCB tracing through the food web, whereby sessile filter feeders derive a greater portion of their dietary PCB from ingestion of trophic level I (phytoplankton) organisms than trophic level II (zooplankton).*

Table 2

1) Water exposure of Reef/Vessel sessile filter feeder will be exposed to some small (i.e., 0-5%) percentage of interior water.

*Response: Agreed. As discussed previously, cell D10 of the model (interior water exposure to sessile filter feeders) has been unblocked to allow the user to input site-specific values, as appropriate. For evaluating potential human health risks, this value will be set at 0%, as this pathway is thought to represent a negligible proportion of the overall PCB uptake into upper trophic level organisms likely to be consumed by humans.*

Table 3

Changes should reflect the changes in values accepted for Table 1. As we discussed on conf. Call, those changes may be reflected from 180 days and "later".

*Response: Agreed. Changes to the diet for Vertebrate Reef Foragers (TL-III) have been modified for the three time periods in question (days 180, 360, and 720) as discussed above for Table 1. The Vertebrate Reef Predator (TL-IV) was modified for day 720, as discussed above for Table 1. The diet for the Vertebrate Reef Predator (TL-IV) was not modified for days 180 and 360, as these days already reflect a high proportion of the overall diet originating from the benthos (50% at day 360; 60% at day 180).*

Turbulence created by placement of Oriskany on the sea floor will mix waters surrounding the reef. As shown in the diagram from Seaman & Sprague (Fig. 4.13), reef occupancy of 20% of water depth will create height of turbulence nearly 100% of water column. Excluding superstructure, Oriskany (from keel to flight deck) will occupy nearly 40% of water column. Turbulence will be very nearly 100% f water column.

Also, Thermocline depth estimate I provided in Atlanta (Nov '04) was not intended to indicate Δ T/S (temp/salinity) magnitude of a true "pycnocline". Summer thermoclines are eliminated in winter by convective mixing. A variable "reverse" – thermocline may occur during cold weather events. Shallow continental shelf waters are more highly mixed than the model represents. That being said, I support the consensus of the TWG regarding the conservatism provided by assuming upper & lower water masses.

*Response: We appreciate the insight you have provided regarding turbulent mixing, and the likelihood that turbulence/vertical mixing associated with the ORISKANY will probably disrupt any thermocline overlying the reef. As discussed in the 6 Jan 05 biology TWG, the approach currently used by PRAM assumes that a thermocline exists, and that advective/turbulent mixing does not occur above the thermocline. This is a conservative approach that is likely to overestimate PCB uptake into some organisms. Because of the very tight timeframe we are currently committed to, we will not be able to revise PRAM to reflect turbulent mixing throughout the entire water column prior to the next submittal of the model. We will reserve the option to incorporate the more realistic mixing pattern you have identified into future versions of PRAM.*

Overall, I am pleased with the products of everyone's hard work. I think we have constructed a good model, and I look forward to seeing the results. Thanks to all for the dedication to a job well done!

*Response: We appreciate the support of the TWG for arriving at consensus on numerous difficult technical issues necessary for successful completion of the project. We believe the hard work of a number of individuals, particularly the author of the model, Mark Goodrich, will result in a quality product we can all be proud of.*

**Dr. Robert Johnston's Comments:**

Benthic community:

The benthic community is composed of organisms living in or on the bottom (US EPA 2004). The benthic community represented in the PRAM includes the benthic infauna, benthic epifauna, benthic foragers, and benthic predators. The modeled infauna are representative of macrobenthic suspension feeders, deposit feeders, and benthic carnivores that spend a predominant portion of their life living within the sediments. Examples of benthic infauna include nematodes, worms, , and a few amphipods, etc. While recognizing that a large portion of the benthic infauna population is made up of micro-organisms (organisms smaller than 0.5 mm, Novitsky 1983) PRAM does not explicitly model the microbial community, but considers the contribution of the microbial community as organic matter or detrital material, which is a major dietary component modeled within the PRAM for the benthic infauna (see below).

*Response: Other commenters (e.g., Dr. Ferry) have recommended that a lower sediment dietary fraction be used. We have developed a compromise between your suggestion and his, which is present in the revised table and defended within the PRAM documentation.*

The benthic infauna compartment is composed of the biologically active zone of the sediment, the interstitial water (pore water). The overlying water just above (2-6 cm) represents the sediment-water interface through which PCBs are transported to and from the sediment bed. The pore water and this overlying boundary layer water are modeled within the PRAM because they are geochemically distinct from the waters below the pycnocline (thermocline). The overlying water contains higher amounts of sedimentary flocs, organic matter, and suspended particles than is present in the water column, and any near-bottom currents present in the water column would be strongly dampened by friction with the bottom at the sediment water interface. Toxicological studies have shown that overlying waters are similar to interstitial water with respect to partitioning and toxicity (Berry et al. 2003a, b). To reflect these processes PRAM uses 100% pore water to model water exposure to benthic infauna (Table "water-exposure").

*Response: We do not agree that 100% pore water exposure is appropriate. Please see our response to Dr. Ferry's comment regarding pore water exposures.*

*Note that portions of Dr Johnston's comments were provided as embedded text statements. We hope that this will not be confusing to other reviewers. (The embedded text statements are shown in highlight in this response document.)*

The benthic infauna diet is composed of 85% sediment, 10% algae, and 20% zooplankton (Table "diet Pel & Ben"). It should be noted that the benthic infauna are not really consuming sediment, rather they are consuming the organic matter (e.g., microfauna) present on the particles, the inorganic matter would pass through the gut, so dietary requirements take into account the amount of calories associated with the organic matter that must be consumed and the energy requirements for the organism(i.e., grams/day consumed is organic matter, not just bulk sediment, OM ~= 2*TOC).

*Response: We are in agreement that consumption is based on the caloric content of the sediment detrital fraction.*

The benthic epifauna community is the organisms that live on the bottom, but spend their time predominantly above the sediment-water interface. Examples of benthic epifauna are sea slugs, sea urchins, sea anemones, shrimp, mussels, etc. Because of their close association with the bottom sediments PRAM assumes that water exposure is 50% pore water and 50% below pycnocline water (Table "water-exposure"). The benthic infauna diet consists of 50% sediment organic matter, 15% organic matter on suspended solids (i.e. detritus), 10% algae, and 10% zooplankton (Table "diet Pel & Ben").

*Response: The diet for the benthic infaunal macroinvertebrates has been adjusted to account for the differences in opinions between commenters and is discussed within the PRAM documentation. Please see our responses to Dr. Ferry's comments.*

The benthic foragers are the lobsters, sea stars, crabs, octopus, etc., that feed on the infauna (50%) and epibenthic community (45%) (Table "diet Pel & Ben"). Because the benthic foragers feed on infauna, PRAM also models incidental consumption of sediment organic matter by assuming that incidental sediment consumption of benthic foragers is 10% of the epifaunal benthos consumed (rounded to 5%). This assumption is consistent with other risk assessments that have evaluated exposure from incidental sediment exposure as part of the consumption pathway (URS 1996, MESO 2000). Water exposure to benthic foragers is modeled as 75% below pycnocline water and 25% pore water (Table "water-exposure"), reflecting the relatively greater mobility of benthic foragers and the less time that they are actually in contact with bedded sediments.

*Response: We have adjusted the diets and water exposures to the benthos in recognition of your and Dr. Ferry's comments, and have developed a written rationale for the values recommended in the attached table.*

The top predators in the benthic community are the flat fish, skates, toad fish, eels, and other carnivorous fish that feed on the benthic foragers (58%), epifauna (20%), and infauna (20%) (Table "diet Pel & Ben"). Because the benthic predators also feed on infauna, incidental sediment consumption was set to 10% of the epifaunal benthos consumed (2%). Because most of the benthic predators spend most of their time in the water column rather than in the sediment, water exposure is modeled as 90% below pycnocline water and 10% pore water (Table "water-exposure")".

*Response: We have adjusted the diets and water exposures to the benthos in recognition of your and Dr. Ferry's comments, and have developed a written rationale for the values recommended in the attached table.*

## APPENDIX H

## EXAMPLE PRAM OUTPUT

**ZOI = 2**

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION

## *RISK ESTIMATES FOR Ex-Oriskany CV34*

| | Cancer Risk Adult & Child | | Hazard Adult & Child | | Cancer Risk Child | | Hazard Child | |
|---|---|---|---|---|---|---|---|---|
| ***RISK ESTIMATES*** | RME | CTE | RME | CTE | RME | CTE | RME | CTE |
| Benthic fish (flounder) | 7.29E-08 | 5.64E-09 | 4.25E-03 | 9.75E-04 | 2.14E-08 | 4.34E-09 | 6.24E-03 | 1.12E-03 |
| Benthic shellfish (lobster) | 2.12E-08 | 1.64E-09 | 1.24E-03 | 2.84E-04 | 6.22E-09 | 1.26E-09 | 1.81E-03 | 3.27E-04 |
| Pelagic fish (jack) | 3.57E-08 | 2.77E-09 | 2.08E-03 | 4.78E-04 | 1.05E-08 | 2.13E-09 | 3.06E-03 | 5.51E-04 |
| Reef fish TL-IV (grouper) | 6.94E-06 | 5.37E-07 | 4.05E-01 | 9.29E-02 | 2.04E-06 | 4.13E-07 | 5.94E-01 | 1.07E-01 |
| Reef fish TL-III (triggerfish) | 4.03E-06 | 3.12E-07 | 2.35E-01 | 5.39E-02 | 1.18E-06 | 2.40E-07 | 3.45E-01 | 6.22E-02 |
| Reef shellfish (crab) | 2.23E-06 | 1.73E-07 | 1.30E-01 | 2.98E-02 | 6.54E-07 | 1.33E-07 | 1.91E-01 | 3.44E-02 |

| ***PREDICTED EXPOSURE CONCENTRATIONS (mg/kg in fresh weight)*** | |
|---|---|
| Benthic fish (flounder) | 1.18E-03 |
| Benthic shellfish (lobster) | 3.45E-04 |
| Pelagic fish (jack) | 5.80E-04 |
| Reef fish TL-IV (grouper) | 1.13E-01 |
| Reef fish TL-III (triggerfish) | 6.55E-02 |
| Reef shellfish (crab) | 3.62E-02 |

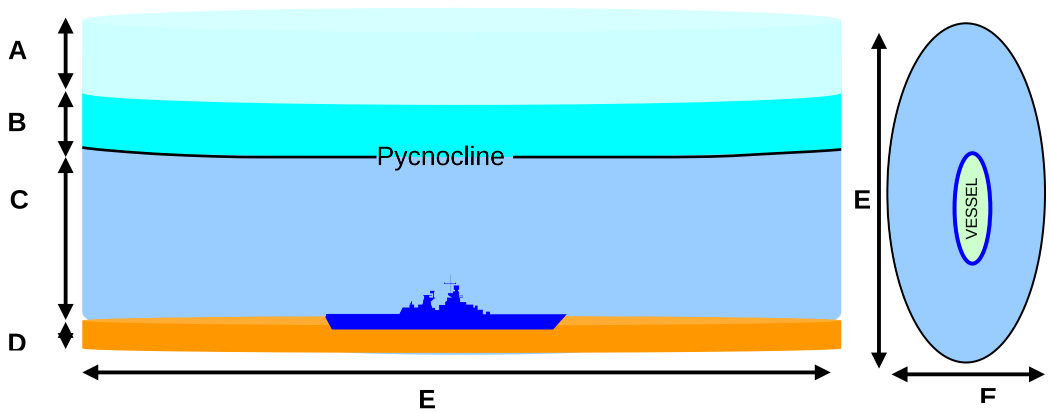
| ***RISK INPUTS - Adult*** | RME | CTE |
|---|---|---|
| Body Weight (BWa) (kg) | 70 | 70 |
| Exposure Frequency (EFa) (days) | 365 | 365 |
| Exposure Duration (EDa) (years) | 24 | 3 |
| Ingestion Rate (IRa) (kg/day) | 0.0261 | 0.0072 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Averaging Time for noncancer (ATnc-adult) | 8760 | 1095 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 2.00E-05 | 4.50E-05 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |
| Ingestion Rates Based on Data from | Gulf Coast | |

| ***RISK INPUTS - Child*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 15 | 15 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Exposure Duration (EDc) (years) | 6 | 6 |
| Ingestion Rate (IRc) (kg/day) | 0.0092916 | 0.0025632 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Averaging Time for noncancer (ATnc-child) | 2190 | 2190 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 2.00E-05 | 4.50E-05 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |
| Child - Adult IR scaling factor | 0.356 | |

| | |
|---|---|
| Zone of Influence Multiplier | 2 |
| Scenario run on | 5/11/05 13:36 |

| ***PCB-LADEN MATERIAL INPUTS*** | Fraction PCB | Release Rate (ng/g-d) | kg Material Onboard | PCB Release (ng/day) |
|---|---|---|---|---|
| Ventilation Gaskets | 3.14E-05 | 1.58E+03 | 1.46E+03 | 7.23E+04 |
| Lubricants | 1.03E-04 | 2.20E+03 | 0.00E+00 | 0.00E+00 |
| Foam Rubber Material | 7.60E-03 | 2.62E+00 | 0.00E+00 | 0.00E+00 |
| Black Rubber Material | 5.29E-05 | 1.58E+03 | 5.40E+03 | 4.50E+05 |
| Electrical Cable | 1.85E-03 | 2.79E+02 | 2.96E+05 | 1.53E+08 |
| Bulkhead Insulation Material | 5.37E-04 | 6.76E+04 | 1.44E+04 | 5.22E+08 |
| Aluminum Paint | 2.00E-05 | 1.11E+04 | 3.87E+05 | 8.62E+07 |
| Total | | | | 7.62E+08 |

| **Ex-Oriskany CV34** | |
|---|---|
| Displacement (tons) | 27100 |
| Length (ft) | 888 |
| Beam (ft) | 120 |




| ZOI = | 2 | |
|---|---|---|
| **Spatial Footprint on Ocean Floor** | | |
| | 1.56E+04 | m2 |
| | 6.00E-03 | mile2 |
| **Modeled Dimensions Outside the Vessel** | | |
| A | 1.00E+01 | m |
| B | 1.50E+01 | m |
| C | 5.00E+01 | m |
| D | 1.00E-01 | m |
| E | 3.00E+02 | m |
| F | 6.60E+01 | m |
| **Volumes** | | |
| Air Column | | |
| Air | 1.56E+05 | m3 |
| Upper Water Column | | |
| Water | 2.33E+05 | m3 |
| TSS | 1.56E+00 | m3 |
| Lower Water Column | | |
| Water | 7.24E+05 | m3 |
| TSS | 4.82E+00 | m3 |
| Inside Vessel | | |
| Water | 5.38E+04 | m3 |
| TSS | 3.59E-01 | m3 |
| Sediment Bed | | |
| Sediment | 7.78E+02 | m3 |

**Abiotic Inputs**

Air Column

| | |
|---|---|
| Active air space height above water column (m) | 10 |

**Total PCB concentrations**

Air Column

| | | |
|---|---|---|
| Air | 6.68E-17 | g/m3 |

| | |
|---|---|
| Air current (m/h) | 13677 |
| Upper Water Column | |
| Temperature (°C) | 24.5 |
| Water depth (m) | 15 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 6.12 |
| Lower Water Column | |
| Temperature (°C) | 19.5 |
| Water depth (m) | 50 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Inside Vessel | |
| Temperature (°C) | 19.5 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Sediment Bed | |
| Sediment density (g/cm3) | 1.5 |
| Active sediment depth (m) | 0.1 |
| Sediment fraction organic carbon | 0.01 |
| All Regions | |
| Suspended solids density (g/cm3) | 1.5 |
| Suspended solids fraction organic carbon | 0.15 |
| Dissolved organic carbon density (g/cm3) | 1 |
| Water current - to out of the ZOI (m/h) | 926 |
| Water current - inside to outside the vessel (m/h) | 9.26 |

| | | |
|---|---|---|
| Upper Water Column | | |
| Freely dissolved in water | 1.02E-12 | mg/L |
| Suspended solids | 1.33E-08 | mg/kg |
| Dissolved organic carbon | 1.78E-07 | mg/kg |
| Lower Water Column | | |
| Freely dissolved in water | 4.39E-09 | mg/L |
| Suspended solids | 1.08E-04 | mg/kg |
| Dissolved organic carbon | 9.88E-04 | mg/kg |
| Inside Vessel | | |
| Freely dissolved in water | 1.80E-06 | mg/L |
| Suspended solids | 4.44E-02 | mg/kg |
| Dissolved organic carbon | 4.06E-01 | mg/kg |
| Sediment Bed | | |
| Freely dissolved in pore water | 4.39E-09 | mg/L |
| Bedded sediment | 7.19E-06 | mg/kg |
| Dissolved organic carbon in pore water | 9.88E-04 | mg/kg |

| **Total PCB concentrations in biota** | | | **Percent Exposures** | |
|---|---|---|---|---|
| Pelagic Community | | | Upper WC | Lower WC |
| Phytoplankton (TL-I) | 1.67E-09 | mg/kg | 100% | 0% |
| Zooplankton (TL-II) | 7.72E-05 | mg/kg | 50% | 50% |
| Planktivore (TL-III) | 3.74E-04 | mg/kg | 80% | 20% |
| Piscivore (TL-IV) | 5.80E-04 | mg/kg | 80% | 20% |
| Reef / Vessel Community | | | Lower WC | Vessel Int. |
| Attached Algae (TL-I) | 7.23E-06 | mg/kg | 100% | 0% |
| Sessile filter feeder (TL-II) | 1.58E-04 | mg/kg | 100% | 0% |
| Invertebrate Omnivore (TL-II) | 1.69E-02 | mg/kg | 80% | 20% |
| Invertebrate Forager (TL-III) | 3.62E-02 | mg/kg | 70% | 30% |
| Vertebrate Forager (TL-III) | 6.55E-02 | mg/kg | 70% | 30% |
| Predator (TL-IV) | 1.13E-01 | mg/kg | 80% | 20% |
| Benthic Community | | | Lower WC | Pore Water |
| Infaunal invert. (TL-II) | 5.48E-05 | mg/kg | 20% | 80% |
| Epifaunal invert. (TL-II) | 1.51E-04 | mg/kg | 50% | 50% |
| Forager (TL-III) | 3.45E-04 | mg/kg | 75% | 25% |
| Predator (TL-IV) | 1.18E-03 | mg/kg | 90% | 10% |

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION
## RISK ESTIMATES FOR Ex-Oriskany CV34 High-End Weight of PCB-Laden Materials
### Supplemental Information

**Scenario Run on** 10/21/2004 14:10

| PCB Homolog | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Molecular Weight (g/mol) | 1.89E+02 | 2.23E+02 | 2.58E+02 | 2.92E+02 | 3.26E+02 | 3.61E+02 | 3.95E+02 | 4.30E+02 | 4.64E+02 | 4.99E+02 |
| Solubility (mg/L) | 2.91E+00 | 6.78E-01 | 8.14E-02 | 6.67E-02 | 2.61E-02 | 9.50E-04 | 2.30E-04 | 2.11E-08 | 4.02E-09 | 1.69E-10 |
| Solubility (mol/m$^3$) | 1.54E-02 | 3.04E-03 | 3.16E-04 | 2.28E-04 | 8.00E-05 | 2.63E-06 | 5.82E-07 | 4.91E-11 | 8.65E-12 | 3.38E-13 |
| Vapor Pressure (Pa) | 6.32E-01 | 1.41E-01 | 5.11E-02 | 2.08E-02 | 2.96E-03 | 3.43E-03 | 2.56E-04 | 8.65E-05 | 2.77E-05 | 1.41E-05 |
| Henry's (Pa-m$^3$/mol) | 4.10E+01 | 4.65E+01 | 1.62E+02 | 9.10E+01 | 3.70E+01 | 1.30E+03 | 4.40E+02 | 1.76E+06 | 3.20E+06 | 4.18E+07 |
| $\log_{10}K_{ow}$ = | 4.47 | 5.24 | 5.52 | 5.92 | 6.50 | 6.98 | 7.19 | 7.70 | 8.35 | 9.60 |
| $\log_{10}K_{oc}$ = | 3.66 | 4.06 | 4.63 | 4.65 | 4.94 | 6.08 | 6.34 | 6.46 | 6.97 | 7.94 |
| $\log_{10}K_{doc}$ = | 3.34 | 4.11 | 4.39 | 4.79 | 5.51 | 5.85 | 6.06 | 6.57 | 7.22 | 8.47 |
| Chemical emission rate (g/day) | 1.37E-05 | 1.12E-01 | 9.95E-03 | 1.69E-01 | 3.20E-01 | 7.57E-02 | 7.37E-02 | 0.00E+00 | 8.28E-04 | 4.62E-04 |
| Chemical emission rate (mol/hr) | 3.03E-09 | 2.09E-05 | 1.61E-06 | 2.42E-05 | 4.08E-05 | 8.74E-06 | 7.77E-06 | 0.00E+00 | 7.43E-08 | 3.86E-08 |
| Biodegradation in sediment (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Biodegradation in water (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Fraction PCB in Material (wt/wt) | 0.0000314 | 0.000103 | 0.76% | 0.0000529 | 0.00185 | 0.000537 | 0.00002 |
| Material Mass Onboard (kg) | 1459 | 0 | 0 | 5397 | 296419 | 14379 | 386528 |
| Total PCBs (kg) | 0.0458126 | 0 | 0 | 0.2855013 | 548.37515 | 7.721523 | 7.73056 |
| Total PCB Release rate (ng/g-PCB per day) | 1.58E+03 | 2.20E+03 | 2.62E+00 | 1.58E+03 | 2.79E+02 | 6.76E+04 | 1.11E+04 |

| Release Rates in nanograms PCB per gram of PCB within the Material | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 4.14E+01 | 3.47E+01 | 0.00E+00 | 4.14E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Dichlorobiphenyl | 1.27E+03 | 1.72E+02 | 3.08E-02 | 1.27E+03 | 2.03E+02 | 5.36E+00 | 0.00E+00 |
| Trichlorobiphenyl | 5.66E+01 | 8.97E+01 | 7.63E-02 | 5.66E+01 | 1.14E+00 | 9.44E+02 | 2.61E+02 |
| Tetrachlorobiphenyl | 1.44E+02 | 1.08E+03 | 1.29E+00 | 1.44E+02 | 1.57E+01 | 2.07E+04 | 1.23E+02 |
| Pentachlorobiphenyl | 6.31E+01 | 6.60E+02 | 3.90E-02 | 6.31E+01 | 1.80E+01 | 3.79E+04 | 2.24E+03 |
| Hexachlorobiphenyl | 0.00E+00 | 9.42E+01 | 5.34E-01 | 0.00E+00 | 2.41E+01 | 6.76E+03 | 1.33E+03 |
| Heptachlorobiphenyl | 5.04E+00 | 7.17E+01 | 6.46E-01 | 5.04E+00 | 1.47E+01 | 1.30E+03 | 7.19E+03 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 1.72E-03 | 0.00E+00 | 1.51E+00 | 0.00E+00 | 0.00E+00 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.43E-01 | 0.00E+00 | 0.00E+00 |
| **Total** | **1.58E+03** | **2.20E+03** | **2.62E+00** | **1.58E+03** | **2.79E+02** | **6.76E+04** | **1.11E+04** |

| Release Rates in nanograms PCB per Day | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint | Total |
|---|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 1.90E+03 | 0.00E+00 | 0.00E+00 | 1.18E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.37E+04 |
| Dichlorobiphenyl | 5.80E+04 | 0.00E+00 | 0.00E+00 | 3.62E+05 | 1.11E+08 | 4.14E+04 | 0.00E+00 | 1.12E+08 |
| Trichlorobiphenyl | 2.59E+03 | 0.00E+00 | 0.00E+00 | 1.62E+04 | 6.25E+05 | 7.29E+06 | 2.02E+06 | 9.95E+06 |
| Tetrachlorobiphenyl | 6.60E+03 | 0.00E+00 | 0.00E+00 | 4.11E+04 | 8.61E+06 | 1.60E+08 | 9.51E+05 | 1.69E+08 |
| Pentachlorobiphenyl | 2.89E+03 | 0.00E+00 | 0.00E+00 | 1.80E+04 | 9.87E+06 | 2.93E+08 | 1.73E+07 | 3.20E+08 |
| Hexachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.32E+07 | 5.22E+07 | 1.03E+07 | 7.57E+07 |
| Heptachlorobiphenyl | 2.31E+02 | 0.00E+00 | 0.00E+00 | 1.44E+03 | 8.06E+06 | 1.01E+07 | 5.56E+07 | 7.37E+07 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.28E+05 | 0.00E+00 | 0.00E+00 | 8.28E+05 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.62E+05 | 0.00E+00 | 0.00E+00 | 4.62E+05 |
| **Total** | 7.23E+04 | 0.00E+00 | 0.00E+00 | 4.50E+05 | 1.53E+08 | 5.22E+08 | 8.62E+07 | 7.62E+08 |

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION
## RISK ESTIMATES FOR Ex-Oriskany CV34 High-End Weight of PCB-Laden Materials
### Supplemental Information

| Air | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 3.22E-20 | 1.98E-16 | 1.30E-17 | 1.74E-16 | 1.91E-16 | 6.72E-18 | 2.40E-18 | 0.00E+00 | 8.51E-22 | 2.74E-24 |
| Air concentration (g/m3) | 2.47E-21 | 1.80E-17 | 1.37E-18 | 2.07E-17 | 2.54E-17 | 9.88E-19 | 3.86E-19 | 0.00E+00 | 1.61E-22 | 5.56E-25 |

| Upper Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 6.67E-18 | 5.04E-14 | 1.22E-14 | 9.85E-14 | 4.71E-14 | 5.99E-14 | 7.57E-15 | 0.00E+00 | 2.11E-14 | 9.20E-16 |
| Water concentration (mg/L) | 3.07E-17 | 2.42E-13 | 1.95E-14 | 3.16E-13 | 4.15E-13 | 1.66E-14 | 6.80E-15 | 0.00E+00 | 3.06E-18 | 1.10E-20 |
| Suspended solids concentration (mg/kg) | 2.12E-14 | 4.15E-10 | 1.23E-10 | 2.14E-09 | 5.36E-09 | 2.99E-09 | 2.23E-09 | 0.00E+00 | 4.24E-12 | 1.44E-13 |
| Dissolved organic carbon (mg/kg) | 6.77E-14 | 3.09E-09 | 4.79E-10 | 1.95E-08 | 1.35E-07 | 1.16E-08 | 7.79E-09 | 0.00E+00 | 5.09E-11 | 3.25E-12 |

| Lower Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 2.35E-14 | 1.81E-10 | 4.61E-11 | 3.80E-10 | 2.18E-10 | 6.75E-10 | 1.31E-10 | 0.00E+00 | 1.83E-09 | 9.95E-10 |
| Water concentration (mg/L) | 1.08E-13 | 8.67E-10 | 7.34E-11 | 1.22E-09 | 1.92E-09 | 1.87E-10 | 1.18E-10 | 0.00E+00 | 2.65E-13 | 1.19E-14 |
| Suspended solids concentration (mg/kg) | 7.47E-11 | 1.48E-06 | 4.64E-07 | 8.25E-06 | 2.48E-05 | 3.37E-05 | 3.87E-05 | 0.00E+00 | 3.68E-07 | 1.55E-07 |
| Dissolved organic carbon (mg/kg) | 2.38E-10 | 1.11E-05 | 1.80E-06 | 7.54E-05 | 6.26E-04 | 1.31E-04 | 1.35E-04 | 0.00E+00 | 4.41E-06 | 3.52E-06 |

| Inside the Vessel | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 9.67E-12 | 7.43E-08 | 1.89E-08 | 1.56E-07 | 8.96E-08 | 2.77E-07 | 5.40E-08 | 0.00E+00 | 7.51E-07 | 4.09E-07 |
| Water concentration (mg/L) | 4.45E-11 | 3.57E-07 | 3.02E-08 | 5.02E-07 | 7.90E-07 | 7.68E-08 | 4.85E-08 | 0.00E+00 | 1.09E-10 | 4.88E-12 |
| Suspended solids concentration (mg/kg) | 3.07E-08 | 6.11E-04 | 1.91E-04 | 3.39E-03 | 1.02E-02 | 1.39E-02 | 1.59E-02 | 0.00E+00 | 1.51E-04 | 6.38E-05 |
| Dissolved organic carbon (mg/kg) | 9.80E-08 | 4.54E-03 | 7.41E-04 | 3.10E-02 | 2.57E-01 | 5.38E-02 | 5.56E-02 | 0.00E+00 | 1.81E-03 | 1.45E-03 |

| Sediment Bed | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 2.35E-14 | 1.81E-10 | 4.61E-11 | 3.80E-10 | 2.18E-10 | 6.75E-10 | 1.31E-10 | 0.00E+00 | 1.83E-09 | 9.95E-10 |
| Pore Water concentration (mg/L) | 1.08E-13 | 8.67E-10 | 7.34E-11 | 1.22E-09 | 1.92E-09 | 1.87E-10 | 1.18E-10 | 0.00E+00 | 2.65E-13 | 1.19E-14 |
| Sediment concentration (mg/kg) | 4.98E-12 | 9.90E-08 | 3.09E-08 | 5.50E-07 | 1.65E-06 | 2.25E-06 | 2.58E-06 | 0.00E+00 | 2.45E-08 | 1.03E-08 |

**Bioenergetic Inputs**

| | Species | Body Weight | Lipid | Moisture | Caloric Density | GE to ME | Met Energy | Caloric Density | Production | Respiration | Excretion | Caloric Density | Met Energy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (kg) | (%-dw) | (%) | (kcal/g-dry weight) | Fraction | (kcal/kg-lipid) | (kcal/kg-lipid) | (% of total) | (% of total) | (% of total) | (kcal/g-wt weight) | (kcal/g-wt weight) |
| **Pelagic Community** | | | | | | | | | | | | | |
| Phytoplankton (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Zooplankton (TL-II) | copepods | 0.000005 | 22% | 76% | 3.6 | 0.65 | 10636 | 16364 | 18% | 24% | 58% | 0.864 | 0.5616 |
| Planktivore (TL-III) | herring | 0.05 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Piscivore (TL-IV) | jack | 0.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| **Reef / Vessel Community** | | | | | | | | | | | | | |
| Attached Algae (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.05 | 5% | 82% | 4.6 | 0.65 | 59800 | 92000 | 28% | 31% | 41% | 0.828 | 0.5382 |
| Invertebrate Omnivore (TL-II) | urchin | 0.05 | 29% | 82% | 4.6 | 0.65 | 10310 | 15862 | 7% | 25% | 68% | 0.828 | 0.5382 |
| Invertebrate Forager (TL-III) | crab | 1 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Vertebrate Forager (TL-III) | triggerfish | 1 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Predator (TL-IV) | grouper | 1.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 0.2 | 0.14 |
| **Benthic Community** | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.01 | 6% | 84% | 4.6 | 0.65 | 50000 | 76923 | 71% | 26% | 3% | 0.736 | 0.4784 |
| Epifaunal invert. (TL-II) | nematode | 0.01 | 6% | 82% | 4.6 | 0.65 | 50000 | 76923 | 31% | 19% | 50% | 0.828 | 0.5382 |
| Forager (TL-III) | lobster | 2 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Predator (TL-IV) | flounder | 3 | 22% | 75% | 4.9 | 0.7 | 15591 | 22273 | 20% | 60% | 20% | 1.225 | 0.8575 |

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION

## RISK ESTIMATES FOR Ex-Oriskany CV34 High-End Weight of PCB-Laden Materials

### Supplemental Information

| Bioenergetic Inputs | | Respiration Rate Allometric Regression Parameters | | | Resp. Rate | Resp. Rate | Consumption | Growth Rate | Consumption | Consumption | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | a | b1 | b2 | 1 / day | gO2 / kg-lipid-day | kcal / kg-lipid-day | 1 / day | g-wt weight / g-wt weight-d | kcal / wet weight-da | As a % of body weight |
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | Algae | | | | | | | | | | |
| Zooplankton (TL-II) | copepods | 0.006375522 | 0 | 0.039935335 | 0.015425453 | 84.24400867 | 1286.168071 | 0.014147849 | 0.32636028 | 0.06790967 | 32.6% |
| Planktivore (TL-III) | herring | 0.0033 | -0.227 | 0.0548 | 0.004949927 | 21.1649 | 129.2512977 | 0.001482433 | 0.01616792 | 0.0090799 | 1.6% |
| Piscivore (TL-IV) | jack | 0.001118602 | -0.55 | 0.12 | 0.000630951 | 2.697821256 | 16.47524431 | 0.000188961 | 0.00139796 | 0.00115739 | 0.1% |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | Algae | | | | | | | | | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.012 | 0 | 0.036 | 0.024213411 | 581.8482643 | 6877.300342 | 0.020930914 | 0.24377539 | 0.0618957 | 24.4% |
| Invertebrate Omnivore (TL-II) | urchin | 0.000675466 | 0 | 0.079181846 | 0.003163548 | 13.1069075 | 192.1012396 | 0.000847751 | 0.03471132 | 0.01002768 | 3.5% |
| Invertebrate Forager (TL-III) | crab | 0.001158234 | 0 | 0.071193202 | 0.004642088 | 60.75673491 | 377.3221989 | 0.003592107 | 0.01678102 | 0.00900593 | 1.7% |
| Vertebrate Forager (TL-III) | triggerfish | 0.015181024 | -0.415 | 0.061 | 0.002837229 | 12.13142452 | 74.08503521 | 0.00084971 | 0.00907693 | 0.00520447 | 0.9% |
| Predator (TL-IV) | grouper | 0.00279 | -0.355 | 0.0811 | 0.001011362 | 4.324384181 | 26.40845301 | 0.000302889 | 0.00264734 | 0.00185519 | 0.3% |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 1903.064429 | 0.017565285 | 0.09800757 | 0.01820852 | 9.8% |
| Epifaunal invert. (TL-II) | nematode | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 2604.19343 | 0.0104949 | 0.09262416 | 0.02803154 | 9.3% |
| Forager (TL-III) | lobster | 0.0035 | -0.13 | 0.066 | 0.00471923 | 61.76639253 | 383.5925529 | 0.003651801 | 0.01899736 | 0.00915559 | 1.9% |
| Predator (TL-IV) | flounder | 0.0046 | -0.24 | 0.067 | 0.002486878 | 13.58174479 | 82.94195291 | 0.000744785 | 0.00974341 | 0.00456181 | 1.0% |

| Dietary Preferences | Suspended Solids (Epilimnion) | Suspended Solids (Hypolimnion) | Sediment | Phytoplankton | Zooplankton | Pelagic Plankitivore | Attached Algae | Reef Sessile Filter Feeder | Invertebrate Omnivore | Reef Invertebrate Forager | Reef Vertebrate Forager | Infaunal Benthos | Epifaunal Benthos | Benthic Forager |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | | | | |
| Phytoplankton (TL1) | | | | | | | | | | | | | | |
| Zooplankton (TL-II) | 15% | 15% | | 70% | | | | | | | | | | |
| Planktivore (TL-III) | | | | | 100% | | | | | | | | | |
| Piscivore (TL-IV) | | | | | 10% | 90% | | | | | | | | |
| **Reef / Vessel Community** | | | | | | | | | | | | | | |
| Attached Algae | | | | | | | | | | | | | | |
| Sessile filter feeder (TL-II) | | 10% | | 80% | 10% | | | | | | | | | |
| Invertebrate Omnivore (TL-II) | | | | | | | 80% | 20% | | | | | | |
| Invertebrate Forager (TL-III) | | 5% | | | 5% | 5% | | 35% | 50% | | | | | |
| Vertebrate Forager (TL-III) | | | | | | 19% | | 19% | 15% | 22% | | 12.5% | 12.5% | |
| Predator (TL-IV) | | | | | | | | | | 15% | 60% | 8% | 8% | 8% |
| **Benthic Community** | | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | | | 50% | 30% | 20% | | | | | | | | | |
| Epifaunal invert. (TL-II) | | | 25% | 30% | 20% | | | | | | | 25% | | |
| Forager (TL-III) | | | 5% | | | | | | | | | 50% | 45% | |
| Predator (TL-IV) | | | 2% | | | | | | | | | 20% | 20% | 58% |

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION
## RISK ESTIMATES FOR Ex-Oriskany CV34 High-End Weight of PCB-Laden Materials
### Supplemental Information

| Water Exposures | | Upper Water Column | Lower Water Column | Vessel Interior | Sediment Pore Water |
|---|---|---|---|---|---|
| **Pelagic Community** | | | | | |
| Phytoplankton (TL1) | Algae | 100% | | | |
| Zooplankton (TL-II) | copepods | 50% | 50% | | |
| Planktivore (TL-III) | herring | 80% | 20% | | |
| Piscivore (TL-IV) | jack | 80% | 20% | | |
| **Reef / Vessel Community** | | | | | |
| Attached Algae | Algae | | 100% | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | | 100% | | |
| Invertebrate Omnivore (TL-II) | urchin | | 80% | 20% | |
| Invertebrate Forager (TL-III) | crab | | 70% | 30% | |
| Vertebrate Forager (TL-III) | triggerfish | | 70% | 30% | |
| Predator (TL-IV) | grouper | | 80% | 20% | |
| **Benthic Community** | | | | | |
| Infaunal invert. (TL-II) | polychaete | | 20% | | 80% |
| Epifaunal invert. (TL-II) | nematode | | 50% | | 50% |
| Forager (TL-III) | lobster | | 75% | | 25% |
| Predator (TL-IV) | flounder | | 90% | | 10% |

**Energy Estimates for Suspended Sediment and Bedded Sediment**

| | GE | ME | ME | as kcal/g-ww |
|---|---|---|---|---|
| Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.01099776 |
| Suspended Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.1649664 |

| Respiratory Efficiencies | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Low body weight (<100g) | 4.335E-01 | 8.000E-01 | 8.000E-01 | 8.000E-01 | 4.492E-01 | 2.582E-01 | 2.018E-01 | 1.127E-01 | 5.303E-02 | 1.255E-02 |
| High body weight (>100g) | 5.000E-01 | 5.000E-01 | 5.000E-01 | 5.000E-01 | 3.769E-01 | 2.857E-01 | 2.526E-01 | 1.888E-01 | 1.295E-01 | 6.299E-02 |
| **Dietary Assimilation Efficiencies** | 27% | 46% | 53% | 62% | 69% | 69% | 68% | 59% | 44% | 16% |

| Tissue Conc. (mg/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 9.143E-13 | 2.422E-08 | 1.948E-09 | 3.159E-08 | 4.150E-08 | 1.659E-09 | 6.797E-10 | 0.000E+00 | 3.062E-13 | 1.097E-15 |
| Zooplankton (TL-II) | 7.287E-09 | 2.706E-04 | 2.729E-05 | 5.151E-04 | 5.109E-04 | 7.310E-05 | 6.504E-05 | 0.000E+00 | 3.261E-07 | 4.821E-08 |
| Planktivore (TL-III) | 1.647E-09 | 2.291E-04 | 4.178E-05 | 1.528E-03 | 2.723E-03 | 4.285E-04 | 3.717E-04 | 0.000E+00 | 1.230E-06 | 6.474E-08 |
| Piscivore (TL-IV) | 4.305E-10 | 4.039E-05 | 1.109E-05 | 8.926E-04 | 4.773E-03 | 1.285E-03 | 1.257E-03 | 0.000E+00 | 3.671E-06 | 8.006E-08 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 3.222E-09 | 8.672E-05 | 7.339E-06 | 1.220E-04 | 1.920E-04 | 1.868E-05 | 1.179E-05 | 0.000E+00 | 2.653E-08 | 1.186E-09 |
| Sessile filter feeder (TL-II) | 1.037E-07 | 3.499E-03 | 3.456E-04 | 6.498E-03 | 6.291E-03 | 5.571E-04 | 4.034E-04 | 0.000E+00 | 1.291E-06 | 1.401E-07 |
| Invertebrate Omnivore (TL-II) | 2.898E-07 | 2.252E-02 | 3.328E-03 | 1.071E-01 | 1.730E-01 | 1.224E-02 | 6.420E-03 | 0.000E+00 | 4.488E-06 | 6.064E-08 |
| Invertebrate Forager (TL-III) | 2.192E-06 | 8.951E-02 | 1.334E-02 | 4.503E-01 | 8.597E-01 | 6.798E-02 | 3.772E-02 | 0.000E+00 | 4.148E-05 | 2.711E-06 |
| Vertebrate Forager (TL-III) | 2.015E-07 | 1.416E-02 | 3.046E-03 | 1.785E-01 | 6.347E-01 | 6.428E-02 | 3.756E-02 | 0.000E+00 | 4.214E-05 | 1.385E-06 |
| Predator (TL-IV) | 1.116E-07 | 7.257E-03 | 1.715E-03 | 1.498E-01 | 1.156E+00 | 1.771E-01 | 1.137E-01 | 0.000E+00 | 1.222E-04 | 2.685E-06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.628E-08 | 1.032E-03 | 1.073E-04 | 2.122E-03 | 2.130E-03 | 1.950E-04 | 1.425E-04 | 0.000E+00 | 3.977E-07 | 2.834E-08 |
| Epifaunal invert. (TL-II) | 3.259E-08 | 1.919E-03 | 2.289E-04 | 5.181E-03 | 5.709E-03 | 5.472E-04 | 4.040E-04 | 0.000E+00 | 1.015E-06 | 5.565E-08 |
| Forager (TL-III) | 1.903E-08 | 1.051E-03 | 1.607E-04 | 4.856E-03 | 7.236E-03 | 6.765E-04 | 4.610E-04 | 0.000E+00 | 7.349E-07 | 1.686E-08 |
| Predator (TL-IV) | 1.685E-09 | 2.802E-04 | 7.385E-05 | 4.574E-03 | 1.378E-02 | 1.658E-03 | 1.171E-03 | 0.000E+00 | 1.505E-06 | 2.213E-08 |

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION
## RISK ESTIMATES FOR Ex-Oriskany CV34 High-End Weight of PCB-Laden Materials
### Supplemental Information

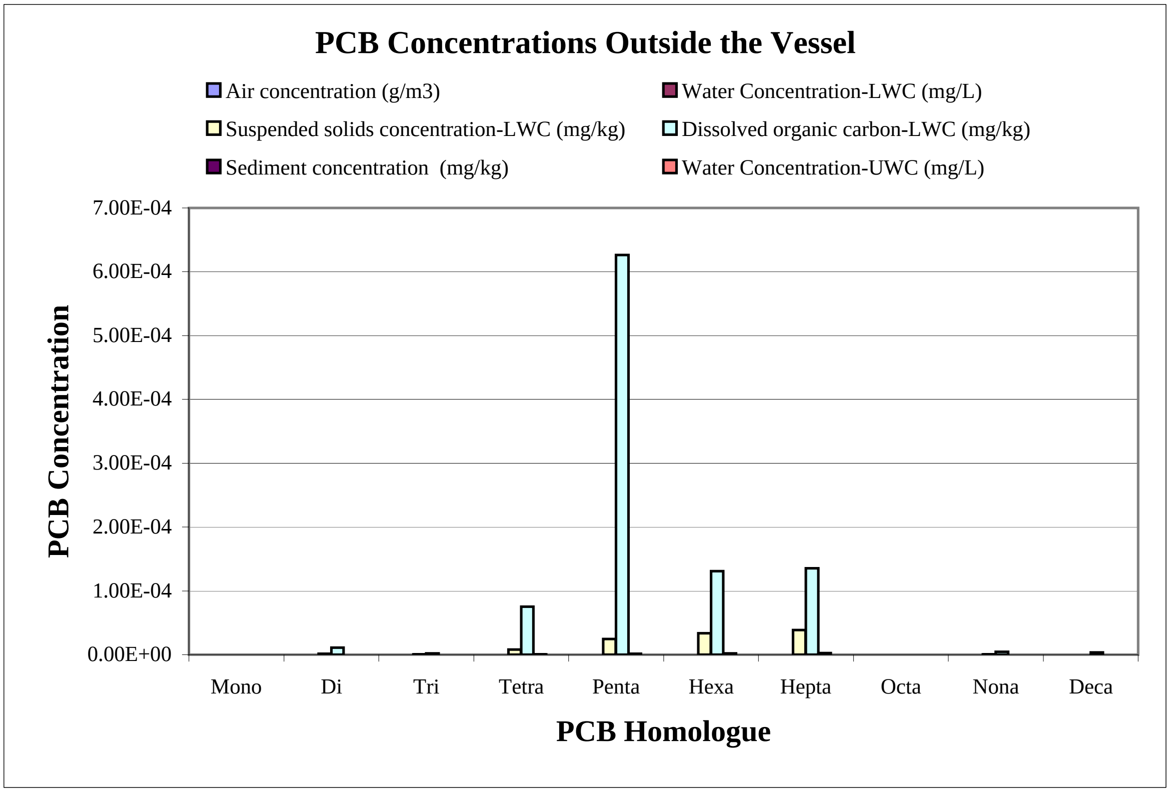
| Tissue Conc. (mg/kg-WW) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.507E-14 | 3.991E-10 | 3.211E-11 | 5.207E-10 | 6.838E-10 | 2.735E-11 | 1.120E-11 | 0.000E+00 | 5.047E-15 | 1.807E-17 | 1.674E-09 |
| Zooplankton (TL-II) | 3.847E-10 | 1.429E-05 | 1.441E-06 | 2.720E-05 | 2.698E-05 | 3.860E-06 | 3.434E-06 | 0.000E+00 | 1.722E-08 | 2.545E-09 | 7.722E-05 |
| Planktivore (TL-III) | 1.157E-10 | 1.610E-05 | 2.935E-06 | 1.073E-04 | 1.913E-04 | 3.010E-05 | 2.611E-05 | 0.000E+00 | 8.639E-08 | 4.548E-09 | 3.740E-04 |
| Piscivore (TL-IV) | 3.024E-11 | 2.837E-06 | 7.791E-07 | 6.270E-05 | 3.353E-04 | 9.028E-05 | 8.828E-05 | 0.000E+00 | 2.579E-07 | 5.625E-09 | 5.804E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 5.309E-11 | 1.429E-06 | 1.209E-07 | 2.010E-06 | 3.165E-06 | 3.078E-07 | 1.944E-07 | 0.000E+00 | 4.372E-10 | 1.955E-11 | 7.228E-06 |
| Sessile filter feeder (TL-II) | 9.335E-10 | 3.149E-05 | 3.110E-06 | 5.848E-05 | 5.662E-05 | 5.014E-06 | 3.631E-06 | 0.000E+00 | 1.162E-08 | 1.261E-09 | 1.584E-04 |
| Invertebrate Omnivore (TL-II) | 1.513E-08 | 1.176E-03 | 1.737E-04 | 5.591E-03 | 9.032E-03 | 6.389E-04 | 3.351E-04 | 0.000E+00 | 2.343E-07 | 3.166E-09 | 1.695E-02 |
| Invertebrate Forager (TL-III) | 5.231E-08 | 2.136E-03 | 3.184E-04 | 1.075E-02 | 2.052E-02 | 1.623E-03 | 9.003E-04 | 0.000E+00 | 9.901E-07 | 6.469E-08 | 3.624E-02 |
| Vertebrate Forager (TL-III) | 1.415E-08 | 9.949E-04 | 2.140E-04 | 1.254E-02 | 4.459E-02 | 4.516E-03 | 2.638E-03 | 0.000E+00 | 2.960E-06 | 9.732E-08 | 6.550E-02 |
| Predator (TL-IV) | 7.841E-09 | 5.098E-04 | 1.205E-04 | 1.052E-02 | 8.122E-02 | 1.244E-02 | 7.984E-03 | 0.000E+00 | 8.585E-06 | 1.886E-07 | 1.128E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.514E-10 | 9.875E-06 | 1.026E-06 | 2.030E-05 | 2.038E-05 | 1.866E-06 | 1.363E-06 | 0.000E+00 | 3.805E-09 | 2.711E-10 | 5.482E-05 |
| Epifaunal invert. (TL-II) | 3.508E-10 | 2.066E-05 | 2.464E-06 | 5.577E-05 | 6.146E-05 | 5.891E-06 | 4.348E-06 | 0.000E+00 | 1.092E-08 | 5.990E-10 | 1.506E-04 |
| Forager (TL-III) | 4.541E-10 | 2.508E-05 | 3.835E-06 | 1.159E-04 | 1.727E-04 | 1.615E-05 | 1.100E-05 | 0.000E+00 | 1.754E-08 | 4.024E-10 | 3.447E-04 |
| Predator (TL-IV) | 9.265E-11 | 1.541E-05 | 4.062E-06 | 2.516E-04 | 7.580E-04 | 9.120E-05 | 6.440E-05 | 0.000E+00 | 8.279E-08 | 1.217E-09 | 1.185E-03 |

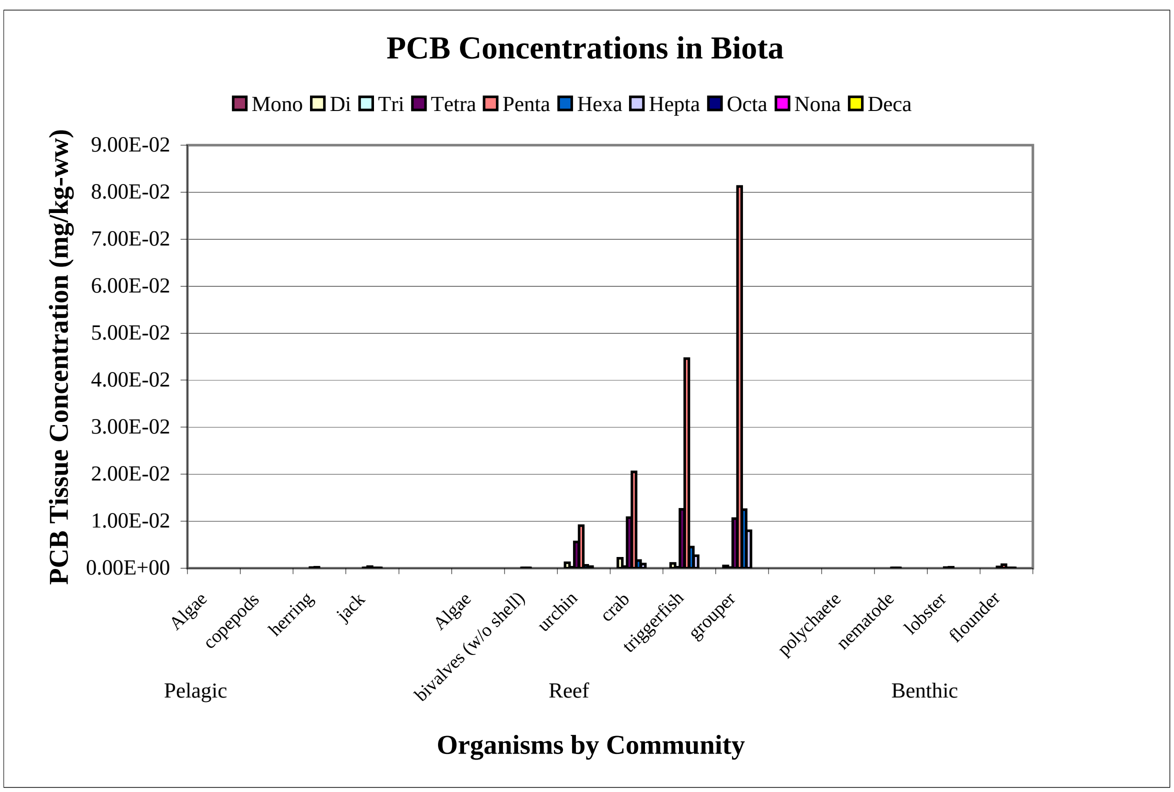
| BAFs (L/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Zooplankton (TL-II) | 1.347E+05 | 6.238E+05 | 7.436E+05 | 8.445E+05 | 5.320E+05 | 7.826E+05 | 1.103E+06 | 0.000E+00 | 2.458E+06 | 8.127E+06 |
| Planktivore (TL-III) | 7.603E+04 | 1.320E+06 | 2.843E+06 | 6.258E+06 | 7.083E+06 | 1.146E+07 | 1.576E+07 | 0.000E+00 | 2.317E+07 | 2.729E+07 |
| Piscivore (TL-IV) | 1.988E+04 | 2.326E+05 | 7.548E+05 | 3.655E+06 | 1.242E+07 | 3.439E+07 | 5.326E+07 | 0.000E+00 | 6.917E+07 | 3.375E+07 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Sessile filter feeder (TL-II) | 9.590E+05 | 4.034E+06 | 4.709E+06 | 5.328E+06 | 3.276E+06 | 2.983E+06 | 3.420E+06 | 0.000E+00 | 4.867E+06 | 1.181E+07 |
| Invertebrate Omnivore (TL-II) | 3.226E+04 | 3.127E+05 | 5.460E+05 | 1.057E+06 | 1.085E+06 | 7.891E+05 | 6.556E+05 | 0.000E+00 | 2.037E+05 | 6.157E+04 |
| Invertebrate Forager (TL-III) | 1.633E+05 | 8.319E+05 | 1.465E+06 | 2.976E+06 | 3.608E+06 | 2.934E+06 | 2.578E+06 | 0.000E+00 | 1.260E+06 | 1.842E+06 |
| Vertebrate Forager (TL-III) | 1.501E+04 | 1.316E+05 | 3.345E+05 | 1.180E+06 | 2.664E+06 | 2.774E+06 | 2.567E+06 | 0.000E+00 | 1.280E+06 | 9.414E+05 |
| Predator (TL-IV) | 1.243E+04 | 1.008E+05 | 2.815E+05 | 1.479E+06 | 7.250E+06 | 1.142E+07 | 1.161E+07 | 0.000E+00 | 5.547E+06 | 2.726E+06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.429E+05 | 1.190E+06 | 1.462E+06 | 1.740E+06 | 1.109E+06 | 1.044E+06 | 1.208E+06 | 0.000E+00 | 1.499E+06 | 2.389E+06 |
| Epifaunal invert. (TL-II) | 3.013E+05 | 2.213E+06 | 3.119E+06 | 4.248E+06 | 2.973E+06 | 2.930E+06 | 3.425E+06 | 0.000E+00 | 3.825E+06 | 4.691E+06 |
| Forager (TL-III) | 1.759E+05 | 1.212E+06 | 2.189E+06 | 3.981E+06 | 3.768E+06 | 3.622E+06 | 3.909E+06 | 0.000E+00 | 2.770E+06 | 1.421E+06 |
| Predator (TL-IV) | 1.557E+04 | 3.231E+05 | 1.006E+06 | 3.750E+06 | 7.177E+06 | 8.877E+06 | 9.928E+06 | 0.000E+00 | 5.673E+06 | 1.865E+06 |

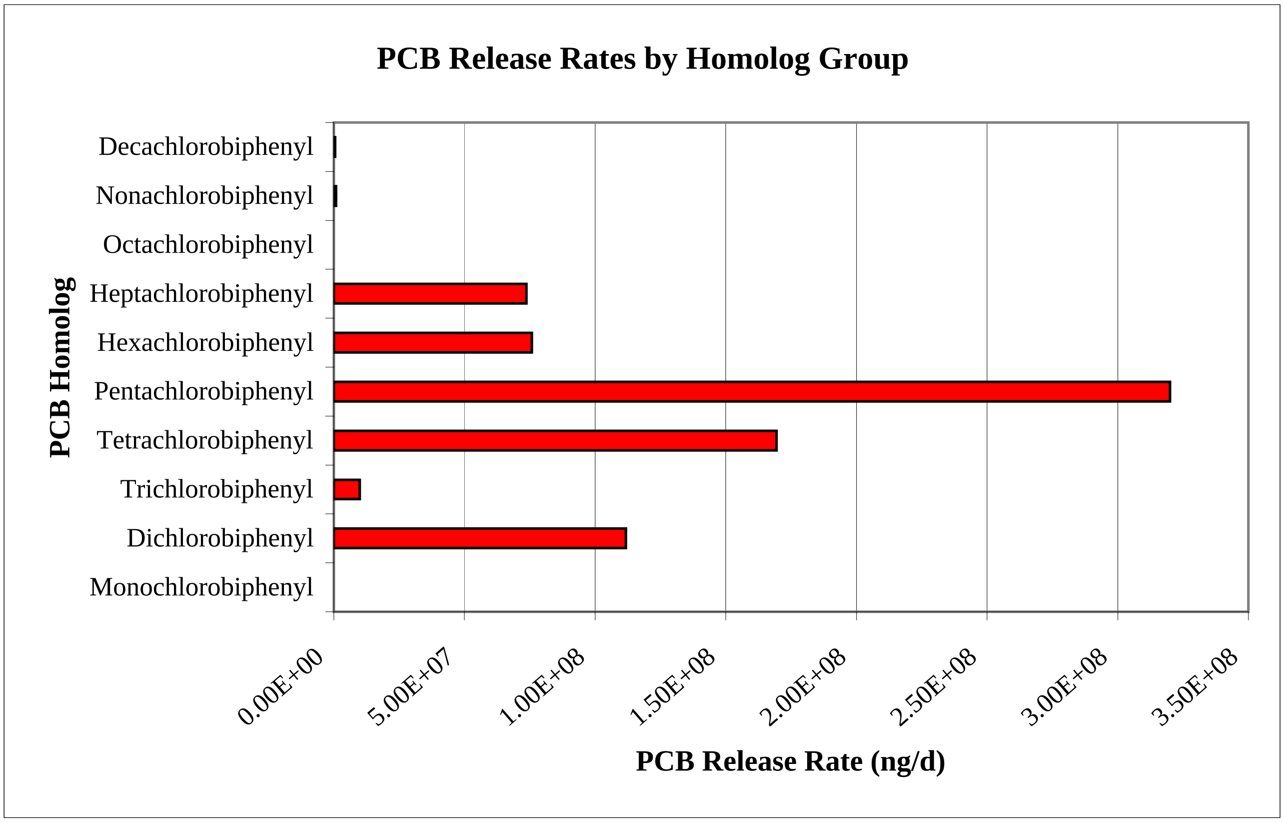
Notes:

Kow = octanol to water partitioning coefficient, Koc = organic carbon partitioning coefficient, Kdoc = dissolved organic carbon partitioning coefficient

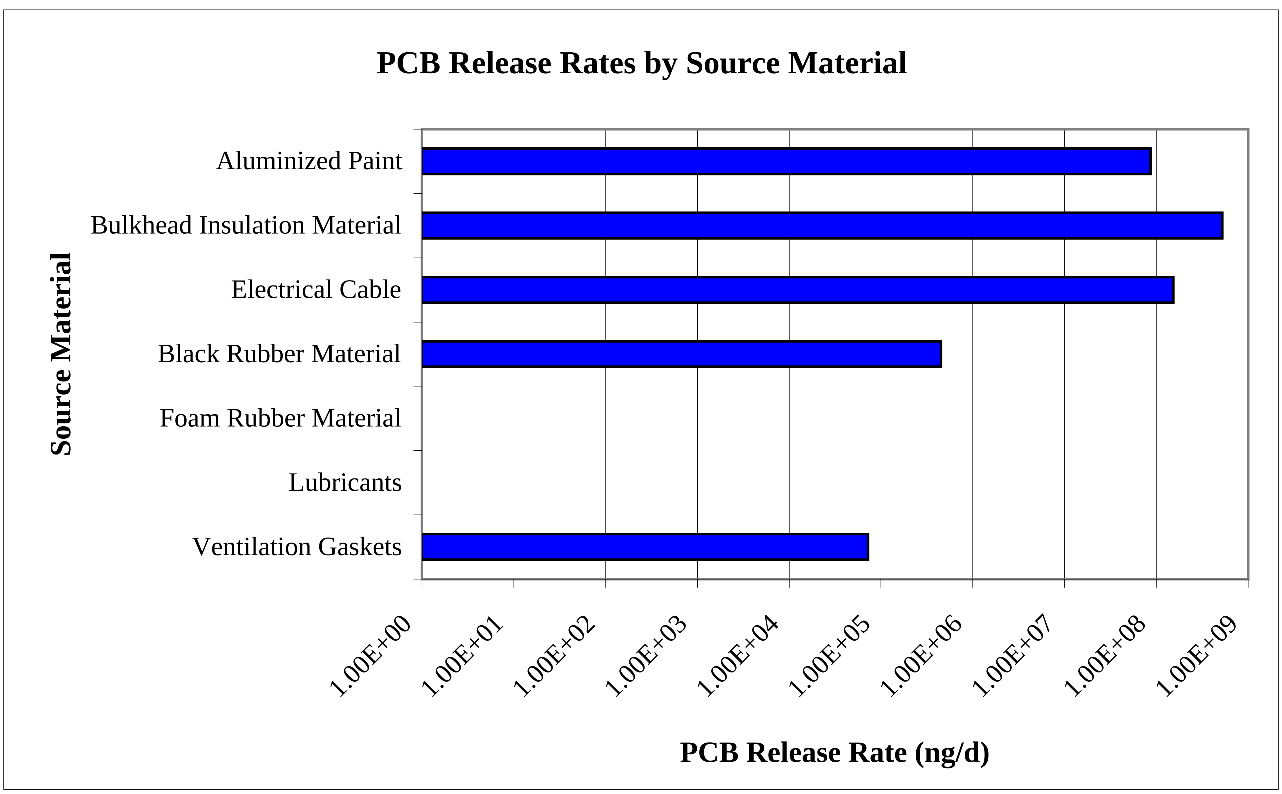
TL = trophic level, ww = wet weight


PCB Concentrations Outside the Vessel
Air concentration (g/m3)
Water Concentration-LWC (mg/L)
Suspended solids concentration-LWC (mg/kg)
Dissolved organic carbon-LWC (mg/kg)
Sediment concentration (mg/kg)
Water Concentration-UWC (mg/L)
PCB Concentration
7.00E-04
6.00E-04
5.00E-04
4.00E-04
3.00E-04
2.00E-04
1.00E-04
0.00E+00
Mono
Di
Tri
Tetra
Penta
Hexa
Hepta
Octa
Nona
Deca
PCB Homologue


PCB Concentrations in Biota
Mono
Di
Tri
Tetra
Penta
Hexa
Hepta
Octa
Nona
Deca
PCB Tissue Concentration (mg/kg-ww)
9.00E-02
8.00E-02
7.00E-02
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
Algae
copepods
herring
jack
Algae
bivalves (w/o shell)
urchin
crab
triggerfish
grouper
polychaete
nematode
lobster
flounder
Pelagic
Reef
Benthic
Organisms by Community



PCB Release Rates by Homolog Group
PCB Homolog
Decachlorobiphenyl
Nonachlorobiphenyl
Octachlorobiphenyl
Heptachlorobiphenyl
Hexachlorobiphenyl
Pentachlorobiphenyl
Tetrachlorobiphenyl
Trichlorobiphenyl
Dichlorobiphenyl
Monochlorobiphenyl
0.00E+00
5.00E+07
1.00E+08
1.50E+08
2.00E+08
2.50E+08
3.00E+08
3.50E+08
PCB Release Rate (ng/d)

PCB Release Rates by Source Material
Source Material
Aluminized Paint
Bulkhead Insulation Material
Electrical Cable
Black Rubber Material
Foam Rubber Material
Lubricants
Ventilation Gaskets
1.00E+00
1.00E+01
1.00E+02
1.00E+03
1.00E+04
1.00E+05
1.00E+06
1.00E+07
1.00E+08
1.00E+09
PCB Release Rate (ng/d)

**ZOI = 5**

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION

## *RISK ESTIMATES FOR Ex-Oriskany CV34*

| | Cancer Risk Adult & Child | | Hazard Adult & Child | | Cancer Risk Child | | Hazard Child | |
|---|---|---|---|---|---|---|---|---|
| ***RISK ESTIMATES*** | RME | CTE | RME | CTE | RME | CTE | RME | CTE |
| Benthic fish (flounder) | 4.23E-08 | 3.28E-09 | 2.47E-03 | 5.66E-04 | 1.24E-08 | 2.52E-09 | 3.62E-03 | 6.53E-04 |
| Benthic shellfish (lobster) | 1.23E-08 | 9.53E-10 | 7.18E-04 | 1.65E-04 | 3.61E-09 | 7.33E-10 | 1.05E-03 | 1.90E-04 |
| Pelagic fish (jack) | 2.07E-08 | 1.61E-09 | 1.21E-03 | 2.78E-04 | 6.08E-09 | 1.23E-09 | 1.77E-03 | 3.20E-04 |
| Reef fish TL-IV (grouper) | 6.86E-06 | 5.31E-07 | 4.00E-01 | 9.18E-02 | 2.01E-06 | 4.08E-07 | 5.87E-01 | 1.06E-01 |
| Reef fish TL-III (triggerfish) | 3.98E-06 | 3.08E-07 | 2.32E-01 | 5.33E-02 | 1.17E-06 | 2.37E-07 | 3.41E-01 | 6.14E-02 |
| Reef shellfish (crab) | 2.21E-06 | 1.71E-07 | 1.29E-01 | 2.95E-02 | 6.48E-07 | 1.31E-07 | 1.89E-01 | 3.41E-02 |

| ***PREDICTED EXPOSURE CONCENTRATIONS (mg/kg in fresh weight)*** | |
|---|---|
| Benthic fish (flounder) | 6.88E-04 |
| Benthic shellfish (lobster) | 2.00E-04 |
| Pelagic fish (jack) | 3.37E-04 |
| Reef fish TL-IV (grouper) | 1.11E-01 |
| Reef fish TL-III (triggerfish) | 6.47E-02 |
| Reef shellfish (crab) | 3.59E-02 |

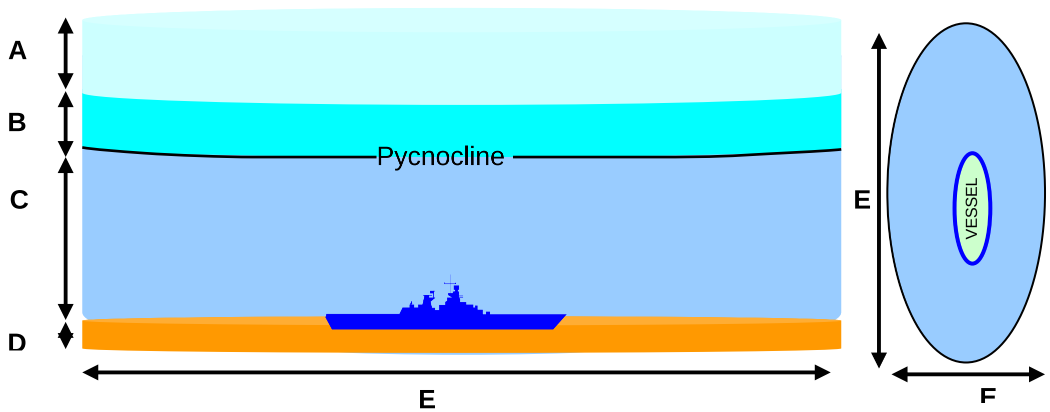
| ***RISK INPUTS - Adult*** | RME | CTE |
|---|---|---|
| Body Weight (BWa) (kg) | 70 | 70 |
| Exposure Frequency (EFa) (days) | 365 | 365 |
| Exposure Duration (EDa) (years) | 24 | 3 |
| Ingestion Rate (IRa) (kg/day) | 0.0261 | 0.0072 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Averaging Time for noncancer (ATnc-adult) | 8760 | 1095 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 2.00E-05 | 4.50E-05 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |
| Ingestion Rates Based on Data from | Gulf Coast | |

| ***RISK INPUTS - Child*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 15 | 15 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Exposure Duration (EDc) (years) | 6 | 6 |
| Ingestion Rate (IRc) (kg/day) | 0.0092916 | 0.0025632 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Averaging Time for noncancer (ATnc-child) | 2190 | 2190 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 2.00E-05 | 4.50E-05 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |
| Child - Adult IR scaling factor | 0.356 | |

| | |
|---|---|
| Zone of Influence Multiplier | 5 |
| Scenario run on | 5/11/05 13:38 |

| ***PCB-LADEN MATERIAL INPUTS*** | Fraction PCB | Release Rate (ng/g-d) | kg Material Onboard | PCB Release (ng/day) |
|---|---|---|---|---|
| Ventilation Gaskets | 3.14E-05 | 1.58E+03 | 1.46E+03 | 7.23E+04 |
| Lubricants | 1.03E-04 | 2.20E+03 | 0.00E+00 | 0.00E+00 |
| Foam Rubber Material | 7.60E-03 | 2.62E+00 | 0.00E+00 | 0.00E+00 |
| Black Rubber Material | 5.29E-05 | 1.58E+03 | 5.40E+03 | 4.50E+05 |
| Electrical Cable | 1.85E-03 | 2.79E+02 | 2.96E+05 | 1.53E+08 |
| Bulkhead Insulation Material | 5.37E-04 | 6.76E+04 | 1.44E+04 | 5.22E+08 |
| Aluminum Paint | 2.00E-05 | 1.11E+04 | 3.87E+05 | 8.62E+07 |
| Total | | | | 7.62E+08 |

| **Ex-Oriskany CV34** | |
|---|---|
| Displacement (tons) | 27100 |
| Length (ft) | 888 |
| Beam (ft) | 120 |




ZOI = 5

| Spatial Footprint on Ocean Floor | | |
|---|---|---|
| | 3.89E+04 | m2 |
| | 1.50E-02 | mile2 |
| **Modeled Dimensions Outside the Vessel** | | |
| A | 1.00E+01 | m |
| B | 1.50E+01 | m |
| C | 5.00E+01 | m |
| D | 1.00E-01 | m |
| E | 3.68E+02 | m |
| F | 1.34E+02 | m |
| **Volumes** | | |
| Air Column | | |
| Air | 3.89E+05 | m3 |
| Upper Water Column | | |
| Water | 5.83E+05 | m3 |
| TSS | 3.89E+00 | m3 |
| Lower Water Column | | |
| Water | 1.89E+06 | m3 |
| TSS | 1.26E+01 | m3 |
| Inside Vessel | | |
| Water | 5.38E+04 | m3 |
| TSS | 3.59E-01 | m3 |
| Sediment Bed | | |
| Sediment | 3.11E+03 | m3 |

**Abiotic Inputs**

Air Column

| | |
|---|---|
| Active air space height above water column (m) | 10 |

**Total PCB concentrations**

Air Column

| | | |
|---|---|---|
| Air | 9.68E-17 | g/m3 |

| | |
|---|---|
| Air current (m/h) | 13677 |
| **Upper Water Column** | |
| Temperature (°C) | 24.5 |
| Water depth (m) | 15 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 6.12 |
| **Lower Water Column** | |
| Temperature (°C) | 19.5 |
| Water depth (m) | 50 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| **Inside Vessel** | |
| Temperature (°C) | 19.5 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| **Sediment Bed** | |
| Sediment density (g/cm3) | 1.5 |
| Active sediment depth (m) | 0.1 |
| Sediment fraction organic carbon | 0.01 |
| **All Regions** | |
| Suspended solids density (g/cm3) | 1.5 |
| Suspended solids fraction organic carbon | 0.15 |
| Dissolved organic carbon density (g/cm3) | 1 |
| Water current - to out of the ZOI (m/h) | 926 |
| Water current - inside to outside the vessel (m/h) | 9.26 |

| | | |
|---|---|---|
| **Upper Water Column** | | |
| Freely dissolved in water | 9.32E-13 | mg/L |
| Suspended solids | 1.22E-08 | mg/kg |
| Dissolved organic carbon | 1.63E-07 | mg/kg |
| **Lower Water Column** | | |
| Freely dissolved in water | 2.55E-09 | mg/L |
| Suspended solids | 6.27E-05 | mg/kg |
| Dissolved organic carbon | 5.74E-04 | mg/kg |
| **Inside Vessel** | | |
| Freely dissolved in water | 1.80E-06 | mg/L |
| Suspended solids | 4.44E-02 | mg/kg |
| Dissolved organic carbon | 4.06E-01 | mg/kg |
| **Sediment Bed** | | |
| Freely dissolved in pore water | 2.55E-09 | mg/L |
| Bedded sediment | 4.18E-06 | mg/kg |
| Dissolved organic carbon in pore water | 5.74E-04 | mg/kg |

| **Total PCB concentrations in biota** | | | **Percent Exposures** | |
|---|---|---|---|---|
| **Pelagic Community** | | | **Upper WC** | **Lower WC** |
| Phytoplankton (TL-I) | 1.54E-09 | mg/kg | 100% | 0% |
| Zooplankton (TL-II) | 4.48E-05 | mg/kg | 50% | 50% |
| Planktivore (TL-III) | 2.17E-04 | mg/kg | 80% | 20% |
| Piscivore (TL-IV) | 3.37E-04 | mg/kg | 80% | 20% |
| **Reef / Vessel Community** | | | **Lower WC** | **Vessel Int.** |
| Attached Algae (TL-I) | 4.20E-06 | mg/kg | 100% | 0% |
| Sessile filter feeder (TL-II) | 9.19E-05 | mg/kg | 100% | 0% |
| Invertebrate Omnivore (TL-II) | 1.67E-02 | mg/kg | 80% | 20% |
| Invertebrate Forager (TL-III) | 3.59E-02 | mg/kg | 70% | 30% |
| Vertebrate Forager (TL-III) | 6.47E-02 | mg/kg | 70% | 30% |
| Predator (TL-IV) | 1.11E-01 | mg/kg | 80% | 20% |
| **Benthic Community** | | | **Lower WC** | **Pore Water** |
| Infaunal invert. (TL-II) | 3.18E-05 | mg/kg | 20% | 80% |
| Epifaunal invert. (TL-II) | 8.74E-05 | mg/kg | 50% | 50% |
| Forager (TL-III) | 2.00E-04 | mg/kg | 75% | 25% |
| Predator (TL-IV) | 6.88E-04 | mg/kg | 90% | 10% |

## PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION
### RISK ESTIMATES FOR Ex-Oriskany CV34 High-End Weight of PCB-Laden Materials
### Supplemental Information

**Scenario Run on** 10/21/2004 **14:10**

| PCB Homolog | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Molecular Weight (g/mol) | 1.89E+02 | 2.23E+02 | 2.58E+02 | 2.92E+02 | 3.26E+02 | 3.61E+02 | 3.95E+02 | 4.30E+02 | 4.64E+02 | 4.99E+02 |
| Solubility (mg/L) | 2.91E+00 | 6.78E-01 | 8.14E-02 | 6.67E-02 | 2.61E-02 | 9.50E-04 | 2.30E-04 | 2.11E-08 | 4.02E-09 | 1.69E-10 |
| Solubility ($mol/m^3$) | 1.54E-02 | 3.04E-03 | 3.16E-04 | 2.28E-04 | 8.00E-05 | 2.63E-06 | 5.82E-07 | 4.91E-11 | 8.65E-12 | 3.38E-13 |
| Vapor Pressure (Pa) | 6.32E-01 | 1.41E-01 | 5.11E-02 | 2.08E-02 | 2.96E-03 | 3.43E-03 | 2.56E-04 | 8.65E-05 | 2.77E-05 | 1.41E-05 |
| Henry's ($Pa\text{-}m^3/mol$) | 4.10E+01 | 4.65E+01 | 1.62E+02 | 9.10E+01 | 3.70E+01 | 1.30E+03 | 4.40E+02 | 1.76E+06 | 3.20E+06 | 4.18E+07 |
| $\log_{10}K_{ow}$ = | 4.47 | 5.24 | 5.52 | 5.92 | 6.50 | 6.98 | 7.19 | 7.70 | 8.35 | 9.60 |
| $\log_{10}K_{oc}$ = | 3.66 | 4.06 | 4.63 | 4.65 | 4.94 | 6.08 | 6.34 | 6.46 | 6.97 | 7.94 |
| $\log_{10}K_{doc}$ = | 3.34 | 4.11 | 4.39 | 4.79 | 5.51 | 5.85 | 6.06 | 6.57 | 7.22 | 8.47 |
| Chemical emission rate (g/day) | 1.37E-05 | 1.12E-01 | 9.95E-03 | 1.69E-01 | 3.20E-01 | 7.57E-02 | 7.37E-02 | 0.00E+00 | 8.28E-04 | 4.62E-04 |
| Chemical emission rate (mol/hr) | 3.03E-09 | 2.09E-05 | 1.61E-06 | 2.42E-05 | 4.08E-05 | 8.74E-06 | 7.77E-06 | 0.00E+00 | 7.43E-08 | 3.86E-08 |
| Biodegradation in sediment (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Biodegradation in water (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Fraction PCB in Material (wt/wt) | 0.0000314 | 0.000103 | 0.76% | 0.0000529 | 0.00185 | 0.000537 | 0.00002 |
| Material Mass Onboard (kg) | 1459 | 0 | 0 | 5397 | 296419 | 14379 | 386528 |
| Total PCBs (kg) | 0.0458126 | 0 | 0 | 0.2855013 | 548.37515 | 7.721523 | 7.73056 |
| Total PCB Release rate (ng/g-PCB per day) | 1.58E+03 | 2.20E+03 | 2.62E+00 | 1.58E+03 | 2.79E+02 | 6.76E+04 | 1.11E+04 |

| Release Rates in nanograms PCB per gram of PCB within the Material | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 4.14E+01 | 3.47E+01 | 0.00E+00 | 4.14E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Dichlorobiphenyl | 1.27E+03 | 1.72E+02 | 3.08E-02 | 1.27E+03 | 2.03E+02 | 5.36E+00 | 0.00E+00 |
| Trichlorobiphenyl | 5.66E+01 | 8.97E+01 | 7.63E-02 | 5.66E+01 | 1.14E+00 | 9.44E+02 | 2.61E+02 |
| Tetrachlorobiphenyl | 1.44E+02 | 1.08E+03 | 1.29E+00 | 1.44E+02 | 1.57E+01 | 2.07E+04 | 1.23E+02 |
| Pentachlorobiphenyl | 6.31E+01 | 6.60E+02 | 3.90E-02 | 6.31E+01 | 1.80E+01 | 3.79E+04 | 2.24E+03 |
| Hexachlorobiphenyl | 0.00E+00 | 9.42E+01 | 5.34E-01 | 0.00E+00 | 2.41E+01 | 6.76E+03 | 1.33E+03 |
| Heptachlorobiphenyl | 5.04E+00 | 7.17E+01 | 6.46E-01 | 5.04E+00 | 1.47E+01 | 1.30E+03 | 7.19E+03 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 1.72E-03 | 0.00E+00 | 1.51E+00 | 0.00E+00 | 0.00E+00 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.43E-01 | 0.00E+00 | 0.00E+00 |
| **Total** | **1.58E+03** | **2.20E+03** | **2.62E+00** | **1.58E+03** | **2.79E+02** | **6.76E+04** | **1.11E+04** |

| Release Rates in nanograms PCB per Day | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint | Total |
|---|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 1.90E+03 | 0.00E+00 | 0.00E+00 | 1.18E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.37E+04 |
| Dichlorobiphenyl | 5.80E+04 | 0.00E+00 | 0.00E+00 | 3.62E+05 | 1.11E+08 | 4.14E+04 | 0.00E+00 | 1.12E+08 |
| Trichlorobiphenyl | 2.59E+03 | 0.00E+00 | 0.00E+00 | 1.62E+04 | 6.25E+05 | 7.29E+06 | 2.02E+06 | 9.95E+06 |
| Tetrachlorobiphenyl | 6.60E+03 | 0.00E+00 | 0.00E+00 | 4.11E+04 | 8.61E+06 | 1.60E+08 | 9.51E+05 | 1.69E+08 |
| Pentachlorobiphenyl | 2.89E+03 | 0.00E+00 | 0.00E+00 | 1.80E+04 | 9.87E+06 | 2.93E+08 | 1.73E+07 | 3.20E+08 |
| Hexachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.32E+07 | 5.22E+07 | 1.03E+07 | 7.57E+07 |
| Heptachlorobiphenyl | 2.31E+02 | 0.00E+00 | 0.00E+00 | 1.44E+03 | 8.06E+06 | 1.01E+07 | 5.56E+07 | 7.37E+07 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.28E+05 | 0.00E+00 | 0.00E+00 | 8.28E+05 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.62E+05 | 0.00E+00 | 0.00E+00 | 4.62E+05 |
| **Total** | 7.23E+04 | 0.00E+00 | 0.00E+00 | 4.50E+05 | 1.53E+08 | 5.22E+08 | 8.62E+07 | 7.62E+08 |

## PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION
## RISK ESTIMATES FOR Ex-Oriskany CV34 High-End Weight of PCB-Laden Materials
### Supplemental Information

| Air | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 4.65E-20 | 2.86E-16 | 1.89E-17 | 2.52E-16 | 2.76E-16 | 9.75E-18 | 3.48E-18 | 0.00E+00 | 1.23E-21 | 3.97E-24 |
| Air concentration (g/m3) | 3.58E-21 | 2.60E-17 | 1.98E-18 | 3.00E-17 | 3.67E-17 | 1.43E-18 | 5.60E-19 | 0.00E+00 | 2.33E-22 | 8.06E-25 |

| Upper Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 6.12E-18 | 4.63E-14 | 1.12E-14 | 9.04E-14 | 4.32E-14 | 5.50E-14 | 6.95E-15 | 0.00E+00 | 1.94E-14 | 8.44E-16 |
| Water concentration (mg/L) | 2.82E-17 | 2.22E-13 | 1.79E-14 | 2.90E-13 | 3.81E-13 | 1.52E-14 | 6.24E-15 | 0.00E+00 | 2.81E-18 | 1.01E-20 |
| Suspended solids concentration (mg/kg) | 1.95E-14 | 3.80E-10 | 1.13E-10 | 1.96E-09 | 4.92E-09 | 2.75E-09 | 2.05E-09 | 0.00E+00 | 3.89E-12 | 1.32E-13 |
| Dissolved organic carbon (mg/kg) | 6.21E-14 | 2.83E-09 | 4.39E-10 | 1.79E-08 | 1.24E-07 | 1.07E-08 | 7.15E-09 | 0.00E+00 | 4.67E-11 | 2.99E-12 |

| Lower Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 1.37E-14 | 1.05E-10 | 2.67E-11 | 2.21E-10 | 1.27E-10 | 3.92E-10 | 7.63E-11 | 0.00E+00 | 1.06E-09 | 5.78E-10 |
| Water concentration (mg/L) | 6.28E-14 | 5.03E-10 | 4.26E-11 | 7.08E-10 | 1.11E-09 | 1.08E-10 | 6.85E-11 | 0.00E+00 | 1.54E-13 | 6.89E-15 |
| Suspended solids concentration (mg/kg) | 4.34E-11 | 8.62E-07 | 2.69E-07 | 4.79E-06 | 1.44E-05 | 1.96E-05 | 2.25E-05 | 0.00E+00 | 2.13E-07 | 9.01E-08 |
| Dissolved organic carbon (mg/kg) | 1.38E-10 | 6.41E-06 | 1.05E-06 | 4.38E-05 | 3.63E-04 | 7.60E-05 | 7.85E-05 | 0.00E+00 | 2.56E-06 | 2.04E-06 |

| Inside the Vessel | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 9.67E-12 | 7.43E-08 | 1.89E-08 | 1.56E-07 | 8.96E-08 | 2.77E-07 | 5.40E-08 | 0.00E+00 | 7.51E-07 | 4.09E-07 |
| Water concentration (mg/L) | 4.45E-11 | 3.57E-07 | 3.02E-08 | 5.02E-07 | 7.90E-07 | 7.68E-08 | 4.85E-08 | 0.00E+00 | 1.09E-10 | 4.88E-12 |
| Suspended solids concentration (mg/kg) | 3.07E-08 | 6.11E-04 | 1.91E-04 | 3.39E-03 | 1.02E-02 | 1.39E-02 | 1.59E-02 | 0.00E+00 | 1.51E-04 | 6.38E-05 |
| Dissolved organic carbon (mg/kg) | 9.80E-08 | 4.54E-03 | 7.41E-04 | 3.10E-02 | 2.57E-01 | 5.38E-02 | 5.56E-02 | 0.00E+00 | 1.81E-03 | 1.45E-03 |

| Sediment Bed | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 1.37E-14 | 1.05E-10 | 2.67E-11 | 2.21E-10 | 1.27E-10 | 3.92E-10 | 7.63E-11 | 0.00E+00 | 1.06E-09 | 5.78E-10 |
| Pore Water concentration (mg/L) | 6.28E-14 | 5.03E-10 | 4.26E-11 | 7.08E-10 | 1.11E-09 | 1.08E-10 | 6.85E-11 | 0.00E+00 | 1.54E-13 | 6.89E-15 |
| Sediment concentration (mg/kg) | 2.89E-12 | 5.75E-08 | 1.80E-08 | 3.19E-07 | 9.60E-07 | 1.30E-06 | 1.50E-06 | 0.00E+00 | 1.42E-08 | 6.01E-09 |

**Bioenergetic Inputs**

| | Species | Body Weight | Lipid | Moisture | Caloric Density | GE to ME | Met Energy | Caloric Density | Production | Respiration | Excretion | Caloric Density | Met Energy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (kg) | (%-dw) | (%) | (kcal/g-dry weight) | Fraction | (kcal/kg-lipid) | (kcal/kg-lipid) | (% of total) | (% of total) | (% of total) | (kcal/g-wt weight) | (kcal/g-wt weight) |
| **Pelagic Community** | | | | | | | | | | | | | |
| Phytoplankton (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Zooplankton (TL-II) | copepods | 0.000005 | 22% | 76% | 3.6 | 0.65 | 10636 | 16364 | 18% | 24% | 58% | 0.864 | 0.5616 |
| Planktivore (TL-III) | herring | 0.05 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Piscivore (TL-IV) | jack | 0.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| **Reef / Vessel Community** | | | | | | | | | | | | | |
| Attached Algae (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.05 | 5% | 82% | 4.6 | 0.65 | 59800 | 92000 | 28% | 31% | 41% | 0.828 | 0.5382 |
| Invertebrate Omnivore (TL-II) | urchin | 0.05 | 29% | 82% | 4.6 | 0.65 | 10310 | 15862 | 7% | 25% | 68% | 0.828 | 0.5382 |
| Invertebrate Forager (TL-III) | crab | 1 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Vertebrate Forager (TL-III) | triggerfish | 1 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Predator (TL-IV) | grouper | 1.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 0.2 | 0.14 |
| **Benthic Community** | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.01 | 6% | 84% | 4.6 | 0.65 | 50000 | 76923 | 71% | 26% | 3% | 0.736 | 0.4784 |
| Epifaunal invert. (TL-II) | nematode | 0.01 | 6% | 82% | 4.6 | 0.65 | 50000 | 76923 | 31% | 19% | 50% | 0.828 | 0.5382 |
| Forager (TL-III) | lobster | 2 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Predator (TL-IV) | flounder | 3 | 22% | 75% | 4.9 | 0.7 | 15591 | 22273 | 20% | 60% | 20% | 1.225 | 0.8575 |

| Bioenergetic Inputs | | Respiration Rate Allometric Regression Parameters | | | Resp. Rate | Resp. Rate | Consumption | Growth Rate | Consumption | Consumption | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | a | b1 | b2 | 1 / day | gO2 / kg-lipid-day | kcal / kg-lipid-day | 1 / day | g-wt weight / g-wt weight-d | kcal / wet weight-da | As a % of body weight |
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | Algae | | | | | | | | | | |
| Zooplankton (TL-II) | copepods | 0.006375522 | 0 | 0.039935335 | 0.015425453 | 84.24400867 | 1286.168071 | 0.014147849 | 0.32636028 | 0.06790967 | 32.6% |
| Planktivore (TL-III) | herring | 0.0033 | -0.227 | 0.0548 | 0.004949927 | 21.1649 | 129.2512977 | 0.001482433 | 0.01616792 | 0.0090799 | 1.6% |
| Piscivore (TL-IV) | jack | 0.001118602 | -0.55 | 0.12 | 0.000630951 | 2.697821256 | 16.47524431 | 0.000188961 | 0.00139796 | 0.00115739 | 0.1% |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | Algae | | | | | | | | | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.012 | 0 | 0.036 | 0.024213411 | 581.8482643 | 6877.300342 | 0.020930914 | 0.24377539 | 0.0618957 | 24.4% |
| Invertebrate Omnivore (TL-II) | urchin | 0.000675466 | 0 | 0.079181846 | 0.003163548 | 13.1069075 | 192.1012396 | 0.000847751 | 0.03471132 | 0.01002768 | 3.5% |
| Invertebrate Forager (TL-III) | crab | 0.001158234 | 0 | 0.071193202 | 0.004642088 | 60.75673491 | 377.3221989 | 0.003592107 | 0.01678102 | 0.00900593 | 1.7% |
| Vertebrate Forager (TL-III) | triggerfish | 0.015181024 | -0.415 | 0.061 | 0.002837229 | 12.13142452 | 74.08503521 | 0.00084971 | 0.00907693 | 0.00520447 | 0.9% |
| Predator (TL-IV) | grouper | 0.00279 | -0.355 | 0.0811 | 0.001011362 | 4.324384181 | 26.40845301 | 0.000302889 | 0.00264734 | 0.00185519 | 0.3% |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 1903.064429 | 0.017565285 | 0.09800757 | 0.01820852 | 9.8% |
| Epifaunal invert. (TL-II) | nematode | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 2604.19343 | 0.0104949 | 0.09262416 | 0.02803154 | 9.3% |
| Forager (TL-III) | lobster | 0.0035 | -0.13 | 0.066 | 0.00471923 | 61.76639253 | 383.5925529 | 0.003651801 | 0.01899736 | 0.00915559 | 1.9% |
| Predator (TL-IV) | flounder | 0.0046 | -0.24 | 0.067 | 0.002486878 | 13.58174479 | 82.94195291 | 0.000744785 | 0.00974341 | 0.00456181 | 1.0% |

| Dietary Preferences | Suspended Solids (Epilimnion) | Suspended Solids (Hypolimnion) | Sediment | Phytoplankton | Zooplankton | Pelagic Plankitivore | Attached Algae | Reef Sessile Filter Feeder | Invertebrate Omnivore | Reef Invertebrate Forager | Reef Vertebrate Forager | Infaunal Benthos | Epifaunal Benthos | Benthic Forager |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | | | | |
| Phytoplankton (TL1) | | | | | | | | | | | | | | |
| Zooplankton (TL-II) | 15% | 15% | | 70% | | | | | | | | | | |
| Planktivore (TL-III) | | | | | 100% | | | | | | | | | |
| Piscivore (TL-IV) | | | | | 10% | 90% | | | | | | | | |
| **Reef / Vessel Community** | | | | | | | | | | | | | | |
| Attached Algae | | | | | | | | | | | | | | |
| Sessile filter feeder (TL-II) | | 10% | | 80% | 10% | | | | | | | | | |
| Invertebrate Omnivore (TL-II) | | | | | | | 80% | 20% | | | | | | |
| Invertebrate Forager (TL-III) | | 5% | | | 5% | 5% | | 35% | 50% | | | | | |
| Vertebrate Forager (TL-III) | | | | | | 19% | | 19% | 15% | 22% | | 12.5% | 12.5% | |
| Predator (TL-IV) | | | | | | | | | | 15% | 60% | 8% | 8% | 8% |
| **Benthic Community** | | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | | | 50% | 30% | 20% | | | | | | | | | |
| Epifaunal invert. (TL-II) | | | 25% | 30% | 20% | | | | | | | 25% | | |
| Forager (TL-III) | | | 5% | | | | | | | | | 50% | 45% | |
| Predator (TL-IV) | | | 2% | | | | | | | | | 20% | 20% | 58% |

| Water Exposures | | Upper Water Column | Lower Water Column | Vessel Interior | Sediment Pore Water |
|---|---|---|---|---|---|
| **Pelagic Community** | | | | | |
| Phytoplankton (TL1) | Algae | 100% | | | |
| Zooplankton (TL-II) | copepods | 50% | 50% | | |
| Planktivore (TL-III) | herring | 80% | 20% | | |
| Piscivore (TL-IV) | jack | 80% | 20% | | |
| **Reef / Vessel Community** | | | | | |
| Attached Algae | Algae | | 100% | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | | 100% | | |
| Invertebrate Omnivore (TL-II) | urchin | | 80% | 20% | |
| Invertebrate Forager (TL-III) | crab | | 70% | 30% | |
| Vertebrate Forager (TL-III) | triggerfish | | 70% | 30% | |
| Predator (TL-IV) | grouper | | 80% | 20% | |
| **Benthic Community** | | | | | |
| Infaunal invert. (TL-II) | polychaete | | 20% | | 80% |
| Epifaunal invert. (TL-II) | nematode | | 50% | | 50% |
| Forager (TL-III) | lobster | | 75% | | 25% |
| Predator (TL-IV) | flounder | | 90% | | 10% |

**Energy Estimates for Suspended Sediment and Bedded Sediment**

| | GE | ME | ME | as kcal/g-ww |
|---|---|---|---|---|
| Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.01099776 |
| Suspended Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.1649664 |

| Respiratory Efficiencies | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Low body weight (<100g) | 4.335E-01 | 8.000E-01 | 8.000E-01 | 8.000E-01 | 4.492E-01 | 2.582E-01 | 2.018E-01 | 1.127E-01 | 5.303E-02 | 1.255E-02 |
| High body weight (>100g) | 5.000E-01 | 5.000E-01 | 5.000E-01 | 5.000E-01 | 3.769E-01 | 2.857E-01 | 2.526E-01 | 1.888E-01 | 1.295E-01 | 6.299E-02 |
| Dietary Assimilation Efficiencies | 27% | 46% | 53% | 62% | 69% | 69% | 68% | 59% | 44% | 16% |

| Tissue Conc. (mg/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 8.387E-13 | 2.222E-08 | 1.787E-09 | 2.899E-08 | 3.807E-08 | 1.523E-09 | 6.239E-10 | 0.000E+00 | 2.811E-13 | 1.007E-15 |
| Zooplankton (TL-II) | 4.231E-09 | 1.571E-04 | 1.585E-05 | 2.991E-04 | 2.967E-04 | 4.244E-05 | 3.776E-05 | 0.000E+00 | 1.893E-07 | 2.799E-08 |
| Planktivore (TL-III) | 9.564E-10 | 1.331E-04 | 2.426E-05 | 8.873E-04 | 1.581E-03 | 2.488E-04 | 2.158E-04 | 0.000E+00 | 7.140E-07 | 3.758E-08 |
| Piscivore (TL-IV) | 2.501E-10 | 2.346E-05 | 6.441E-06 | 5.183E-04 | 2.772E-03 | 7.462E-04 | 7.296E-04 | 0.000E+00 | 2.131E-06 | 4.648E-08 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 1.870E-09 | 5.035E-05 | 4.260E-06 | 7.080E-05 | 1.115E-04 | 1.084E-05 | 6.847E-06 | 0.000E+00 | 1.540E-08 | 6.887E-10 |
| Sessile filter feeder (TL-II) | 6.022E-08 | 2.031E-03 | 2.006E-04 | 3.773E-03 | 3.652E-03 | 3.235E-04 | 2.342E-04 | 0.000E+00 | 7.497E-07 | 8.135E-08 |
| Invertebrate Omnivore (TL-II) | 2.883E-07 | 2.235E-02 | 3.298E-03 | 1.060E-01 | 1.708E-01 | 1.202E-02 | 6.275E-03 | 0.000E+00 | 4.231E-06 | 5.249E-08 |
| Invertebrate Forager (TL-III) | 2.186E-06 | 8.904E-02 | 1.325E-02 | 4.464E-01 | 8.506E-01 | 6.702E-02 | 3.707E-02 | 0.000E+00 | 4.056E-05 | 2.689E-06 |
| Vertebrate Forager (TL-III) | 2.009E-07 | 1.406E-02 | 3.019E-03 | 1.767E-01 | 6.272E-01 | 6.326E-02 | 3.683E-02 | 0.000E+00 | 4.112E-05 | 1.369E-06 |
| Predator (TL-IV) | 1.112E-07 | 7.216E-03 | 1.703E-03 | 1.483E-01 | 1.143E+00 | 1.745E-01 | 1.116E-01 | 0.000E+00 | 1.199E-04 | 2.665E-06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 1.525E-08 | 5.992E-04 | 6.227E-05 | 1.232E-03 | 1.237E-03 | 1.132E-04 | 8.273E-05 | 0.000E+00 | 2.309E-07 | 1.645E-08 |
| Epifaunal invert. (TL-II) | 1.892E-08 | 1.114E-03 | 1.329E-04 | 3.008E-03 | 3.315E-03 | 3.177E-04 | 2.345E-04 | 0.000E+00 | 5.892E-07 | 3.231E-08 |
| Forager (TL-III) | 1.105E-08 | 6.101E-04 | 9.328E-05 | 2.819E-03 | 4.201E-03 | 3.928E-04 | 2.676E-04 | 0.000E+00 | 4.266E-07 | 9.788E-09 |
| Predator (TL-IV) | 9.779E-10 | 1.627E-04 | 4.287E-05 | 2.656E-03 | 8.002E-03 | 9.627E-04 | 6.798E-04 | 0.000E+00 | 8.739E-07 | 1.285E-08 |

**PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION**

**RISK ESTIMATES FOR Ex-Oriskany CV34 High-End Weight of PCB-Laden Materials**

**Supplemental Information**

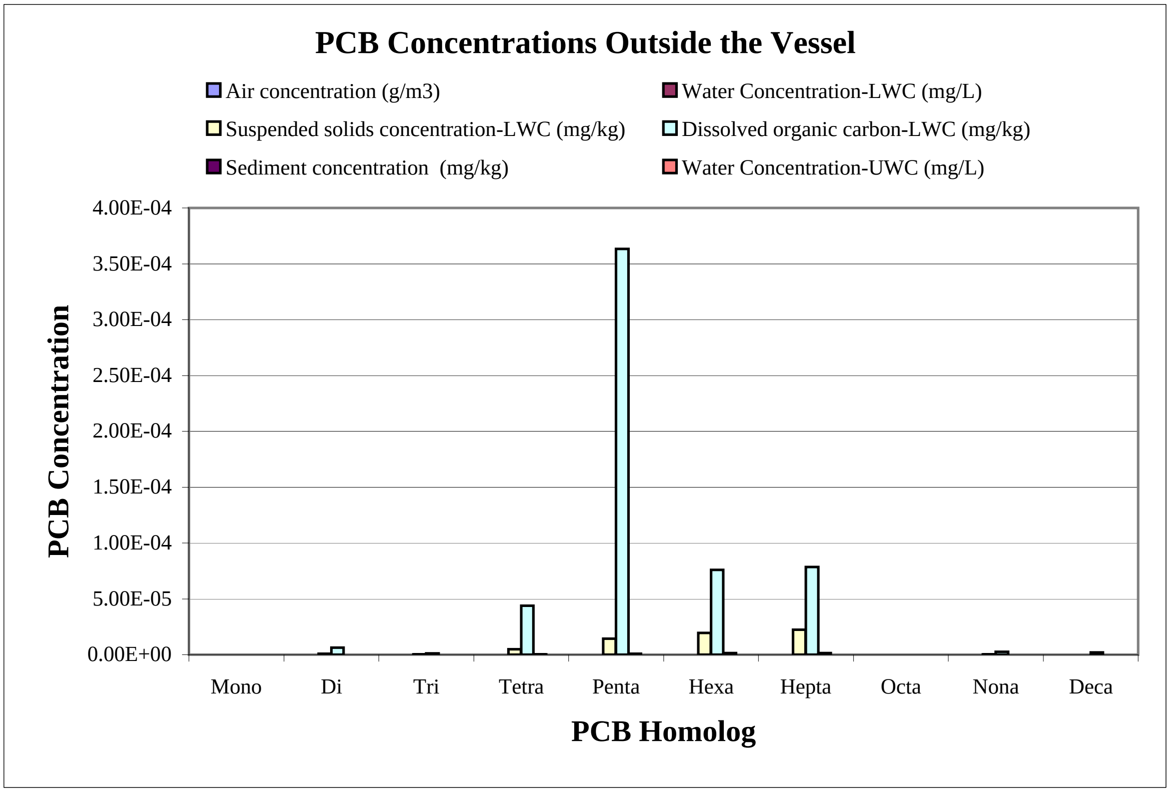
| Tissue Conc. (mg/kg-WW) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.382E-14 | 3.661E-10 | 2.946E-11 | 4.777E-10 | 6.275E-10 | 2.510E-11 | 1.028E-11 | 0.000E+00 | 4.633E-15 | 1.659E-17 | 1.536E-09 |
| Zooplankton (TL-II) | 2.234E-10 | 8.295E-06 | 8.368E-07 | 1.579E-05 | 1.567E-05 | 2.241E-06 | 1.994E-06 | 0.000E+00 | 9.996E-09 | 1.478E-09 | 4.484E-05 |
| Planktivore (TL-III) | 6.719E-11 | 9.348E-06 | 1.704E-06 | 6.233E-05 | 1.111E-04 | 1.748E-05 | 1.516E-05 | 0.000E+00 | 5.016E-08 | 2.640E-09 | 2.172E-04 |
| Piscivore (TL-IV) | 1.757E-11 | 1.648E-06 | 4.525E-07 | 3.641E-05 | 1.947E-04 | 5.242E-05 | 5.125E-05 | 0.000E+00 | 1.497E-07 | 3.265E-09 | 3.371E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 3.082E-11 | 8.297E-07 | 7.021E-08 | 1.167E-06 | 1.837E-06 | 1.787E-07 | 1.128E-07 | 0.000E+00 | 2.538E-10 | 1.135E-11 | 4.196E-06 |
| Sessile filter feeder (TL-II) | 5.420E-10 | 1.828E-05 | 1.806E-06 | 3.395E-05 | 3.287E-05 | 2.911E-06 | 2.108E-06 | 0.000E+00 | 6.748E-09 | 7.322E-10 | 9.194E-05 |
| Invertebrate Omnivore (TL-II) | 1.505E-08 | 1.167E-03 | 1.722E-04 | 5.534E-03 | 8.918E-03 | 6.275E-04 | 3.276E-04 | 0.000E+00 | 2.209E-07 | 2.740E-09 | 1.675E-02 |
| Invertebrate Forager (TL-III) | 5.217E-08 | 2.125E-03 | 3.163E-04 | 1.065E-02 | 2.030E-02 | 1.600E-03 | 8.848E-04 | 0.000E+00 | 9.682E-07 | 6.418E-08 | 3.588E-02 |
| Vertebrate Forager (TL-III) | 1.411E-08 | 9.880E-04 | 2.121E-04 | 1.241E-02 | 4.406E-02 | 4.444E-03 | 2.587E-03 | 0.000E+00 | 2.889E-06 | 9.615E-08 | 6.471E-02 |
| Predator (TL-IV) | 7.809E-09 | 5.069E-04 | 1.196E-04 | 1.042E-02 | 8.031E-02 | 1.226E-02 | 7.840E-03 | 0.000E+00 | 8.420E-06 | 1.872E-07 | 1.115E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 1.460E-10 | 5.733E-06 | 5.958E-07 | 1.179E-05 | 1.183E-05 | 1.083E-06 | 7.915E-07 | 0.000E+00 | 2.209E-09 | 1.574E-10 | 3.183E-05 |
| Epifaunal invert. (TL-II) | 2.037E-10 | 1.199E-05 | 1.431E-06 | 3.238E-05 | 3.568E-05 | 3.420E-06 | 2.525E-06 | 0.000E+00 | 6.343E-09 | 3.478E-10 | 8.744E-05 |
| Forager (TL-III) | 2.636E-10 | 1.456E-05 | 2.226E-06 | 6.728E-05 | 1.003E-04 | 9.375E-06 | 6.388E-06 | 0.000E+00 | 1.018E-08 | 2.336E-10 | 2.001E-04 |
| Predator (TL-IV) | 5.379E-11 | 8.946E-06 | 2.358E-06 | 1.461E-04 | 4.401E-04 | 5.295E-05 | 3.739E-05 | 0.000E+00 | 4.806E-08 | 7.065E-10 | 6.879E-04 |

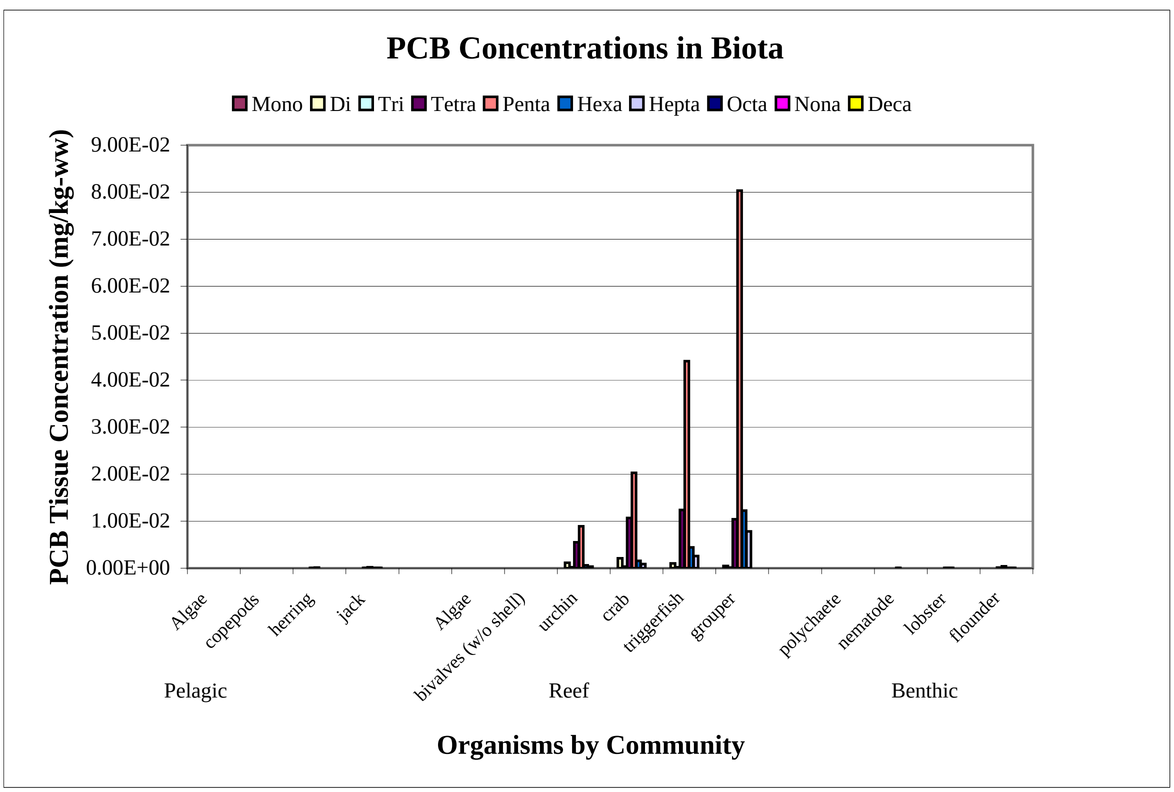
| BAFs (L/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Zooplankton (TL-II) | 1.347E+05 | 6.238E+05 | 7.437E+05 | 8.446E+05 | 5.321E+05 | 7.827E+05 | 1.103E+06 | 0.000E+00 | 2.458E+06 | 8.127E+06 |
| Planktivore (TL-III) | 7.602E+04 | 1.319E+06 | 2.842E+06 | 6.256E+06 | 7.082E+06 | 1.146E+07 | 1.575E+07 | 0.000E+00 | 2.317E+07 | 2.729E+07 |
| Piscivore (TL-IV) | 1.988E+04 | 2.325E+05 | 7.546E+05 | 3.654E+06 | 1.241E+07 | 3.439E+07 | 5.326E+07 | 0.000E+00 | 6.917E+07 | 3.375E+07 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Sessile filter feeder (TL-II) | 9.590E+05 | 4.034E+06 | 4.709E+06 | 5.328E+06 | 3.276E+06 | 2.983E+06 | 3.420E+06 | 0.000E+00 | 4.867E+06 | 1.181E+07 |
| Invertebrate Omnivore (TL-II) | 3.223E+04 | 3.116E+05 | 5.434E+05 | 1.051E+06 | 1.076E+06 | 7.781E+05 | 6.433E+05 | 0.000E+00 | 1.928E+05 | 5.351E+04 |
| Invertebrate Forager (TL-III) | 1.633E+05 | 8.295E+05 | 1.459E+06 | 2.957E+06 | 3.579E+06 | 2.899E+06 | 2.540E+06 | 0.000E+00 | 1.235E+06 | 1.831E+06 |
| Vertebrate Forager (TL-III) | 1.500E+04 | 1.310E+05 | 3.324E+05 | 1.170E+06 | 2.639E+06 | 2.736E+06 | 2.523E+06 | 0.000E+00 | 1.252E+06 | 9.322E+05 |
| Predator (TL-IV) | 1.243E+04 | 1.006E+05 | 2.806E+05 | 1.470E+06 | 7.197E+06 | 1.130E+07 | 1.144E+07 | 0.000E+00 | 5.462E+06 | 2.716E+06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.429E+05 | 1.190E+06 | 1.462E+06 | 1.740E+06 | 1.109E+06 | 1.044E+06 | 1.208E+06 | 0.000E+00 | 1.499E+06 | 2.389E+06 |
| Epifaunal invert. (TL-II) | 3.013E+05 | 2.213E+06 | 3.119E+06 | 4.248E+06 | 2.973E+06 | 2.930E+06 | 3.425E+06 | 0.000E+00 | 3.825E+06 | 4.691E+06 |
| Forager (TL-III) | 1.759E+05 | 1.212E+06 | 2.189E+06 | 3.981E+06 | 3.768E+06 | 3.622E+06 | 3.909E+06 | 0.000E+00 | 2.770E+06 | 1.421E+06 |
| Predator (TL-IV) | 1.557E+04 | 3.231E+05 | 1.006E+06 | 3.751E+06 | 7.177E+06 | 8.878E+06 | 9.928E+06 | 0.000E+00 | 5.673E+06 | 1.865E+06 |

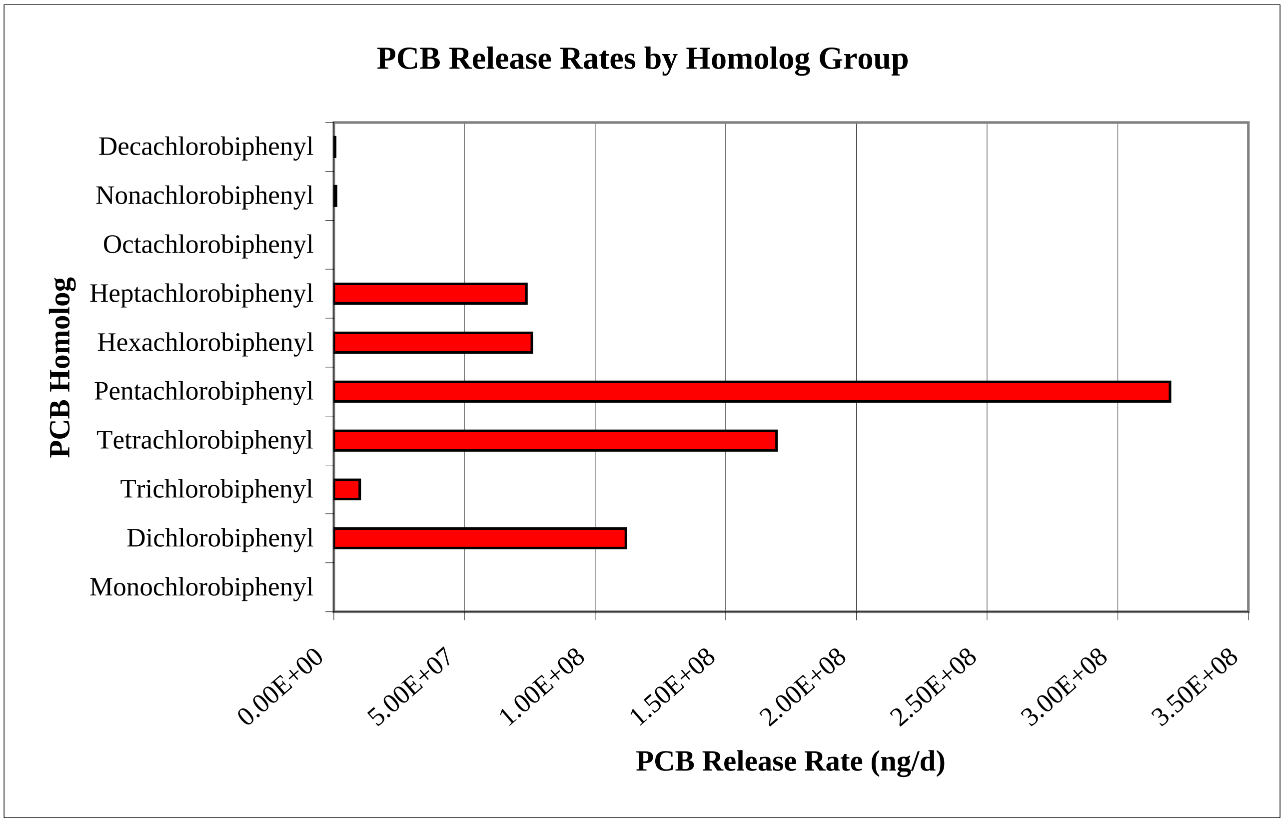
Notes:

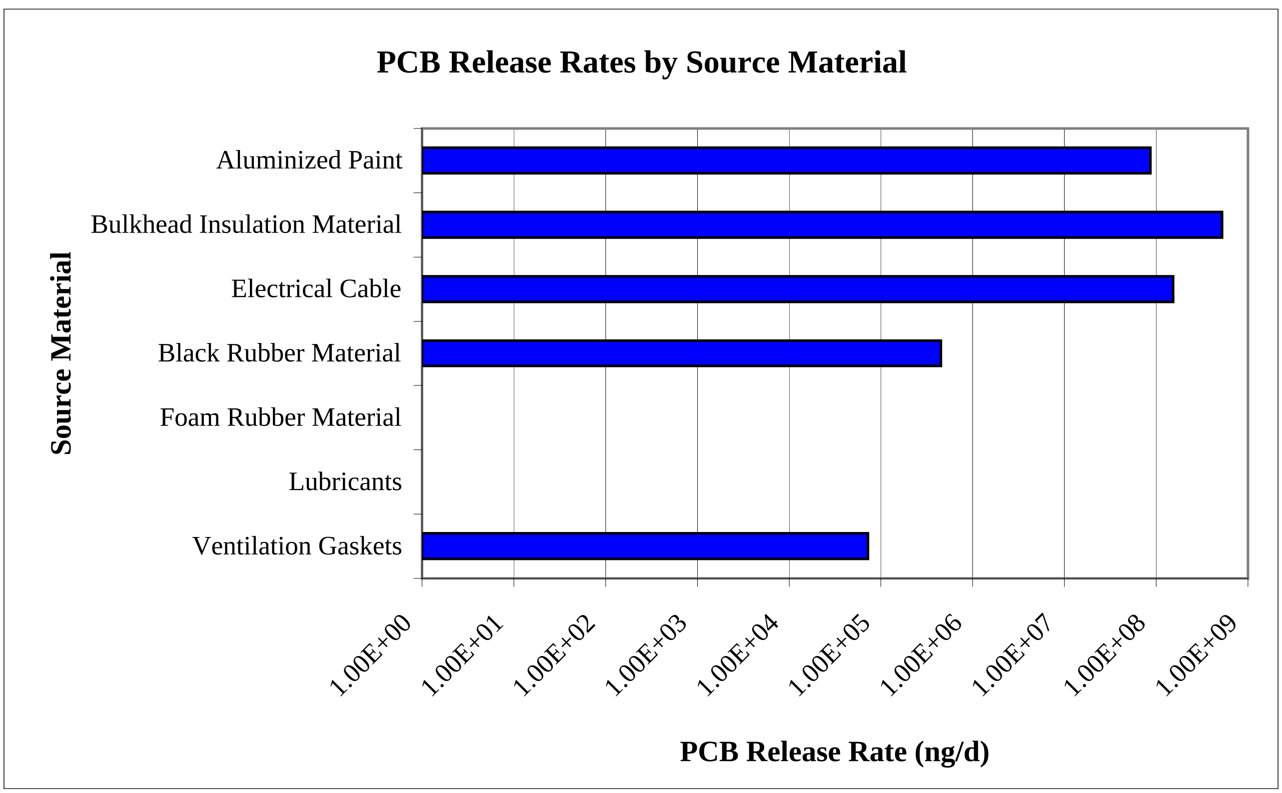
Kow = octanol to water partitioning coefficient, Koc = organic carbon partitioning coefficient, Kdoc = dissolved organic carbon partitioning coefficient

TL = trophic level, ww = wet weight


PCB Concentrations Outside the Vessel
Air concentration (g/m3)
Water Concentration-LWC (mg/L)
Suspended solids concentration-LWC (mg/kg)
Dissolved organic carbon-LWC (mg/kg)
Sediment concentration (mg/kg)
Water Concentration-UWC (mg/L)
PCB Concentration
4.00E-04
3.50E-04
3.00E-04
2.50E-04
2.00E-04
1.50E-04
1.00E-04
5.00E-05
0.00E+00
Mono
Di
Tri
Tetra
Penta
Hexa
Hepta
Octa
Nona
Deca
PCB Homolog


PCB Concentrations in Biota
Mono
Di
Tri
Tetra
Penta
Hexa
Hepta
Octa
Nona
Deca
PCB Tissue Concentration (mg/kg-ww)
9.00E-02
8.00E-02
7.00E-02
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
Algae
copepods
herring
jack
Algae
bivalves (w/o shell)
urchin
crab
triggerfish
grouper
polychaete
nematode
lobster
flounder
Pelagic
Reef
Benthic
Organisms by Community


PCB Release Rates by Homolog Group
PCB Homolog
Decachlorobiphenyl
Nonachlorobiphenyl
Octachlorobiphenyl
Heptachlorobiphenyl
Hexachlorobiphenyl
Pentachlorobiphenyl
Tetrachlorobiphenyl
Trichlorobiphenyl
Dichlorobiphenyl
Monochlorobiphenyl
0.00E+00
5.00E+07
1.00E+08
1.50E+08
2.00E+08
2.50E+08
3.00E+08
3.50E+08
PCB Release Rate (ng/d)


PCB Release Rates by Source Material
Source Material
Aluminized Paint
Bulkhead Insulation Material
Electrical Cable
Black Rubber Material
Foam Rubber Material
Lubricants
Ventilation Gaskets
1.00E+00
1.00E+01
1.00E+02
1.00E+03
1.00E+04
1.00E+05
1.00E+06
1.00E+07
1.00E+08
1.00E+09
PCB Release Rate (ng/d)

# APPENDIX I

## Response to EPA Comments on Ex-ORISKANY Artificial Reef Project:

**Prospective Risk Assessment Model (PRAM). June 2005 (Draft Final)**

| Comment No. | EPA's Comments | Responses |
|---|---|---|
| 1 | When PRAM version 1.3c was initially reviewed by EPA during Fall 2004, numerous and potentially serious shortcomings were identified regarding aspects of the model's conceptual formulation, technical documentation, identification of model assumptions and uncertainties, and quality assurance. The vast majority of these shortcomings have been addressed in PRAM version 1.4c. EPA believes that the U.S. Navy has developed a credible modeling tool that can be used to analyze the fate and transport, bioaccumulation, and potential impacts of PCBs that can be expected to be leached from a decommissioned naval vessel that has been remediated and deployed as an artificial reef under certain prescribed conditions. In particular, PRAM version 1.4c appears to be a credible tool for predicting expected steady-state or chronic levels of PCB contamination that are likely to occur from the artificial reefing of the ex-Oriskany off the coast of Pensacola, FL assuming no pre-existing PCB contamination. Although EPA Program and Regional Offices often use exposure and bioaccumulation modeling approaches different from those employed by PRAM, PRAM is nonetheless based on a sound conceptual framework and utilizes widely accepted scientific principles to make its predictions. | We acknowledge the comment that PRAM 1.4c is based on accepted scientific principles and is a credible modeling tool that can be used to predict PCB levels that are likely to occur from the artificial reefing of the ex-Oriskany off the coast of Pensacola, FL, assuming no pre-existing PCB contamination. |
| 2 | PRAM's conceptual framework as outlined in Sections 1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.2, and 3.3 is well done. PRAM's technical documentation in Sections 2.5, 2.6, and 2.7 is clear and comprehensive within the stated objectives and scales of resolution of the model. Issues related to the model uncertainties, mathematical sensitivities, and data quality are adequately discussed in Sections 2.3, 2.4, 4.1, and 4.9 and in Appendix F. | We acknowledge the comment that PRAM's conceptual framework and technical documentation in the referred sections are well done, clear and adequate. |
| 3 | EPA reviewers found PRAM model predictions to be credible and logically consistent. For example, PRAM predictions for the model option "*Estimate risk given kilograms of PCB-laden material*" using the default loadings and parameters corresponding to a 73% removal of PCB source materials from the ex-Oriskany seemed reasonable to EPA reviewers who focused on PRAM predictions for penta-PCB (i.e., the dominant PCB homologue on the ex-Oriskany and in most other environmental assessments) in triggerfish (i.e., reef/vessel vertebrate foragers) and groupers (i.e., reef/vessel predators). These biotic endpoints were selected not only because of their recreational importance but also because EPA reviewers had independent datasets to cross-check PRAM predictions against BASS/FGETS predictions. Whereas the predicted penta-PCB concentrations in the upper water column for ZOIs equal to 2 and 5 were 4.15E-7 and 3.81E-7 ng/L, respectively, the predicted concentrations in the lower water column for ZOIs equal to 2 and 5 were 1.92E-3 and 1.11E-3 ng/L, respectively. The four orders of magnitude difference between the upper and lower column concentrations seems realistic and corroborates EPA's original concern regarding the conceptual boundaries of PRAM version 1.3 and its associated ZOIs. Importantly, these predictions are properly | We appreciate that the reviewer conducted the separate analyses and demonstrated that PRAM predictions are reasonable and consistent with those reported in literature. |

| Comment No. | EPA's Comments | Responses |
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| | bounded by simple screening calculation. For example, assume that the prevailing current over the ex-Oriskany is always parallel to the length of the ship and has a constant velocity of 0.575 mph (= 22,228 m/d). The total flow of water over the PCB source material would therefore be approximately 5.28E10 L/day assuming a total water depth of 65m and a vessel beam wide of 120 feet. The emission rate of penta-PCB into this current volume predicted by PRAM is 3.20E8 ng/day. Dividing this emission rate by the estimated current volume yields a predicted "point" concentration equal to 6.06E-3 ng/L. If this calculation is repeated assuming that the prevailing current over the ex-Oriskany is always parallel to the beam of the ship, the estimated "point" concentration equals 0.818E-3 ng/L. PRAM's bioaccumulation predictions for this scenario are also credible. For example, the lipid-based BAFs predicted by PRAM for penta-PCBs in triggerfish and grouper are approximately 2.64E6 and 7.19E6, respectively. Because the lipid fraction of both of these species is assumed to be 0.07, these lipid-based BAFs are equivalent to $\log_{10}$ whole-fish BAFs equal to 5.27 and 5.70. Both of these latter values agree well with EPA's independent BASS/FGETS model predictions made for these species (i.e., $\log_{10}$ BAF ≈ 5.32 for triggerfish and $\log_{10}$ BAF ≈ 5.68 for gag grouper). Whereas the whole-body concentrations of penta-PCB for triggerfish and groupers in a ZOI of 2 are 0.0446 and 0.0812 mg/kg, respectively, whole-body concentrations for triggerfish and groupers in a ZOI of 5 are 0.0441 and 0.0803 mg/kg, respectively. | |
| 4 | Although EPA finds PRAM model predictions to be credible, EPA is nevertheless concerned with the fact that PRAM currently assumes that the reefed ship of concern is the only source of PCBs that must be considered. Currently, users cannot evaluate the very real scenario of reefing a ship in waters that have pre-existing PCB contamination. For example, what if this reef were to be sunk off the coast of New Jersey or in one of the Great Lakes. Even though the risk associated with sinking the vessel at a pristine site may be acceptable, sinking it at a site that already has PCBs at the site may exceed an acceptable risk. This is a critical shortcoming of PRAM 1.4c that should be corrected in a future version. | The Navy concurs that the incorporation of ambient PCB levels would make the model a more comprehensive risk assessment tool and such capability may be considered for a future version of PRAM to support the National Permit. |
| 5 | EPA believes the some of PRAM could be better documented. For example, PRAM could use more up-to-date QSAR equations to derive estimates for several physical/chemicals properties of PCBs (e.g., Koc (Page 2-13), Kdoc (Page 2-14), and water solubility (Page 2-32)). PRAM currently uses freshwater solubilities of PCBs rather than (the more appropriate) sea water solubilities of PCBs to estimate Henry's Law Constants (Page 2-32). It was still unclear to some EPA reviewers how PRAM justifies the use of information, data, and models for fresh water systems in a deep water marine system. | The Navy appreciates EPA's continued support of QSARs in PRAM. The QSARs utilized in PRAM will be considered for updating reefing of future vessels, once data supporting the update becomes available.<br><br>To the best of our knowledge, PCB solubility data in freshwater are relatively abundant whereas solubility data in salt water are scarce. Furthermore, use of solubility for freshwater, which is generally larger than that for salt water, is more conservative since more dissolved PCBs would be available for uptake and bioaccumulation. |

| Comment No. | EPA's Comments | Responses |
|---|---|---|
| 6 | EPA believes that the Navy should clearly state that the PRAM risk assessment tool was specifically developed because it may not be possible to remove all **<u>regulated PCBs</u>** on the vessel. PRAM was not merely developed "to assess the potential risks, to human health and the environment that could be associated with deploying decommissioned ships as artificial reefs." Statements such as that made on Page 1-5 under section 1.2.3, 2nd paragraph, 1st sentence, should be revised as:<br><br>"The PRAM was developed in order to be able to assess the potential risks, to human health and the environment, that could be associated with leaving PCBs of greater than or equal to 50ppm on decommissioned ships that will be deployed as artificial reefs." | The statement on Page 1-5 will be revised as requested. |
| 7 | General Editorial Comment: A consistent units notation should be used throughout the report. For example, the units of fugacity capacity appear as<br><br>mols / m3 * Pa page 2-30<br><br>while the units of the Henry's Law Constant, the reciprocal of fugacity capacity, appear as<br><br>Equation (12)<br><br>Pa - m3/mol pages 2-31 and 2-33<br><br>A simple, unambiguous power notation should be used throughout the report. For example, the units of fugacity capacity should be reported consistently as [mols C $Pa^{-1} \cdot m^{-3}$] or some variation thereof. Similarly, the units of the Henry's Law Constant should be reported consistently as [$Pa \cdot m^{3}$ C $mol^{-1}$] or some variation thereof.<br><br>A consistent notation should also be adopted to designate the type of mass (or other fundamental unit) that is being reference. For example, in most places within the text this is done using subscripts (e.g., mgPCB or kglp). However, in other place subscripts use is abandoned or inconsistently applied (e.g., gO2/gC or gO2/kglp-day).<br><br>Finally, "day" as a unit should be consistently spelled out or consistently abbreviated as "d." | All unit notations throughout the document will be checked for consistency. |

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| Comment No. | **EPA's Comments** | **Responses** |
| **SPECIFIC COMMENTS** | | |
| 1 | Acknowledgement: Under the Technical Working Group participants, EPA Headquarters: Laura Johnson noted that she is not a Dr. | Ms. Johnson's title will be changed. |
| 2 | Dedication: EPA believes that it is entirely fitting and appropriate for the Navy to dedicate this document to Mark Goodrich. | Comment acknowledged. |
| 3 | Pages iii -v: Page numbers for Figures, Tables, and Appendices should be given. | Tables, Figures and Appendices are presented in separate sections, in sequential order, and therefore have no page numbers to reference in the Table of Contents. |
| 4 | Page 1-1, Section 1.1 2nd paragraph: The stated "problem" should also include an ecological component. | Although PRAM outputs are currently being used as inputs to an ecological risk assessment, the original problem outlined in Section 1.1 accurately describes the genesis of PRAM. The documentation will be revised to reflect the evolution of PRAM into a tool useful for predicting risks to both human health and the environment. The following sentence will be added to the end of the 2nd paragraph of Section 1.1:<br><br>"Since the adoption of this initial problem statement, PRAM has also been utilized to determine the ecological risks associated with residual PCBs onboard a sunken-vessel artificial reef." |
| 5 | Page 1-1, footnote #3: Although the Office of Water was recognized in the Acknowledgements as having participated on the Technical Workgroup, they are not acknowledged elsewhere. Please insert OW into the list of participants in foot note #3. Also delete SINKEX from this and all documents. With these edits the third footnote should be read as follows:<br><br>The REEFEX interagency Technical Working Group (TWG) was comprised of U.S. Environmental Protection Agency (USEPA) representatives from the Office of Pollution Prevention and Toxics (USEPA OPPT) and the Office of Water (USEPA OW), Navy representatives, and contractors to the Navy. | The referenced footnote will be revised as follows:<br>The REEFEX interagency Technical Working Group (TWG) was comprised of representatives of the U.S. Environmental Protection Agency (USEPA) Region 4, the Office of Pollution Prevention and Toxics (USEPA OPPT), the Office of Water (USEPA OW), the State of Florida (Florida Fish and Wildlife Commission, Escambia County Marine Resources Division), Navy representatives, and contractors to the Navy.<br><br>References to SINKEX will be deleted in all locations. |
| 6 | Page 1-2, 1st full paragraph, 2nd sentence: Please delete SINKEX. Although some members of the TWG for the ex-Oriskany project do overlap with those who have participated on SINKEX workgroups in the past, the two workgroups were established for completely different projects. Pairing together as presented in this document gives a very different perception. | The reference to SINKEX will be deleted in the referenced location. |
| 7 | Page 1-2, 1st full paragraph, 7th and 13th sentences: These sentences refer to "external peer review" and "peer review," respectively. Does either of these reviews actually meet the criteria of a peer review? Perhaps they could just say "review." | The terms "external peer review" and "peer review" will be changed to "review." |
| 8 | Page 1-2, footnote #4: The vessel information presented does not give a clear | The year of vessel construction will be added to the referenced footnote. |

| Comment No. | EPA's Comments | Responses |
|---|---|---|
| | picture of the concerns associated with this vessel. Putting the year of decommissioning is not as important as the year the vessel was built – which dictates the types of materials that were initially used on the vessel. | |
| 9 | Page 1-7: The citation *Mackay (2001)* is missing from the References in Section 5. | The following citation will be added to the reference section:<br><br>Mackay, D. 2001. "Multimedia Environmental Models: The Fugacity Approach – Second Edition," Lewis Publishers, Boca Raton, pp.1-261. |
| 10 | Page 1-8: The citation *Exposure Factors Handbook (1997)* should be *Exposure Factors Handbook (USEPA, 1997)*. | The citation will be changed to: *Exposure Factors Handbook (USEPA, 1997)*. |
| 11 | Page 1-9, Section 1.2.6, all three bullets: Because the Navy states that PRAM uses empirical data from the three significant sources (listed as the bullets), these documents are as important as the "Primary Deliverables." For this reason, a thorough review of these documents should take place as well. | The Navy understands that these three documents (CACI report, Leach Rate Study and Fish Consumption Survey) are important to the review of PRAM, therefore they were included in the package submitted to EPA and additional review. |
| 12 | Page 1-13, Section 1.4.2, 1st paragraph, 1st sentence: This paragraph could provide more detail regarding the Navy's project. This could easily be addressed in the first sentence by stating exactly what the Navy would like to do … to leave approximately 722 pounds of regulated PCBs on the ex-Oriskany at the time of its deployment to be an artificial reef. Does this document ever state what the Navy plans to do? | The first sentence of the paragraph will be changed to read:<br><br>"Human health and ecological risk assessments associated with using the vessel as an artificial reef must be conducted before the ex-ORISKANY is utilized as an artificial reef with approximately 722 pounds of regulated PCBs onboard at the time of its reefing." |
| 13 | Page 1-14: The text pertaining to the Project Manager/Project Coordinator contact information is incorrect. The email address for Elizabeth Freese is incorrect (it should read elizabeth.freese@navy.mil), and is Washington Navy Yard, D.C. really a city? | Washington Navy Yard, D.C. is the correct mailing address, but the email address will be changed to: *elizabeth.freese@navy.mil*. |
| 14 | Page 2-2, Last sentence: The goal of PRAM is to analyze the potential risk of leaving regulated PCBs on the vessel. This significant point is left out. The last sentence could be re-written as follows:<br><br>"The goal is to provide decision makers with additional information about the potential exposure conditions and human health risks associated with the ex-Oriskany artificial reef so they can determine whether the artificial reef would present an unacceptable risk to human health or the environment." | The sentence will be rewritten as requested and will include mentioning of ecorisk support in accordance with specific comment #4 above. |
| 15 | Page 2-8: The reported units for conductance, i.e., (mol/day), in the third line from the bottom of the Page are incorrect. The correct units are (m/day). | The referenced units will be changed to: *m/day*. |
| 16 | Page 2-8 and elsewhere: The citation *(USEPA, 1982)* is missing from the References in Section 5. Is this citation supposed to be for the EXAMS fate and transport model? | The reference is indeed for the EXAMS fate and transport model, which is referenced on page 5-8 with other USEPA references. The reference will be revised as follows to avoid further confusion:<br><br>USEPA (United State Environmental Protection Agency). 1982. Exposure Analysis Modeling System (EXAMS): User Manual and System Documentation. Office of Research and Development, Environmental |

| Comment No. | EPA's Comments | Responses |
|---|---|---|
| | | Research Laboratory, Athens, GA., EPA-600/3-82-023 |
| 17 | Page 2-9: In the explanation the parameters/variables of Equation (3), the variables Mi and Mj should be subscripted. | The referenced variables will be changed to: $M_i$ and $M_j$. |
| 18 | Page 2-14: The citation *(Kleinow and Goodrich, 1994)* is missing from the References in Section 5. However, the references do list *Kleinow, K.M. and M.S. Goodrich. 1993*. | The correct date for the citation is 1993. The narrative citation will be revised. |
| 19 | Page 2-15: By standard mathematical conventions, Log10 should be reported either as $\mathrm{Log}_{10}$ or as simply Log. | References to the base 10 logarithm throughout the document will be changed to: $Log_{10}$. |

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| Comment No. | **EPA's Comments** | **Responses** |
| 20 | Page 2-15, first paragraph: There is an apparent inconsistency in the PRAM documentation relative to potential degradation of PCBs. In particular, is the residence time in the sunken vessel sufficient to allow degradation of PCBs? | The last sentence of this paragraph will be deleted. The abiotic PRAM module allows input of biodegradation rates. |
| 21 | Pages 2-15 to 2-27: Sections 2.3 seem out of place to some reviewers. EPA suggests making these sections the last two sections in Chapter 2 since their content depends directly on the model descriptions in the current Sections 2.5, 2.6, and 2.7. | Sections 2.3 and 2.4 will be moved to the end of Section 2. |
| 22 | Pages 2-38 and 2-39, Equations (25) – (28): The subscripts on the parameters φ should be *DOC* not *DC*. | The subscripts will be changed to *DOC* in Equations (25), (26), and (28). |
| 23 | Page 2-46, last paragraph: Incorrect units are reported for Henry's Law Constant. | The units reported for Henry's Law Constant will be stated as Pa – $M^3$/mol. |
| 24 | Page 2-50: The citation *Jury et al. (1983)* is missing from the References in Section 5. However, the references do list *Jury 1983*. | The citation in the reference section will be revised to read:<br><br>Jury, W., W. Spencer, and W. Farmer. 1983. Behavior assessment model for trace organics in soil: I. Model description. Journal of Environmental Quality. 12:558-564. |
| 25 | Page 2-69, Section 2.6.2.5, second paragraph: Should there be more consideration given to people eating crabs and lobsters (why should sports fish be the only focus)? The Navy does state that people would eat them (also see Page 2-75, 2nd paragraph, 2nd sentence). | The Navy had intended to imply crabs and lobsters. The clause (primarily top predator fish) will be revised to (primarily top predators – finfish and shellfish). |
| 26 | Page 2-72, Section 2.6.3.2, 1st paragraph, 3rd sentence: The sentence does not seem to make sense. Should "these waters" be replaced with "these algae"? | Either "these waters" or "these algae" would be correct since both the algae and the waters to which they are exposed are below the pycnocline. To avoid further confusion, the third and fourth sentences of the referenced paragraph will be combined into the following sentence:<br><br>"Since the top portion of the ship is predicted to be below the pycnocline, the attached algae have been assumed to be exposed solely to the lower water column (Table 6)." |
| 27 | Page 2-85: The citation *Thurston and Gehrke, 1993* is misplaced from the References in Section 5. | The following citation will be added to the references:<br><br>Thurston, R.V. and P.C. Gehrke, 1993. Respiratory oxygen requirements of fishes: description of OXYREF, a data file based on test results reported in the published literature. p. 95-108. In R.C. Russo & R.V. Thurston (eds.) Fish Physiology, Toxicology, and Water Quality Management. Proceedings of an International Symposium, Sacramento, California, USA, September 18-19, 1990. US Environmental Protection Agency EPA/600/R-93/157. |
| 28 | Page 2-86, Equation (107): The units reported for the respiration rate r are technically incorrect. Although the units are reported to be [1/day], they are in fact [$g_{O2}Cg_{ww}^{-1}Cday^{-1}$]. Note that the units of the following equation, Equation (108), are correct and follow directly from this comment/correction. | The units presented in Equation 107 are technically correct and consistent with those used in the literature for a metabolic rate, though some authors cite the rate as $g_{ww}/g_{ww}$-day. It is critical to maintain the distinction between a metabolic rate and a direct rate since the metabolic rate does not include the mass of oxygen taken up by the organism. Equation 108 outlines the conversion to a direct rate of oxygen consumption and includes assumed |

| Comment No. | EPA's Comments | Responses |
|---|---|---|
| | | ratios between oxygen and carbon and between carbon and dry weight. |
| 29 | Page 2-90: The citation *(Kleinow and Goodrich, 1992)* is missing from the References in Section 5. However, the references do list *Kleinow, K.M. and M.S. Goodrich. 1993*. | The correct date for the citation is 1993. The narrative citation will be revised. |
| 30 | Page 2-93, Equation (123): This equation is the calibration equation suggested by Barber (2003) for the Gobas and Mackay uptake model; see Equation (107) and Table 14/Model 5 in Barber (2003). If the intent of the authors is to calibrate PRAM Equations (118) – (122) using the results of Barber (2003), the authors should use the results reported for the Norstrom-Neely-Thomann model in Table 14 of Barber (2003). In this case the desired calibration equation would be something like<br>$Ku_{\text{calibrated}} = 3.87\ Ku_{\text{Equation (118)}}^{0.854}$ | The intent of the authors was to respond to USEPA's (Dr. M. Craig Barber's) comment dated September 15, 2004. The Response to USEPA's Comment Report was submitted in Appendix K of the Human Health Risk Assessment (see Response to Comment 1.1). Dr. Barber requested that the previously used algorithm in PRAM to estimate gill uptake and excretion be either calibrated or replaced. The authors chose to replace the algorithm. Dr. Barber's comment did not specify a preference for a specific replacement algorithm. The authors do not intend to further replace the algorithm to support evaluation of the ex-ORISKANY for deployment as an artificial reef. The Navy will consider gill uptake and excretion algorithm replacement as a future upgrade to PRAM to support the National Permit. |

| Comment No. | EPA's Comments | Responses |
|---|---|---|
| 31 | Page 2-95: The citation *Gobas and Mackay (1987)* is missing from the References in Section 5. | The following citation will be added to the Reference section:<br><br>Gobas, F.A.P.C. and Mackay, D. 1987. Dynamics of Hydrophobic Organic Chemical Bioconcentration in Fish. Environ. Toxicol. Chem. 6, 495-504. |
| 32 | Page 3-3: More appropriate terms are "volatilize" and "wind" rather than "volatize" and "wind current," respectively. | The listed corrections will be made to the PRAM documentation. |
| 33 | Page 5-4: The correct spelling of "W. Brock Meely" in the references is "W. Brock Neely." | The listed correction will be made to the PRAM documentation. |
| **GENERAL COMMENTS BY SAB** | | |
| 1 | The PRAM is well documented for the bioaccumulation and human health modules, but there are gaps in the discussion, presentation of algorithms, and presentation of physical transfer processes that are critically missing from the fate and transport module. This should include a good explanation of why a fugacity-based model was selected for use in a very dynamic water environment, a better description of the transfer functions between the four water components, better documentation of the parameters selected for the model, and an expanded discussion of the uncertainty associated with the PRAM output. | Fugacity-based models are based on the assumption that contaminants in the environment, including water column, sediments and organic-sorption particles, reach ultimate balance, chemically. The REEFEX TWG agreed that the results provided by the fugacity model were adequate to support the human health and ecological risk assessments for the ex-ORISKANY. The PRAM model adopts the Level III fugacity approach, which predicts steady-state, non-equilibrium conditions in all the media. The algorithms and presentation of transfer functions in the model documentation evolve from Level I and Level II, which primarily dictate conservation of mass under the mass balance assumption. The details of these algorithms and their evolutions can be found in the published references attached in the documentation. Before finalizing PRAM documentation, we will conduct a thorough review of the document to make sure that parameters selected for the model are referenced or documented. Where appropriate, in response to specific comments on PRAM, we will expand our discussion of the uncertainty section to provide a better understanding of the strengths and limitations of the model. |

| Comment No. | EPA's Comments | Responses |
|---|---|---|
| 3.1 | There are some inconsistencies which state whether the PRAM is applied to human health and/or the environment. This should be clearer. | PRAM has built-in modules to estimate PCB concentrations in abiotic and biotic media, and has a built-in human health risk characterization module to estimate human health carcinogenic risk and non-carcinogenic hazard. PRAM does not have a built-in ecological risk assessment module, but its output from the abiotic and biotic/food-web modules can be used, as the Ex-ORISKANY study does, to characterize risks to ecological receptors. More details follow:<br><br>The abiotic module in PRAM is a fate and transport model based on the fugacity approach. The module calculates concentrations of PCBs in the near reef environment (water and sediment). To support an ecological risk assessment, the PRAM-calculated abiotic concentrations can be compared to published benchmark concentrations related to marine organism concentrations for PCBs in marine environments.<br><br>The biotic module in PRAM is a food-web uptake-bioaccumulation model that calculates bioaccumulation factors (BAFs) and bioconcentration factors (BCFs) for each organism in the food web as well as PCB tissue concentrations. To support an ecological risk assessment, the PRAM-calculated BAFs and BCFs can be compared to published benchmark values for marine environments.<br><br>The human health risk characterization module in PRAM calculates incremental risks to human health from the consumption of fish associated with the artificial reef. To support a human health risk assessment, the PRAM-calculated human health carcinogenic risks and hazard indices can be compared to EPA acceptable points of departure or benchmarks for assessment of incremental human health impacts.<br><br>The text in the PRAM documentation will be revised to provide the above information. |
| 3.2 | Microorganisms are left out of the food web. | PRAM does not currently include a discrete or explicit microbial uptake and degradation pathway. These processes will be considered for inclusion in the next version of PRAM. However, the microorganisms were not totally left out of the food web, they have been incorporated into the suspended solids and sediment compartments as follows. The abiotic module in PRAM calculates PCB concentrations in suspended solids for each water compartment (upper water column, lower water column, and vessel interior) and PCB concentrations in the sediment. The suspended solids and sediments have a fraction organic carbon value assigned. This fraction organic carbon is assumed to represent both living and dead microorganisms. The organic |

| Comment No. | EPA's Comments | Responses |
|---|---|---|
| | | carbon fractions for these media are assigned caloric energy values providing food for higher trophic level organisms in the food web. |
| 3.3 | The existence of a pycnocline to bound the lower/upper water compartments in PRAM, and in the TDM, appears to have been invoked in order to provide for a conservative analysis; i.e., a smaller water volume for the initial distribution of released PCBs. This should be stated explicitly. Pycnoclines are likely more dynamic and variable in reality than described and used in PRAM. | The pycnocline is known to exist in the vicinity of the selected reefing location for the ex-ORISKANY. The REEFEX TWG determined that the model would be more technically complete if the pycnocline was included as a flux boundary between the upper and lower water columns. PRAM is a steady-state model, and an average annual depth for the pycnocline was determined based on both reported data and consultation with local divers. This average depth is included in the revised PRAM model per the negotiated agreement between the EPA and Navy.<br><br>The Navy acknowledges the seasonal variability of the pycnocline's location, and will be adding a discussion of this variability. This discussion will reference data from NOAA that indicates that the pycnocline is shallow in the summer, deepens during the fall months, and disintegrates or goes deeper in the winter months. The text will also be expanded to discuss how seasonal variability in the pycnocline, upwelling in the vicinity of the ship or weather events such as hurricanes may potentially disrupt the pycnocline and impact the PRAM-predicted health risks. |
| 6.1 | The TDM (and the PRAM) need to be validated before their usefulness for other applications can be confirmed. Thus there is a need for a validation protocol to be specified for the PRAM, one that takes into account that such "higher order" models require a redefined approach to validation. Since data sets that stress all aspects of the model do not, and are unlikely to exist, or are prohibitively expensive, the usual approach of comparing output with data is not practical. The Panel recommends following the protocol developed by Beck at the University of Georgia. | We agree with the reviewers' comments; full scale model calibration/verification is extremely difficult, if not impossible. While there have been various published reports/papers discussing model calibration/verification, most of them are on the conceptual aspect of this issue, including the paper by Beck at the University of Georgia, recommended by the panel. There have been no widely-accepted protocols for model calibration/verification. While PRAM has not been calibrated or verified, the model compiles and adopts many algorithms and bioaccumulation models commonly used by EPA which have been validated and published in peer-reviewed journals. The validation process and data to be collected from the ex-ORISKANY to be used for that purpose will be discussed within the Science Workgroup for the National Permit |

# APPENDIX J

## Response to EPA's December 2, 2005 Second Round of Comments on Ex-ORISKANY Artificial Reef Project: Prospective Risk Assessment Model (PRAM). June 2005 (Draft Final).

| Comment | Comment | Responses |
|---|---|---|
| General Comment No. 5 | The Navy responded to Comment 5 by saying they will update the QSARs for physical/chemical properties for future vessels, but by omission of its mention, apparently not for ex-Oriskany. It is not clear why, since the suggested updates were minor. | We agree that the updates are minor, but the scarcity of data for sea water-based QSARs will require additional research and agency coordination that cannot be completed prior to issuance of final documents for the ex-Oriskany. Given the short time frame available for completing the evaluation of risks associated with the ex-Oriskany, including the utilization of PRAM outputs in the ERA and HHRA, the Navy believes the best course of action is to update QSARs in future versions of PRAM when relevant data becomes available. The research and incorporation of updated QSARs will be conducted in consultation with the National Permit Workgroup, which will make the final decision of which QSARs to utilize in PRAM.<br><br>It should be noted that the QSARs in the current version of PRAM use solubility data for freshwater, which is more conservative for risk predictions for ERA and HHRA, since PCBs are more soluble in freshwater than saltwater, and thus more dissolved PCBs are available for uptake and bioaccumulation.<br><br>Comment will be deferred for resolution in the National Approval discussion unless stated otherwise |

# Appendix K: An Evaluation of the Prospective Risk Assessment Model (PRAM Version 1.4c) to Predict the Bioaccumulation of PCBs in the Food Chain of a Sunken Ship Artificial Reef

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## Introduction

The output from the TDM and PRAM models were evaluated to the extent possible to identify any biases and verify the reliability of the results. Because the models are simulating future conditions, no field data are readily available to validate the model output. However model performance was evaluated to assure that the model results were internally consistent, that the predictions of the model conformed to the physiochemical properties being modeled, and that results produced by the model were consistent with similar studies reported in the literature. Critical in this evaluation was to judge whether the model could reliably perform the task of predicting PCB bioaccumulation in the reef environment. This provides an important quality assurance that PRAM can be used to support the risk assessment (Beck et al. 1997, Chen and Beck 1999, Beck and Chen 2000).

## Model Evaluation

Model performance was evaluated to assure that the model results are internally consistent (the same set of inputs gives the same set of results), that the predictions of the model conform with the physiochemical properties being modeled, and that results produced by the model were consistent with similar studies reported in the literature.

The main quality control check on the TDM model (NEHC/SSC-SD 2005b, 2006b) was to assure that mass balance was accounted for within the model. Subroutines were incorporated into the model to check for conservation of mass and the simulation results were evaluated to determine whether the results were reasonable approximations of natural phenomena. Additionally, Dr. Keith Little (RTI, International, Research Triangle Park, NC) conducted a detailed third party peer review of the model code and output to assure that model structure, algorithms, kinetics, and simulated output conformed to accepted conventions and standards with satisfactory results (Dr. Keith Little, RTI, International, personal communication). Dr. Little also performed a similar review of PRAM 1.4, which also met with satisfactory results (Dr. Keith Little, RTI, International, personal communication).

The PRAM output was compared to literature values to evaluate the validity and accuracy of the biological uptake and trophic transfer algorithms. The results of this evaluation are provided below.

**Zone of Influence**

Initial runs using PRAM 1.4c (NEHC/SSC-SD 2005a, 2006a) were conducted to verify model stability and accuracy by assuring that the model provided the same set of results for the same set of inputs and verifying that the model was functioning properly. A series of PRAM runs were conducted by keeping all parameters constant using the default values and varying the ZOI parameter from 1, 2, 3, 4, 5, and 10 (see Appendix K.2 PRAM Output for Varying ZOI). Changing the ZOI only changes the physical dimensions of the model – the volume of air, water, and sediment included in the model (Figure K- 1) – all the physical, chemical, and bioenergetic equations and food chain linkages remain the same. Only the volume of water in the vessel's interior remains constant at $5.38 \times 10^4$ $m^3$ (14,214,003 gallons). The ZOI represents a column of water directly around the ship. At ZOI=1 the water column boundary is defined by the hull of the ship, there is no sediment compartment,[1] the lower water column is the water surrounding the ship which extends up to the pycnocline and is about 3 times larger (range 2.87 to 3.29 for ZOI=1 to 10) than the upper water column and about 4.5 times larger (range 4.31 to 4.83 for ZOI=1 to 10) than the overlying air compartment. The interior of the vessel was interpreted as the interior compartments of ship, the spaces separated from the water column by bulkheads, passageways, and hatches. The hangar-deck and other spaces that are open to ocean currents were considered to be the exterior of the ship. These are the primary surfaces that will be used as substrate by colonizing reef organisms where they will be exposed to PCB concentrations in the lower water column.

For purposes of evaluating ecological effects from water column exposure the bulk water concentration ($C_{BW}$) was calculated as:

$$C_{BW} = C_{W\_FD} + TSS \times C_{TSS} + DOC \times C_{DOC} \text{ [mg/L]} \qquad [1]$$

where

$C_{W\_FD}$ = Freely dissolved concentration in water [mg/L]
$C_{TSS}$ = Concentration in suspended sediments [mg/Kg]
$C_{DOC}$ = Concentration in dissolved organic carbon [mg/Kg]
TSS = The amount of suspended sediment = 10 [mg/L]
DOC = The amount of dissolved organic matter = 0.6 [mg/L]

Based on the default inputs for PRAM (Appendix K.2.2 PRAM Default Parameters (ZOI =2 )) changing the ZOI from 1 to 10 resulted in about a 40% to 75% decrease in the concentration of the lower water column and pore water, a 10% to 20% decrease in the upper water column concentration, and the interior vessel water concentration remained constant at $6.7 \times 10^{-4}$ mg/L (Figure K- 2). The interior vessel water was about 2-3 orders of magnitude higher than the concentration of the lower water column, 5 orders of magnitude higher than the concentrations in sediment pore water, and 6 orders of magnitude higher than the concentrations predicted for the upper water column.

Total PCB concentrations in the sediment also decreased 40-80% as a function of ZOI, with the greatest decrease occurring between ZOI=1 and ZOI=2 when the sediment bed is added to the model (Figure K- 3, NEHC/SSC-SD 2005a, 2006a). Slight increases in the concentration

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[1] Although the sediment compartment is undefined for ZOI=1 PRAM still provides results for sediment and porewater concentrations, so it was assumed that this represented sediments "very "close to the ship, e.g. ≤ 15 m from the ship, such as sediment that could accumulate on the flight or hanger decks.

of Total PCB in the air compartment were modeled as a function of ZOI (Figure K- 4). This was probably due to the effect of increasing the boundary between air and water, which resulted in an increase in the mass transfer of PCBs between the upper water column and the overlying air as the ZOI was increased.

The change in concentration of Total PCB modeled by PRAM in food chains of the pelagic, benthic, and reef communities as a function of changes in the ZOI is shown in Figure K-5 and summarized in Table K - 1. The concentration of Total PCB modeled in the pelagic and benthic food chains decreased in proportion to the 40-75% reduction observed for the lower water column and pore water concentrations. However, the upper trophic levels of the reef community remained relatively constant, decreasing by less than 2-4% over the range of ZOIs used. This is because the accumulation of PCBs in the reef community is controlled by exposure to interior vessel water that does not change as a function of ZOI.

**Bioaccumulation Factor**

The lipid-based bioaccumulation factor ($BAF_{LIPID}$) is defined as the lipid based concentration of a -chemical ($C_{Lipid}$) in a organism divided by the freely dissolved concentration in the water ($C_{W\_FD}$):

$$BAF_{LIPID} = C_{Lipid} / C_{W\_FD} \quad [2]$$

The $BAF_{LIPID}$ represents the amount of chemical bioaccumulated from exposure to water and food (Fisk et al. 1998, 2001). In PRAM the $BAF_{LIPID}$ is calculated using the weighted average of the steady state water concentration in each compartment of the model that the organism is exposed to (interior water, lower water column, upper water column, and pore water, NEHC/SSC-SD 2005a, p2-84). Since changing the ZOI only affects the physical dimensions of the model, varying the ZOI has the effect of reduce the steady concentrations of the abiotic compartments because the size of the compartments are changed (NEHC/SSC-SD 2005a, p2-10). Therefore, changing the ZOI should not appreciably the $BAF_{LIPID}$s predicted by the model because PCB concentrations in target tissues are expected to decrease in proportion to that of all environmental media (biotic as well as abiotic) as the dilution volume of the ZOI changes.

The $BAF_{LIPID}$ obtained from PRAM with a ZOI=1 for the components of the pelagic, benthic, and reef communities as a function of Log($K_{ow}$) are shown in Figure K- 6. The $BAF_{LIPID}$s followed the generally expected behavior of higher bioaccumulation of homologs with a $K_{ow} > 4.7$. The primary producers (phytoplankton and algae) had a constant $BAF_{LIPID}$ for the di- to decachlorobiphenyls reflecting the fact that a constant BCF was used for the homologs with $K_{ow} > 5.0$, as is recommended in the literature (Spacie et al. 1995, Connolly 1991, NEHC/SSC-SD 2005a, p2-82). The highest $BAF_{LIPID}$s were calculated for jack, herring, crab, and grouper, while lower $BAF_{LIPID}$s were obtained for the benthic community, zooplankton from the pelagic community, and urchin and triggerfish from the reef community. The $BAF_{LIPID}$s calculated for bivalves followed a different pattern than the other species, the bivalve $BAF_{LIPID}$s were relatively constant for the homologs modeled. Only slight changes in the modeled $BAF_{LIPID}$s were detected over the range of ZOI=1 to 10 (Figure K- 7, Table K - 2).

**Predicting PCB bioaccumulation**

The accuracy of PRAM to predict bioaccumulation between trophic levels was evaluated by comparing data reported in the literature on PCB bioaccumulation as a function of diet to predictions obtained from PRAM. The important aspect of this evaluation is not necessarily to reproduce the predicted concentrations, but to evaluate whether the general pattern (increasing bioaccumulation as a function of $K_{ow}$), degree of biomagnification between trophic levels, and determine if the relative magnitude of the accumulation is in agreement with literature data. In a study on the bioaccumulation of PCBs in the top predators (Chinook and Coho salmon) of the food chain in tributaries to Lake Michigan, Jackson et al. (2001) reported statistically significant regressions that predicted PCB homolog levels in salmon (TL4) as a function of tissue concentrations in pelagic mysids (*Mysis relicta*) and benthic amphipods (*Diporeia* spp.), which occupied TL2 in the limnetic food chain.

$$C_{Salmon(i)} = \mathbf{m_i}(C_{Prey(i)}) + \mathbf{b_i} \qquad [3]$$

where

| | | |
|---|---|---|
| $C_{Salmon(i)}$ | = | Concentration of homolog(i) in Coho or Chinook salmon |
| $C_{Prey(i)}$ | | PCB concentration of homolog(i) in mysid or amphipod |
| $\mathbf{m_i}$ | = | Slope for homolog(i) |
| $\mathbf{b_i}$ | = | Intercept for homolog(i) |

The food chain studied by Jackson et al. (2001) was very similar to the pelagic and benthic communities modeled by PRAM and there was a high degree of correlation between the TL2 macroinvertebrates and the TL3 salmon because the macroinvertebrates were the main route of transfer in the pelagic (mysid) and benthic (amphipod) food webs in the lake. Using the concentrations predicted by PRAM for TL2 pelagic (zooplankton) and benthic (infauna) prey the regressions were used to predict the PCB concentrations in the TL4 pelagic (jack) and benthic (flounder) and compared to the TL4 concentrations modeled by PRAM. When both the slope and intercept of the regression were used the results showed a similar pattern, but the PRAM predictions were less than what was obtained using the regressions, with a greater difference for the pelagic food chain than for the benthic food web (Figure K- 8). A similar pattern was found for the predicted Total PCB concentrations, PRAM under predicted bioaccumulation in the pelagic food chain was within the range obtained for the benthic food chain Figure K- 9. Note, that the Coho and Chinook concentrations for the benthic community and Chinook concentration for the lower chlorinated homologs could not be predicted, because the prey concentration were too low and the regression with intercept resulted in a negative value. This probably occurred because the modeled concentrations were outside (lower) than the empirical data used to calculate the regression. However, when PCB homologs were predicted using just the slope from the regression a much better agreement was obtained between PRAM and the regression results for both the pelagic and benthic communities for homologs (Figure K- 10) and Total PCB (Figure K- 11).

These predictions are based on the assumption that the Lake Michigan food chains are similar to the pelagic and benthic food chains modeled in PRAM, which is a fairly reasonable assumption given that the food chain studied by Jackson et al. (2001) was relatively simple and that the primary route of exposure was through the diet. Jackson et al. (2001) reported that the diet of secondary consumers (alewife and scorpion fish, for pelagic and benthic food chains, respectively) was made up of "almost pure" mysids and amphipods leaving little doubt about the route of PCB transfer in the food chain to the tertiary consumers (salmon). It is reasonable to compare the PRAM output with the values obtained using just the slope of the uptake regressions, because the intercept is very site-specific and affected by factors like analytical detection limits, analytical and sampling biases, and differences in contaminant residues in wild fish due differences in gender, age, size, health, and other geographic variations in the sample population (Johnston et al. 2002). Although there are undoubtedly differences in the source signatures of PCBs present in Lake Michigan compared to the source of PCBs in PRAM, the sources are probably all derived from Aroclor mixtures and any PCBs released would be subjected to the same physical, chemical, and biological processes that are modeled in PRAM. The good agreement between the PRAM predictions and the uptake regressions shows that PRAM is providing reasonable estimates for this aspect of the model.

The purpose of the comparison above was to determine if PRAM could model the pattern of PCBs bioaccumulated as a function of $K_{ow}$, the degree of biomagnification between trophic levels, and the magnitude of the accumulation relative to the concentration in the prey. Note that Figure K- 8 and Figure K- 10 show that accumulation for individual congeners from Jackson (et al. 2001) and homologs from PRAM while Figure K- 9 and Figure K- 11 show Total PCB reported by Jackson (et al. 2001) and Total PCB (sum of homologs) from PRAM, and different regressions were used for each (that is why the Predator (IV) concentration is higher than coho). Figure K- 10 shows that PRAM does very well in predicting the bioaccumulation of homologs with a Kow ≥6.5 (penta-, hexa-, and heptachlorobiphenyl), these homologs account for 49%, 10%, and 10%, respectively of the total PCBs released at steady state from materials expected to be on the ex-ORISKANY after sinking.

**Biomagnification between trophic levels**

Another means of evaluating the output from PRAM is to compare the relative increase in bioaccumulation as a function of the links in the food chain or trophic level (Stapleton et al 2001, Fisk et al. 2001). This approach evaluates the biomagnification (BMF) factor, or step increase in PCB accumulation moving from one trophic level to the next, by comparing the relative increases in PCBs between predator and prey modeled by PRAM to data reported in the literature.

The lipid-based, trophic level corrected $BMF_{TLC}$ is calculated by the ratio of the lipid-based tissue concentration of the predator ($C_{PRED\_L}$) to its prey ($C_{PREY\_L}$) normalized to the TL of each organism (Fisk et al. 2001):

$$BMF_{TLC} = \frac{C_{PRED\_L} / C_{PREY\_L}}{TL_{PRED} / TL_{PREY}} \qquad [4]$$

The TL for the PRAM food chain was calculated based on the weighted average of each component of a organism's diet:

$$TL_{(j)} = 1 + \Sigma\, f_{diet(i)} \times TL_{Prey(i)} \qquad [5]$$

where

$TL_{(j)}$ = Trophic level for species (j), summed for number of (i) prey items modeled

$f_{diet(i)}$ = Fraction of diet for prey item (i)

$TL_{Prey(i)}$ Trophic level of prey item (i)

The default dietary preferences used by PRAM and the TL determined by diet for each compartment modeled in the food chain is shown in Table K - 3. For the calculations it was assumed that algae and plankton were assigned a TL of 1, and suspended sediments in the upper water column, suspended sediment in the lower water column, and sediment were assigned a TL of 1.125, 1.250, and 1.5, respectively, to represent the relative increase in recycled detrital matter in the sediment pool.

Stapleton et al. (2001) reported Total PCB concentrations in the pelagic, benthic, and demersal food chains in Grand Traverse Bay Lake Michigan for which $BMF_{TLC}$'s were calculated. Fisk et al (2001) reported $BMF_{TLC}$'s for PCB congeners in a demersal food chain from Arctic waters of the Northwater Polynya near northern Greenland, and Mackintosk et al. (2004) reported data on the accumulation of six PCB congeners in a coastal marine food web in False Creek Harbor, Vancouver, BC, Canada. These studies provide data on the bioaccumulation of Total PCBs and specific congeners from a wide range of ecosystems for comparison to PRAM.

The following food chains were evaluated:

| Food Chain | TL2 | TL3 | TL4 |
|---|---|---|---|
| Grand Traverse Bay | | | |
| Pelagic | Zooplankton → | Alewife → | Lake Trout |
| Benthic | Amphipod → | Sculpin → | Salmon |
| Demersal | Mysid → | Bloater → | Burbot |
| Northwater Polynya | | | |
| Demersal | Copepods → | Amphipod → | Arctic Cod |
| False Creek Harbor | | | |
| Pelagic | Juvenile Perch → | Greenling → | Dogfish |
| Benthic | Clams → | English Sole → | Dogfish |
| Demersal | Juvenile Perch → | Staghorn Sculpin → | Dogfish |

The $BMF_{TLC}$ obtained for the predictions from PRAM compared very well to the literature values from the studies cited above (Figure K- 12, Table K - 4). This analysis assumed that the food chain links evaluated were similar and subject to the same physical and chemical processes modeled in PRAM. Although there is uncertainty associated with the trophic level assignments reported in the literature studies, the TL assignments were all based on measurements of $\delta N^{13}$ and $\delta C^{13}$ isotopes. In calculating the $BMF_{TLC}$'s it was assumed that 100% of the diet came from the prey species being evaluated, which actually varied in PRAM as it does in natural food webs. The analysis provides a way to independently evaluate model performance by comparing the relative increases in PCB accumulation along specific links of the food chain. Another source of uncertainty is that the PCB concentrations from the literature were reported as sums of congeners (Stapleton et al. 2001, Fisk et al. 2001) or individual PCBs (Mackintosh et al. 2001) and the PRAM output was evaluated as the sum of homologs (Total PCB). More detailed evaluations could be performed for individual homologs and groups of congeners to further evaluate the model. Based on the current analysis it appears that the predictions from PRAM agree with the expected BMFs of PCBs in similar food chains.

**Trophic level and Bioaccumulation Factors**

The relationship between trophic level and BAFs was evaluated by comparing measured BAFs reported by Burkhard et al. (2003, Figure K- 13) to the BAFs predicted by PRAM as a function of Kow (Figure K- 14). The comparison of the lipid-based bioaccumulation factors ($BAF_{LIPID}$s) predicted by PRAM and BAFs reported for 13 species of fish from Green Bay Lake

Michigan, the Hudson River, and Lake Ontario generally showed good agreement, although there appeared to be less PCBs accumulated for homologs between $Log(K_{ow})$ 6 and 7, the penta- and hexachlorobiphenyls. The fact that PRAM showed the general trend of increasing $BAF_{LIPID}$s as a function of $Log(K_{ow})$ that tracks the literature values is very encouraging. The deviation from literature values for some of the TL3 (triggerfish) and TL4 (flounder and grouper) indicates that some model tuning may be warranted. The invertebrate predators were included on the plot for comparison purposes; comparable data on the $BAF_{LIPID}$s in upper trophic level invertebrates are currently not available. Data for the higher chlorinated congeners and homologs with $Log(K_{ow}) > 7$ were also not available. The $BAF_{LIPID}$s for hepta- to decachlorobiphenyls would probably begin to decline as was indicated by the PRAM results.

In comparing the results from PRAM to $BAF_{LIPID}$s obtained from field data, it must be noted that there are many reasons for variability in $BAF_{LIPID}$s obtained from field data. These include differences in the actual trophic level and the nominal or measured (with $\delta N^{13}$ and $\delta C^{13}$ isotopes), the fact that most ecosystems are in disequilibria with chemical inputs and losses, errors and biases in sampling and analytical chemistry, and difference in age, size, gender, growth rate, and reproductive status of the specimens sampled (Burkhard et al. 2003, Johnston et al. 2002).

**Food Web Magnification Factors**

Perhaps the best way of evaluating the PRAM output is to look at bioaccumulation across the food web as a whole by calculating the Food Web Magnification Factor (FWMF, Fisk et al. 2001):

$$FWMF = e^{b} \quad [6]$$

Where $b$ is the slope of the log-linear (natural log) regression between PCB concentration and TL:

$$Ln(PCB) = a + b(TL) \quad [7]$$

The regression takes into account bioaccumulation within the food web as a whole and $b$ represents the rate of PCB accumulation as a chemical (in this case PCBs) moves up the food chain. When FWMF > 1 it means that the chemical is biomagnifing; FWMF < 1 indicates trophic dilution (Fisk et al. 2001, Mackintosh et al. 2004).

The FWMF for the pelagic, benthic, and reef food chains modeled by PRAM were calculated with the default PRAM output (ZOI=2) by regressing the Ln(PCB) for each homolog against the TLs calculated for the pelagic, benthic, and reef communities to obtain the regression coefficient ($b$) for each of the homologs (Figure K- 15, Figure K- 16, Figure K- 17 and Table K - 5). The resulting FWMFs from PRAM were compared to FWMFs reported for the Northwater Polynya Arctic Food Web (Fisk et al. 2001), the False Creek Harbor food web (Mackintosh et al. 2004), and a marine food web from Bohai Bay, China (Wan et al. 2005, Figure K- 18).

The highest FWMFs obtained from PRAM were for the hexa-, hepta-, and nonachlorobiphenyls in the reef and pelagic communities. The homologs with $Log(K_{ow}) < 5.6$ did not biomagnify in any of the communities and decachlorobiphenyl did not biomagnify in the benthic food web. There was very good agreement between the FWMF predicted by PRAM and the literature values. The PRAM results encompassed the range of FWMFs reported in the literature with the reef community having the highest FWMFs. Once again, the PRAM results follow the general trend observed in the literature data. There is quite a bit of scatter in the literature data, because values were calculated for individual congeners (including coplanar and non-coplanar PCBs) within greatly varying food webs. The Arctic food web encompassed a wide range of predator-prey interactions including sea birds and mammals (Fisk et al. 2001), while the marine food webs from Canada and China had similar structure at the lower TL they supported different top-level predators (Mackintosh et al. 2004, Wan et al. 2005).

## Summary of Model Evaluations

These results add to the confidence that PRAM is able to model food chain bioaccumulation of PCBs with reasonable accuracy. The model validation analysis described above for PRAM only evaluated the trophic transfer mechanisms in the model, which are independent of the input conditions (PCB releases rates) and transport processes also simulated in the model. While there is uncertainty about the results obtained from PRAM the analysis shows that PRAM is giving reasonable and plausible results that can be used to assess risks associated with the ex-ORISKANY. Comparison of the overall food web magnification factor (FWMF) obtained from PRAM to data available from field studies showed that biomagnification in the reef community modeled by PRAM was higher than all the available literature values (Figure K- 18) and the FWMF for the pelagic and benthic communities fell within the range of the field data. This adds to confidence that the results from PRAM are valid. Although some fine-tuning of certain aspects of the model may be desirable, the good agreement with literature values indicates that the results from PRAM are plausible and reasonably good estimates of what would occur given that the other model assumptions and input procedures are accurate representations of what is occurring at the site.

# Appendix K Tables

Table K-1. Summary of PCB concentrations (mg/Kg-ww) predicted by PRAM for ZOI=1, 2, 3, 4, 5, and 10.

## ZOI=1

| Tissue Conc. (mg/kg-WW) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.676E-14 | 4.439E-10 | 3.571E-11 | 5.792E-10 | 7.606E-10 | 3.041E-11 | 1.246E-11 | 0.000E+00 | 5.612E-15 | 2.010E-17 | 1.862E-09 |
| Zooplankton (TL-II) | 6.050E-10 | 2.246E-05 | 2.266E-06 | 4.277E-05 | 4.242E-05 | 6.070E-06 | 5.400E-06 | 0.000E+00 | 2.708E-08 | 4.003E-09 | 1.214E-04 |
| Planktivore (TL-III) | 1.819E-10 | 2.531E-05 | 4.615E-06 | 1.688E-04 | 3.008E-04 | 4.733E-05 | 4.107E-05 | 0.000E+00 | 1.359E-07 | 7.152E-09 | 5.880E-04 |
| Piscivore (TL-IV) | 4.755E-11 | 4.461E-06 | 1.225E-06 | 9.859E-05 | 5.272E-04 | 1.420E-04 | 1.388E-04 | 0.000E+00 | 4.055E-07 | 8.845E-09 | 9.127E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 8.350E-11 | 2.248E-06 | 1.902E-07 | 3.161E-06 | 4.977E-06 | 4.841E-07 | 3.057E-07 | 0.000E+00 | 6.876E-10 | 3.074E-11 | 1.137E-05 |
| Sessile filter feeder (TL-II) | 1.468E-09 | 4.952E-05 | 4.891E-06 | 9.197E-05 | 8.903E-05 | 7.886E-06 | 5.710E-06 | 0.000E+00 | 1.828E-08 | 1.983E-09 | 2.490E-04 |
| Invertebrate Omnivore (TL-II | 1.523E-08 | 1.188E-03 | 1.758E-04 | 5.668E-03 | 9.186E-03 | 6.545E-04 | 3.455E-04 | 0.000E+00 | 2.527E-07 | 3.746E-09 | 1.722E-02 |
| Invertebrate Forager (TL-III) | 5.250E-08 | 2.152E-03 | 3.213E-04 | 1.087E-02 | 2.081E-02 | 1.654E-03 | 9.215E-04 | 0.000E+00 | 1.020E-06 | 6.540E-08 | 3.674E-02 |
| Vertebrate Forager (TL-III) | 1.421E-08 | 1.004E-03 | 2.165E-04 | 1.272E-02 | 4.530E-02 | 4.613E-03 | 2.709E-03 | 0.000E+00 | 3.057E-06 | 9.893E-08 | 6.657E-02 |
| Predator (TL-IV) | 7.885E-09 | 5.138E-04 | 1.217E-04 | 1.066E-02 | 8.247E-02 | 1.270E-02 | 8.181E-03 | 0.000E+00 | 8.810E-06 | 1.906E-07 | 1.147E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 3.954E-10 | 1.553E-05 | 1.614E-06 | 3.193E-05 | 3.205E-05 | 2.934E-06 | 2.144E-06 | 0.000E+00 | 5.984E-09 | 4.264E-10 | 8.621E-05 |
| Epifaunal invert. (TL-II) | 5.517E-10 | 3.249E-05 | 3.875E-06 | 8.770E-05 | 9.664E-05 | 9.264E-06 | 6.838E-06 | 0.000E+00 | 1.718E-08 | 9.420E-10 | 2.368E-04 |
| Forager (TL-III) | 7.142E-10 | 3.944E-05 | 6.031E-06 | 1.823E-04 | 2.716E-04 | 2.539E-05 | 1.730E-05 | 0.000E+00 | 2.758E-08 | 6.328E-10 | 5.421E-04 |
| Predator (TL-IV) | 1.457E-10 | 2.423E-05 | 6.388E-06 | 3.956E-04 | 1.192E-03 | 1.434E-04 | 1.013E-04 | 0.000E+00 | 1.302E-07 | 1.914E-09 | 1.863E-03 |

## ZOI=2

| Tissue Conc. (mg/kg-WW) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.507E-14 | 3.991E-10 | 3.211E-11 | 5.207E-10 | 6.838E-10 | 2.735E-11 | 1.120E-11 | 0.000E+00 | 5.047E-15 | 1.807E-17 | 1.674E-09 |
| Zooplankton (TL-II) | 3.847E-10 | 1.429E-05 | 1.441E-06 | 2.720E-05 | 2.698E-05 | 3.860E-06 | 3.434E-06 | 0.000E+00 | 1.722E-08 | 2.545E-09 | 7.722E-05 |
| Planktivore (TL-III) | 1.157E-10 | 1.610E-05 | 2.935E-06 | 1.073E-04 | 1.913E-04 | 3.010E-05 | 2.611E-05 | 0.000E+00 | 8.639E-08 | 4.548E-09 | 3.740E-04 |
| Piscivore (TL-IV) | 3.024E-11 | 2.837E-06 | 7.791E-07 | 6.270E-05 | 3.353E-04 | 9.028E-05 | 8.828E-05 | 0.000E+00 | 2.579E-07 | 5.625E-09 | 5.804E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 5.309E-11 | 1.429E-06 | 1.209E-07 | 2.010E-06 | 3.165E-06 | 3.078E-07 | 1.944E-07 | 0.000E+00 | 4.372E-10 | 1.955E-11 | 7.228E-06 |
| Sessile filter feeder (TL-II) | 9.335E-10 | 3.149E-05 | 3.110E-06 | 5.848E-05 | 5.662E-05 | 5.014E-06 | 3.631E-06 | 0.000E+00 | 1.162E-08 | 1.261E-09 | 1.584E-04 |
| Invertebrate Omnivore (TL-II | 1.513E-08 | 1.176E-03 | 1.737E-04 | 5.591E-03 | 9.032E-03 | 6.389E-04 | 3.351E-04 | 0.000E+00 | 2.343E-07 | 3.166E-09 | 1.695E-02 |
| Invertebrate Forager (TL-III) | 5.231E-08 | 2.136E-03 | 3.184E-04 | 1.075E-02 | 2.052E-02 | 1.623E-03 | 9.003E-04 | 0.000E+00 | 9.901E-07 | 6.469E-08 | 3.624E-02 |
| Vertebrate Forager (TL-III) | 1.415E-08 | 9.949E-04 | 2.140E-04 | 1.254E-02 | 4.459E-02 | 4.516E-03 | 2.638E-03 | 0.000E+00 | 2.960E-06 | 9.732E-08 | 6.550E-02 |
| Predator (TL-IV) | 7.841E-09 | 5.098E-04 | 1.205E-04 | 1.052E-02 | 8.122E-02 | 1.244E-02 | 7.984E-03 | 0.000E+00 | 8.585E-06 | 1.886E-07 | 1.128E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.514E-10 | 9.875E-06 | 1.026E-06 | 2.030E-05 | 2.038E-05 | 1.866E-06 | 1.363E-06 | 0.000E+00 | 3.805E-09 | 2.711E-10 | 5.482E-05 |
| Epifaunal invert. (TL-II) | 3.508E-10 | 2.066E-05 | 2.464E-06 | 5.577E-05 | 6.146E-05 | 5.891E-06 | 4.348E-06 | 0.000E+00 | 1.092E-08 | 5.990E-10 | 1.506E-04 |
| Forager (TL-III) | 4.541E-10 | 2.508E-05 | 3.835E-06 | 1.159E-04 | 1.727E-04 | 1.615E-05 | 1.100E-05 | 0.000E+00 | 1.754E-08 | 4.024E-10 | 3.447E-04 |
| Predator (TL-IV) | 9.265E-11 | 1.541E-05 | 4.062E-06 | 2.516E-04 | 7.580E-04 | 9.120E-05 | 6.440E-05 | 0.000E+00 | 8.279E-08 | 1.217E-09 | 1.185E-03 |

Table K-1 Cont.

## ZOI=3

| Tissue Conc. (mg/kg-WW) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.442E-14 | 3.819E-10 | 3.073E-11 | 4.983E-10 | 6.545E-10 | 2.618E-11 | 1.072E-11 | 0.000E+00 | 4.831E-15 | 1.730E-17 | 1.602E-09 |
| Zooplankton (TL-II) | 3.007E-10 | 1.117E-05 | 1.127E-06 | 2.126E-05 | 2.109E-05 | 3.017E-06 | 2.684E-06 | 0.000E+00 | 1.346E-08 | 1.989E-09 | 6.036E-05 |
| Planktivore (TL-III) | 9.043E-11 | 1.258E-05 | 2.294E-06 | 8.391E-05 | 1.495E-04 | 2.353E-05 | 2.041E-05 | 0.000E+00 | 6.753E-08 | 3.555E-09 | 2.923E-04 |
| Piscivore (TL-IV) | 2.364E-11 | 2.218E-06 | 6.091E-07 | 4.901E-05 | 2.621E-04 | 7.057E-05 | 6.900E-05 | 0.000E+00 | 2.016E-07 | 4.396E-09 | 4.537E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 4.150E-11 | 1.117E-06 | 9.453E-08 | 1.571E-06 | 2.474E-06 | 2.406E-07 | 1.519E-07 | 0.000E+00 | 3.418E-10 | 1.528E-11 | 5.649E-06 |
| Sessile filter feeder (TL-II) | 7.297E-10 | 2.461E-05 | 2.431E-06 | 4.571E-05 | 4.425E-05 | 3.919E-06 | 2.838E-06 | 0.000E+00 | 9.084E-09 | 9.857E-10 | 1.238E-04 |
| Invertebrate Omnivore (TL-II | 1.509E-08 | 1.171E-03 | 1.729E-04 | 5.561E-03 | 8.973E-03 | 6.330E-04 | 3.312E-04 | 0.000E+00 | 2.273E-07 | 2.944E-09 | 1.684E-02 |
| Invertebrate Forager (TL-III) | 5.224E-08 | 2.131E-03 | 3.173E-04 | 1.070E-02 | 2.041E-02 | 1.611E-03 | 8.923E-04 | 0.000E+00 | 9.787E-07 | 6.442E-08 | 3.606E-02 |
| Vertebrate Forager (TL-III) | 1.413E-08 | 9.913E-04 | 2.130E-04 | 1.247E-02 | 4.432E-02 | 4.478E-03 | 2.612E-03 | 0.000E+00 | 2.923E-06 | 9.671E-08 | 6.509E-02 |
| Predator (TL-IV) | 7.825E-09 | 5.083E-04 | 1.201E-04 | 1.047E-02 | 8.075E-02 | 1.235E-02 | 7.909E-03 | 0.000E+00 | 8.499E-06 | 1.879E-07 | 1.121E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 1.965E-10 | 7.718E-06 | 8.022E-07 | 1.587E-05 | 1.593E-05 | 1.458E-06 | 1.066E-06 | 0.000E+00 | 2.974E-09 | 2.119E-10 | 4.285E-05 |
| Epifaunal invert. (TL-II) | 2.742E-10 | 1.615E-05 | 1.926E-06 | 4.359E-05 | 4.804E-05 | 4.604E-06 | 3.399E-06 | 0.000E+00 | 8.539E-09 | 4.682E-10 | 1.177E-04 |
| Forager (TL-III) | 3.550E-10 | 1.960E-05 | 2.998E-06 | 9.058E-05 | 1.350E-04 | 1.262E-05 | 8.600E-06 | 0.000E+00 | 1.371E-08 | 3.145E-10 | 2.694E-04 |
| Predator (TL-IV) | 7.241E-11 | 1.204E-05 | 3.175E-06 | 1.966E-04 | 5.925E-04 | 7.128E-05 | 5.034E-05 | 0.000E+00 | 6.471E-08 | 9.512E-10 | 9.260E-04 |

## ZOI=4

| Tissue Conc. (mg/kg-WW) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.406E-14 | 3.724E-10 | 2.996E-11 | 4.859E-10 | 6.382E-10 | 2.552E-11 | 1.046E-11 | 0.000E+00 | 4.711E-15 | 1.687E-17 | 1.562E-09 |
| Zooplankton (TL-II) | 2.540E-10 | 9.431E-06 | 9.514E-07 | 1.796E-05 | 1.781E-05 | 2.548E-06 | 2.267E-06 | 0.000E+00 | 1.137E-08 | 1.680E-09 | 5.098E-05 |
| Planktivore (TL-III) | 7.638E-11 | 1.063E-05 | 1.938E-06 | 7.087E-05 | 1.263E-04 | 1.987E-05 | 1.724E-05 | 0.000E+00 | 5.703E-08 | 3.002E-09 | 2.469E-04 |
| Piscivore (TL-IV) | 1.997E-11 | 1.873E-06 | 5.144E-07 | 4.140E-05 | 2.214E-04 | 5.960E-05 | 5.827E-05 | 0.000E+00 | 1.702E-07 | 3.713E-09 | 3.832E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 3.504E-11 | 9.434E-07 | 7.983E-08 | 1.327E-06 | 2.089E-06 | 2.032E-07 | 1.283E-07 | 0.000E+00 | 2.886E-10 | 1.290E-11 | 4.771E-06 |
| Sessile filter feeder (TL-II) | 6.162E-10 | 2.078E-05 | 2.053E-06 | 3.860E-05 | 3.737E-05 | 3.310E-06 | 2.397E-06 | 0.000E+00 | 7.672E-09 | 8.324E-10 | 1.045E-04 |
| Invertebrate Omnivore (TL-II | 1.507E-08 | 1.168E-03 | 1.725E-04 | 5.545E-03 | 8.940E-03 | 6.297E-04 | 3.290E-04 | 0.000E+00 | 2.234E-07 | 2.821E-09 | 1.678E-02 |
| Invertebrate Forager (TL-III) | 5.220E-08 | 2.127E-03 | 3.167E-04 | 1.067E-02 | 2.034E-02 | 1.604E-03 | 8.878E-04 | 0.000E+00 | 9.723E-07 | 6.427E-08 | 3.595E-02 |
| Vertebrate Forager (TL-III) | 1.412E-08 | 9.894E-04 | 2.125E-04 | 1.243E-02 | 4.416E-02 | 4.458E-03 | 2.597E-03 | 0.000E+00 | 2.902E-06 | 9.637E-08 | 6.486E-02 |
| Predator (TL-IV) | 7.815E-09 | 5.075E-04 | 1.198E-04 | 1.044E-02 | 8.048E-02 | 1.229E-02 | 7.868E-03 | 0.000E+00 | 8.451E-06 | 1.875E-07 | 1.117E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 1.659E-10 | 6.518E-06 | 6.774E-07 | 1.340E-05 | 1.345E-05 | 1.231E-06 | 8.999E-07 | 0.000E+00 | 2.512E-09 | 1.790E-10 | 3.619E-05 |
| Epifaunal invert. (TL-II) | 2.316E-10 | 1.364E-05 | 1.626E-06 | 3.681E-05 | 4.057E-05 | 3.888E-06 | 2.870E-06 | 0.000E+00 | 7.211E-09 | 3.954E-10 | 9.941E-05 |
| Forager (TL-III) | 2.998E-10 | 1.656E-05 | 2.531E-06 | 7.650E-05 | 1.140E-04 | 1.066E-05 | 7.263E-06 | 0.000E+00 | 1.158E-08 | 2.656E-10 | 2.275E-04 |
| Predator (TL-IV) | 6.115E-11 | 1.017E-05 | 2.681E-06 | 1.661E-04 | 5.004E-04 | 6.020E-05 | 4.251E-05 | 0.000E+00 | 5.465E-08 | 8.033E-10 | 7.821E-04 |

Table K-1 Cont.

## ZOI=5

| Tissue Conc. (mg/kg-WW) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.382E-14 | 3.661E-10 | 2.946E-11 | 4.777E-10 | 6.275E-10 | 2.510E-11 | 1.028E-11 | 0.000E+00 | 4.633E-15 | 1.659E-17 | 1.536E-09 |
| Zooplankton (TL-II) | 2.234E-10 | 8.295E-06 | 8.368E-07 | 1.579E-05 | 1.567E-05 | 2.241E-06 | 1.994E-06 | 0.000E+00 | 9.996E-09 | 1.478E-09 | 4.484E-05 |
| Planktivore (TL-III) | 6.719E-11 | 9.348E-06 | 1.704E-06 | 6.233E-05 | 1.111E-04 | 1.748E-05 | 1.516E-05 | 0.000E+00 | 5.016E-08 | 2.640E-09 | 2.172E-04 |
| Piscivore (TL-IV) | 1.757E-11 | 1.648E-06 | 4.525E-07 | 3.641E-05 | 1.947E-04 | 5.242E-05 | 5.125E-05 | 0.000E+00 | 1.497E-07 | 3.265E-09 | 3.371E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 3.082E-11 | 8.297E-07 | 7.021E-08 | 1.167E-06 | 1.837E-06 | 1.787E-07 | 1.128E-07 | 0.000E+00 | 2.538E-10 | 1.135E-11 | 4.196E-06 |
| Sessile filter feeder (TL-II) | 5.420E-10 | 1.828E-05 | 1.806E-06 | 3.395E-05 | 3.287E-05 | 2.911E-06 | 2.108E-06 | 0.000E+00 | 6.748E-09 | 7.322E-10 | 9.194E-05 |
| Invertebrate Omnivore (TL-II | 1.505E-08 | 1.167E-03 | 1.722E-04 | 5.534E-03 | 8.918E-03 | 6.275E-04 | 3.276E-04 | 0.000E+00 | 2.209E-07 | 2.740E-09 | 1.675E-02 |
| Invertebrate Forager (TL-III) | 5.217E-08 | 2.125E-03 | 3.163E-04 | 1.065E-02 | 2.030E-02 | 1.600E-03 | 8.848E-04 | 0.000E+00 | 9.682E-07 | 6.418E-08 | 3.588E-02 |
| Vertebrate Forager (TL-III) | 1.411E-08 | 9.880E-04 | 2.121E-04 | 1.241E-02 | 4.406E-02 | 4.444E-03 | 2.587E-03 | 0.000E+00 | 2.889E-06 | 9.615E-08 | 6.471E-02 |
| Predator (TL-IV) | 7.809E-09 | 5.069E-04 | 1.196E-04 | 1.042E-02 | 8.031E-02 | 1.226E-02 | 7.840E-03 | 0.000E+00 | 8.420E-06 | 1.872E-07 | 1.115E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 1.460E-10 | 5.733E-06 | 5.958E-07 | 1.179E-05 | 1.183E-05 | 1.083E-06 | 7.915E-07 | 0.000E+00 | 2.209E-09 | 1.574E-10 | 3.183E-05 |
| Epifaunal invert. (TL-II) | 2.037E-10 | 1.199E-05 | 1.431E-06 | 3.238E-05 | 3.568E-05 | 3.420E-06 | 2.525E-06 | 0.000E+00 | 6.343E-09 | 3.478E-10 | 8.744E-05 |
| Forager (TL-III) | 2.636E-10 | 1.456E-05 | 2.226E-06 | 6.728E-05 | 1.003E-04 | 9.375E-06 | 6.388E-06 | 0.000E+00 | 1.018E-08 | 2.336E-10 | 2.001E-04 |
| Predator (TL-IV) | 5.379E-11 | 8.946E-06 | 2.358E-06 | 1.461E-04 | 4.401E-04 | 5.295E-05 | 3.739E-05 | 0.000E+00 | 4.806E-08 | 7.065E-10 | 6.879E-04 |

## ZOI=10

| Tissue Conc. (mg/kg-WW) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.326E-14 | 3.513E-10 | 2.827E-11 | 4.585E-10 | 6.023E-10 | 2.410E-11 | 9.872E-12 | 0.000E+00 | 4.449E-15 | 1.593E-17 | 1.474E-09 |
| Zooplankton (TL-II) | 1.517E-10 | 5.634E-06 | 5.684E-07 | 1.073E-05 | 1.064E-05 | 1.522E-06 | 1.354E-06 | 0.000E+00 | 6.788E-09 | 1.003E-09 | 3.045E-05 |
| Planktivore (TL-III) | 4.564E-11 | 6.349E-06 | 1.158E-06 | 4.234E-05 | 7.545E-05 | 1.187E-05 | 1.030E-05 | 0.000E+00 | 3.406E-08 | 1.793E-09 | 1.475E-04 |
| Piscivore (TL-IV) | 1.194E-11 | 1.119E-06 | 3.074E-07 | 2.473E-05 | 1.323E-04 | 3.560E-05 | 3.480E-05 | 0.000E+00 | 1.017E-07 | 2.217E-09 | 2.289E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 2.093E-11 | 5.634E-07 | 4.767E-08 | 7.923E-07 | 1.248E-06 | 1.213E-07 | 7.662E-08 | 0.000E+00 | 1.724E-10 | 7.707E-12 | 2.849E-06 |
| Sessile filter feeder (TL-II) | 3.680E-10 | 1.241E-05 | 1.226E-06 | 2.306E-05 | 2.232E-05 | 1.977E-06 | 1.431E-06 | 0.000E+00 | 4.582E-09 | 4.971E-10 | 6.243E-05 |
| Invertebrate Omnivore (TL-II | 1.502E-08 | 1.163E-03 | 1.715E-04 | 5.509E-03 | 8.868E-03 | 6.224E-04 | 3.242E-04 | 0.000E+00 | 2.149E-07 | 2.551E-09 | 1.666E-02 |
| Invertebrate Forager (TL-III) | 5.211E-08 | 2.120E-03 | 3.153E-04 | 1.061E-02 | 2.021E-02 | 1.589E-03 | 8.779E-04 | 0.000E+00 | 9.585E-07 | 6.394E-08 | 3.572E-02 |
| Vertebrate Forager (TL-III) | 1.409E-08 | 9.850E-04 | 2.113E-04 | 1.235E-02 | 4.383E-02 | 4.412E-03 | 2.564E-03 | 0.000E+00 | 2.857E-06 | 9.563E-08 | 6.436E-02 |
| Predator (TL-IV) | 7.795E-09 | 5.056E-04 | 1.192E-04 | 1.037E-02 | 7.990E-02 | 1.218E-02 | 7.776E-03 | 0.000E+00 | 8.347E-06 | 1.865E-07 | 1.109E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 9.910E-11 | 3.893E-06 | 4.046E-07 | 8.004E-06 | 8.036E-06 | 7.355E-07 | 5.375E-07 | 0.000E+00 | 1.500E-09 | 1.069E-10 | 2.161E-05 |
| Epifaunal invert. (TL-II) | 1.383E-10 | 8.144E-06 | 9.714E-07 | 2.199E-05 | 2.423E-05 | 2.322E-06 | 1.714E-06 | 0.000E+00 | 4.307E-09 | 2.361E-10 | 5.938E-05 |
| Forager (TL-III) | 1.790E-10 | 9.887E-06 | 1.512E-06 | 4.569E-05 | 6.809E-05 | 6.366E-06 | 4.337E-06 | 0.000E+00 | 6.915E-09 | 1.586E-10 | 1.359E-04 |
| Predator (TL-IV) | 3.652E-11 | 6.074E-06 | 1.601E-06 | 9.918E-05 | 2.989E-04 | 3.595E-05 | 2.539E-05 | 0.000E+00 | 3.264E-08 | 4.798E-10 | 4.671E-04 |

Table K-2. Summary of BAFs (L/Kg-lipid) calculated by PRAM for ZOI=1, 2, 5, and 10.

## ZOI=1

| BAFs (L/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Zooplankton (TL-II) | 1.347E+05 | 6.237E+05 | 7.436E+05 | 8.445E+05 | 5.319E+05 | 7.826E+05 | 1.103E+06 | 0.000E+00 | 2.458E+06 | 8.127E+06 |
| Planktivore (TL-III) | 7.604E+04 | 1.320E+06 | 2.844E+06 | **6.259E+06** | 7.084E+06 | 1.147E+07 | 1.576E+07 | 0.000E+00 | 2.317E+07 | 2.729E+07 |
| Piscivore (TL-IV) | 1.988E+04 | 2.326E+05 | 7.549E+05 | 3.656E+06 | **1.242E+07** | **3.439E+07** | **5.326E+07** | 0.000E+00 | **6.917E+07** | **3.375E+07** |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Sessile filter feeder (TL-II) | **9.590E+05** | **4.034E+06** | 4.709E+06 | 5.328E+06 | 3.275E+06 | 2.983E+06 | 3.420E+06 | 0.000E+00 | 4.867E+06 | 1.181E+07 |
| Invertebrate Omnivore (TL-II | 3.231E+04 | 3.143E+05 | **5.495E+05** | 1.066E+06 | 1.097E+06 | 8.039E+05 | 6.721E+05 | 0.000E+00 | 2.185E+05 | 7.246E+04 |
| Invertebrate Forager (TL-III) | 1.634E+05 | 8.353E+05 | 1.474E+06 | 3.001E+06 | 3.648E+06 | 2.981E+06 | 2.630E+06 | 0.000E+00 | 1.294E+06 | 1.856E+06 |
| Vertebrate Forager (TL-III) | 1.502E+04 | 1.324E+05 | 3.373E+05 | 1.193E+06 | 2.698E+06 | 2.825E+06 | 2.627E+06 | 0.000E+00 | 1.318E+06 | 9.538E+05 |
| Predator (TL-IV) | 1.243E+04 | 1.010E+05 | 2.827E+05 | 1.490E+06 | 7.321E+06 | 1.159E+07 | 1.183E+07 | 0.000E+00 | 5.661E+06 | 2.739E+06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.429E+05 | 1.190E+06 | 1.462E+06 | 1.740E+06 | 1.109E+06 | 1.044E+06 | 1.208E+06 | 0.000E+00 | 1.499E+06 | 2.389E+06 |
| Epifaunal invert. (TL-II) | 3.013E+05 | 2.213E+06 | 3.119E+06 | 4.248E+06 | 2.973E+06 | 2.930E+06 | 3.425E+06 | 0.000E+00 | 3.825E+06 | 4.691E+06 |
| Forager (TL-III) | 1.759E+05 | 1.212E+06 | 2.189E+06 | 3.981E+06 | 3.768E+06 | 3.622E+06 | 3.908E+06 | 0.000E+00 | 2.770E+06 | 1.421E+06 |
| Predator (TL-IV) | 1.557E+04 | 3.231E+05 | 1.006E+06 | 3.750E+06 | 7.176E+06 | 8.877E+06 | 9.928E+06 | 0.000E+00 | 5.673E+06 | 1.865E+06 |
| | 9.590E+05 | 4.034E+06 | 4.709E+06 | 6.259E+06 | 1.242E+07 | 3.439E+07 | 5.326E+07 | 0.000E+00 | 6.917E+07 | 3.375E+07 |

## ZOI=2

| BAFs (L/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Zooplankton (TL-II) | 1.347E+05 | 6.238E+05 | 7.436E+05 | 8.445E+05 | 5.320E+05 | 7.826E+05 | 1.103E+06 | 0.000E+00 | 2.458E+06 | 8.127E+06 |
| Planktivore (TL-III) | 7.603E+04 | 1.320E+06 | 2.843E+06 | 6.258E+06 | 7.083E+06 | 1.146E+07 | 1.576E+07 | 0.000E+00 | 2.317E+07 | 2.729E+07 |
| Piscivore (TL-IV) | 1.988E+04 | 2.326E+05 | 7.548E+05 | 3.655E+06 | 1.242E+07 | 3.439E+07 | 5.326E+07 | 0.000E+00 | 6.917E+07 | 3.375E+07 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Sessile filter feeder (TL-II) | 9.590E+05 | 4.034E+06 | 4.709E+06 | 5.328E+06 | 3.276E+06 | 2.983E+06 | 3.420E+06 | 0.000E+00 | 4.867E+06 | 1.181E+07 |
| Invertebrate Omnivore (TL-II | 3.226E+04 | 3.127E+05 | 5.460E+05 | 1.057E+06 | 1.085E+06 | 7.891E+05 | 6.556E+05 | 0.000E+00 | 2.037E+05 | 6.157E+04 |
| Invertebrate Forager (TL-III) | 1.633E+05 | 8.319E+05 | 1.465E+06 | 2.976E+06 | 3.608E+06 | 2.934E+06 | 2.578E+06 | 0.000E+00 | 1.260E+06 | 1.842E+06 |
| Vertebrate Forager (TL-III) | 1.501E+04 | 1.316E+05 | 3.345E+05 | 1.180E+06 | 2.664E+06 | 2.774E+06 | 2.567E+06 | 0.000E+00 | 1.280E+06 | 9.414E+05 |
| Predator (TL-IV) | 1.243E+04 | 1.008E+05 | 2.815E+05 | 1.479E+06 | 7.250E+06 | 1.142E+07 | 1.161E+07 | 0.000E+00 | 5.547E+06 | 2.726E+06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.429E+05 | 1.190E+06 | 1.462E+06 | 1.740E+06 | 1.109E+06 | 1.044E+06 | 1.208E+06 | 0.000E+00 | 1.499E+06 | 2.389E+06 |
| Epifaunal invert. (TL-II) | 3.013E+05 | 2.213E+06 | 3.119E+06 | 4.248E+06 | 2.973E+06 | 2.930E+06 | 3.425E+06 | 0.000E+00 | 3.825E+06 | 4.691E+06 |
| Forager (TL-III) | 1.759E+05 | 1.212E+06 | 2.189E+06 | 3.981E+06 | 3.768E+06 | 3.622E+06 | 3.909E+06 | 0.000E+00 | 2.770E+06 | 1.421E+06 |
| Predator (TL-IV) | 1.557E+04 | 3.231E+05 | 1.006E+06 | 3.750E+06 | 7.177E+06 | 8.877E+06 | 9.928E+06 | 0.000E+00 | 5.673E+06 | 1.865E+06 |

Table K-2 Cont.

# ZOI=5

| BAFs (L/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Zooplankton (TL-II) | 1.347E+05 | 6.238E+05 | 7.437E+05 | 8.446E+05 | 5.321E+05 | 7.827E+05 | 1.103E+06 | 0.000E+00 | 2.458E+06 | 8.127E+06 |
| Planktivore (TL-III) | 7.602E+04 | 1.319E+06 | 2.842E+06 | 6.256E+06 | 7.082E+06 | 1.146E+07 | 1.575E+07 | 0.000E+00 | 2.317E+07 | 2.729E+07 |
| Piscivore (TL-IV) | 1.988E+04 | 2.325E+05 | 7.546E+05 | 3.654E+06 | 1.241E+07 | 3.439E+07 | 5.326E+07 | 0.000E+00 | 6.917E+07 | 3.375E+07 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Sessile filter feeder (TL-II) | 9.590E+05 | 4.034E+06 | 4.709E+06 | 5.328E+06 | 3.276E+06 | 2.983E+06 | 3.420E+06 | 0.000E+00 | 4.867E+06 | 1.181E+07 |
| Invertebrate Omnivore (TL-II | 3.223E+04 | 3.116E+05 | 5.434E+05 | 1.051E+06 | 1.076E+06 | 7.781E+05 | 6.433E+05 | 0.000E+00 | 1.928E+05 | 5.351E+04 |
| Invertebrate Forager (TL-III) | 1.633E+05 | 8.295E+05 | 1.459E+06 | 2.957E+06 | 3.579E+06 | 2.899E+06 | 2.540E+06 | 0.000E+00 | 1.235E+06 | 1.831E+06 |
| Vertebrate Forager (TL-III) | 1.500E+04 | 1.310E+05 | 3.324E+05 | 1.170E+06 | 2.639E+06 | 2.736E+06 | 2.523E+06 | 0.000E+00 | 1.252E+06 | 9.322E+05 |
| Predator (TL-IV) | 1.243E+04 | 1.006E+05 | 2.806E+05 | 1.470E+06 | 7.197E+06 | 1.130E+07 | 1.144E+07 | 0.000E+00 | 5.462E+06 | 2.716E+06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.429E+05 | 1.190E+06 | 1.462E+06 | 1.740E+06 | 1.109E+06 | 1.044E+06 | 1.208E+06 | 0.000E+00 | 1.499E+06 | 2.389E+06 |
| Epifaunal invert. (TL-II) | 3.013E+05 | 2.213E+06 | 3.119E+06 | 4.248E+06 | 2.973E+06 | 2.930E+06 | 3.425E+06 | 0.000E+00 | 3.825E+06 | 4.691E+06 |
| Forager (TL-III) | 1.759E+05 | 1.212E+06 | 2.189E+06 | 3.981E+06 | 3.768E+06 | 3.622E+06 | 3.909E+06 | 0.000E+00 | 2.770E+06 | 1.421E+06 |
| Predator (TL-IV) | 1.557E+04 | 3.231E+05 | 1.006E+06 | 3.751E+06 | 7.177E+06 | 8.878E+06 | 9.928E+06 | 0.000E+00 | 5.673E+06 | 1.865E+06 |

# ZOI=10

| BAFs (L/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Zooplankton (TL-II) | 1.347E+05 | 6.239E+05 | 7.438E+05 | 8.447E+05 | 5.321E+05 | 7.827E+05 | 1.103E+06 | 0.000E+00 | 2.458E+06 | 8.127E+06 |
| Planktivore (TL-III) | 7.601E+04 | 1.319E+06 | 2.841E+06 | **6.254E+06** | 7.080E+06 | 1.146E+07 | 1.575E+07 | 0.000E+00 | 2.317E+07 | 2.729E+07 |
| Piscivore (TL-IV) | 1.988E+04 | 2.325E+05 | 7.544E+05 | 3.653E+06 | **1.241E+07** | **3.438E+07** | **5.325E+07** | 0.000E+00 | **6.917E+07** | **3.375E+07** |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Sessile filter feeder (TL-II) | **9.590E+05** | **4.035E+06** | **4.709E+06** | 5.329E+06 | 3.276E+06 | 2.983E+06 | 3.421E+06 | 0.000E+00 | 4.867E+06 | 1.181E+07 |
| Invertebrate Omnivore (TL-II | 3.221E+04 | 3.111E+05 | 5.422E+05 | 1.048E+06 | 1.071E+06 | 7.733E+05 | 6.379E+05 | 0.000E+00 | 1.879E+05 | 4.991E+04 |
| Invertebrate Forager (TL-III) | 1.632E+05 | 8.284E+05 | 1.456E+06 | 2.949E+06 | 3.565E+06 | 2.883E+06 | 2.523E+06 | 0.000E+00 | 1.224E+06 | 1.827E+06 |
| Vertebrate Forager (TL-III) | 1.500E+04 | 1.308E+05 | 3.315E+05 | 1.166E+06 | 2.628E+06 | 2.720E+06 | 2.503E+06 | 0.000E+00 | 1.240E+06 | 9.282E+05 |
| Predator (TL-IV) | 1.243E+04 | 1.005E+05 | 2.801E+05 | 1.466E+06 | 7.174E+06 | 1.124E+07 | 1.137E+07 | 0.000E+00 | 5.425E+06 | 2.712E+06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.429E+05 | 1.190E+06 | 1.462E+06 | 1.740E+06 | 1.109E+06 | 1.044E+06 | 1.208E+06 | 0.000E+00 | 1.499E+06 | 2.389E+06 |
| Epifaunal invert. (TL-II) | 3.013E+05 | 2.213E+06 | 3.120E+06 | 4.249E+06 | 2.974E+06 | 2.930E+06 | 3.426E+06 | 0.000E+00 | 3.825E+06 | 4.691E+06 |
| Forager (TL-III) | 1.759E+05 | 1.212E+06 | 2.190E+06 | 3.982E+06 | 3.768E+06 | 3.622E+06 | 3.909E+06 | 0.000E+00 | 2.770E+06 | 1.421E+06 |
| Predator (TL-IV) | 1.557E+04 | 3.231E+05 | 1.006E+06 | 3.751E+06 | 7.178E+06 | 8.878E+06 | 9.929E+06 | 0.000E+00 | 5.673E+06 | 1.865E+06 |
| | 9.590E+05 | 4.035E+06 | 4.709E+06 | 6.254E+06 | 1.241E+07 | 3.438E+07 | 5.325E+07 | 0.000E+00 | 6.917E+07 | 3.375E+07 |

Table K-3. Calculation of PCB biomagnification factors ($BMF_{TLC}$) for trophic levels (TL) 3:2, 4:3, and 4:2 observed in pelagic, demersal, and benthic food webs from Grand Traverse Bay, Lake Michigan (Stapleton et al. 2001), False Creek Harbor, Vancouver, BC Canada (Mackintosh et al. 2004), a demersal food web from the Northwater Polynya, Arctic (Fisk, Hobson, & Norstrom 2001), and predicted by PRAM.

| | | average | | | average - std | | | average + std | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Data from Stapleton et al. 2001 | | sumPCB | $BMF_{TLC}$ | | | $BMF_{TLC}$ | | | $BMF_{TLC}$ | |
| Lake Pelagic | TL | ng/g lipid | 3:2 / 4:3 | 4:2 | sumPCB n | 3:2 / 4:3 | 4:2 | sumPCB n | 3:2 / 4:3 | 4:2 |
| Zooplankton | 2.00 | 1120.0 | | | 351.0 | | | 2914.3 | | |
| Alewife | 3.00 | 4957.4 | 3.0 | | 2144.7 | 4.1 | | 16833.3 | 3.9 | |
| Lake Trout | 4.00 | 8522.7 | 1.3 | 3.8 | 4048.1 | 1.4 | 5.8 | 16801.6 | 0.7 | 2.9 |
| Lake Demersal | | | | | | | | | | |
| Mysid | 2.00 | 828.6 | | | 378.9 | | | 1777.8 | | |
| Bloater | 3.00 | 13135.6 | 10.6 | | 6740.5 | 11.9 | | 26089.7 | 9.8 | |
| Burbot | 4.00 | 17750.0 | 1.0 | 10.7 | 17750.0 | 2.0 | 23.4 | 17750.0 | 0.5 | 5.0 |
| Lake Benthic | | | | | | | | | | |
| Amphipod | 2.00 | 1447.1 | | | 670.8 | | | 3310.0 | | |
| Sculpin | 3.00 | 3468.2 | 1.6 | | 1479.8 | 1.5 | | 7073.2 | 1.4 | |
| Salmon | 4.00 | 23788.5 | 5.1 | 8.2 | 23788.5 | 12.1 | 17.7 | 23788.5 | 2.5 | 3.6 |
| Data from Mackintosh et al. 2004 | | | | | | | | | | |
| | | PCB118 | $BMF_{TLC}$ | | | $BMF_{TLC}$ | | | $BMF_{TLC}$ | |
| Coastal Pelagic | TL | ng/g lipid | 3:2 / 4:3 | 4:2 | PCB118 n | 3:2 / 4:3 | 4:2 | PCB118 n | 3:2 / 4:3 | 4:2 |
| Juvenile Perch | 2.30 | 263.0 | | | 166.0 | | | 416.9 | | |
| Greenling | 3.81 | 354.8 | 0.8 | | 95.5 | 0.3 | | 1318.3 | 1.9 | |
| Dogfish | 4.07 | 645.7 | 1.7 | 1.4 | 302.0 | 3.0 | 1.0 | 1380.4 | 1.0 | 1.9 |
| Coastal Demersal | | | | | | | | | | |
| Oyster | 2.48 | 64.6 | | | 37.2 | | | 112.2 | | |
| Crab | 3.55 | 467.7 | 5.1 | | 245.5 | 4.6 | | 891.3 | 5.5 | |
| Dogfish | 4.07 | 645.7 | 1.2 | 6.1 | 302.0 | 1.1 | 5.0 | 1380.4 | 1.4 | 7.5 |
| Coastal Benthic | | | | | | | | | | |
| Manila Clam/Geoduck Clam | 2.40 | 34.5 | | | 3.0 | | | 134.9 | | |
| English Sole | 3.64 | 549.5 | 10.5 | | 112.2 | 25.1 | | 2691.5 | 13.2 | |
| Dogfish | 4.07 | 645.7 | 1.1 | 11.0 | 302.0 | 2.4 | 60.3 | 1380.4 | 0.5 | 6.0 |
| Reported by Fisk, Hobson, & Norstrom 2001 | | | | | | | | | | |
| | | | $BMF_{TLC}$ | | | | | | | |
| Arctic Benthic | TL | sumPCB | 3:2 / 4:3 | 4:2 | | | | | | |
| Copepod | 2.0 | | | | | | | | | |
| Amphipod | 2.6 | | 7.8 | | | | | | | |
| Artic Cod | 3.7 | | 0.9 | | | | | | | |

Table K-3 Cont.

Data from PRAM 1.4C

| Tissue Conc. (mg/kg-lipid) | | mg/Kg Lipic | $BMF_{TLC}$ | |
|---|---|---|---|---|
| **Pelagic Community** | TL | Total PCB | 3:2 / 4:3 | 4:2 |
| Phytoplankton (TL1) | 1.00 | 1.02E-07 | | |
| Zooplankton (TL-II) | 2.06 | 0.001462 | | |
| Planktivore (TL-III) | 3.06 | 0.005323 | 2.4 | |
| Piscivore (TL-IV) | 3.96 | 0.008262 | 1.2 | 2.9 |
| **Reef / Vessel Community** | | | | |
| Attached Algae | 1.00 | 0.000439 | | |
| Sessile filter feeder (TL-II) | 2.13 | 0.017595 | | |
| Invertebrate Omnivore (TL-II) | 2.23 | 0.324634 | | |
| Invertebrate Forager (TL-III) | 3.18 | 1.518546 | 3.3 | |
| Vertebrate Forager (TL-III) | 2.96 | 0.932337 | 2.2 | |
| Predator (TL-IV) | 3.95 | 1.605862 | 1.3 | 2.79 |
| **Benthic Community** | | | | |
| Infaunal invert. (TL-II) | 2.46 | 0.005729 | | |
| Epifaunal invert. (TL-II) | 2.70 | 0.013991 | | |
| Forager (TL-III) | 3.52 | 0.014441 | 1.8 | |
| Predator (TL-IV) | 4.10 | 0.021541 | 1.3 | 2.3 |

Table K-4. The food web magnification factor (FWMF) calculated from the regression of ln(PCB) versus TL to obtain the slope (b) for the accumulation of each homolog in the pelagic, reef, and benthic communities modeled by PRAM.

| Food Chain | chemical | log(Kow) | b | $r^2$ | FWMF |
|---|---|---|---|---|---|
| PELAGIC | Mono | 4.474 | -1.488 | 1.00 | 0.23 |
| PELAGIC | Di | 5.236 | -0.9857 | 0.79 | 0.37 |
| PELAGIC | Tri | 5.521 | -0.4574 | 0.41 | 0.63 |
| PELAGIC | Tetra | 5.922 | 0.304 | 0.28 | 1.36 |
| PELAGIC | Penta | 6.4951 | 1.1852 | 0.94 | 3.27 |
| PELAGIC | Hexa | 6.9761 | 1.5136 | 0.99 | 4.54 |
| PELAGIC | Hepta | 7.19 | 1.5619 | 0.99 | 4.77 |
| PELAGIC | Nona | 8.351 | 1.2752 | 0.99 | 3.58 |
| PELAGIC | Deca | 9.603 | 0.2675 | 0.99 | 1.31 |
| REEF | Mono | 4.474 | 0.1444 | 0.00 | 1.16 |
| REEF | Di | 5.236 | 0.2575 | 0.03 | 1.29 |
| REEF | Tri | 5.521 | 0.6319 | 0.13 | 1.88 |
| REEF | Tetra | 5.922 | 1.316 | 0.38 | 3.73 |
| REEF | Penta | 6.4951 | 2.285 | 0.63 | 9.83 |
| REEF | Hexa | 6.9761 | 2.6 | 0.73 | 13.46 |
| REEF | Hepta | 7.19 | 2.597 | 0.77 | 13.42 |
| REEF | Nona | 8.351 | 2.3579 | 0.89 | 10.57 |
| REEF | Deca | 9.603 | 2.1129 | 0.79 | 8.27 |
| BENTHIC | Mono | 4.474 | -1.576 | 0.75 | 0.21 |
| BENTHIC | Di | 5.236 | -0.865 | 0.65 | 0.42 |
| BENTHIC | Tri | 5.521 | -0.34 | 0.28 | 0.71 |
| BENTHIC | Tetra | 5.922 | 0.3047 | 0.30 | 1.36 |
| BENTHIC | Penta | 6.4951 | 0.9336 | 0.83 | 2.54 |
| BENTHIC | Hexa | 6.9761 | 1.0687 | 0.85 | 2.91 |
| BENTHIC | Hepta | 7.19 | 1.0346 | 0.82 | 2.81 |
| BENTHIC | Nona | 8.351 | 0.5492 | 0.55 | 1.73 |
| BENTHIC | Deca | 9.603 | -0.4238 | 0.39 | 0.65 |

# **Appendix** K **Figures**

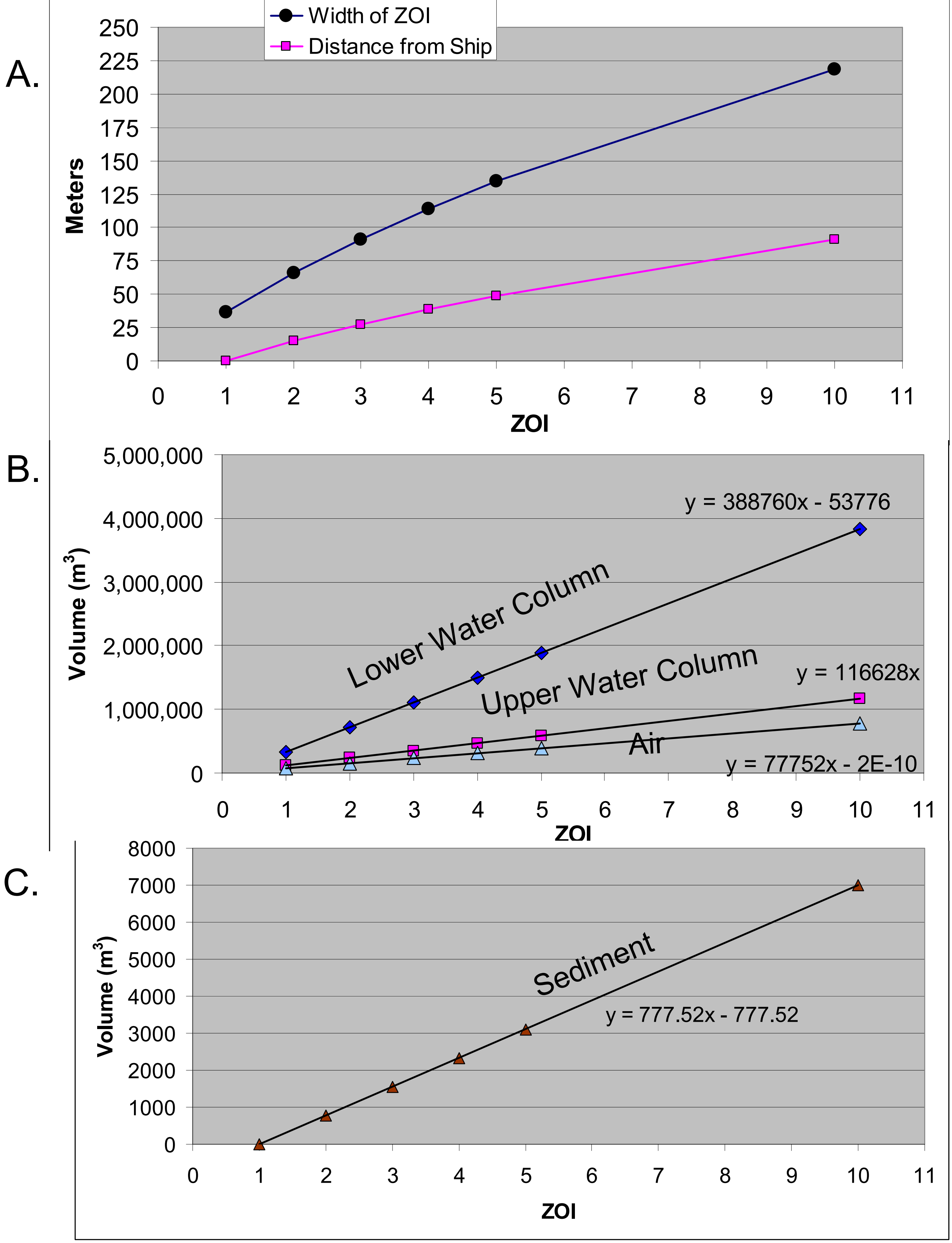
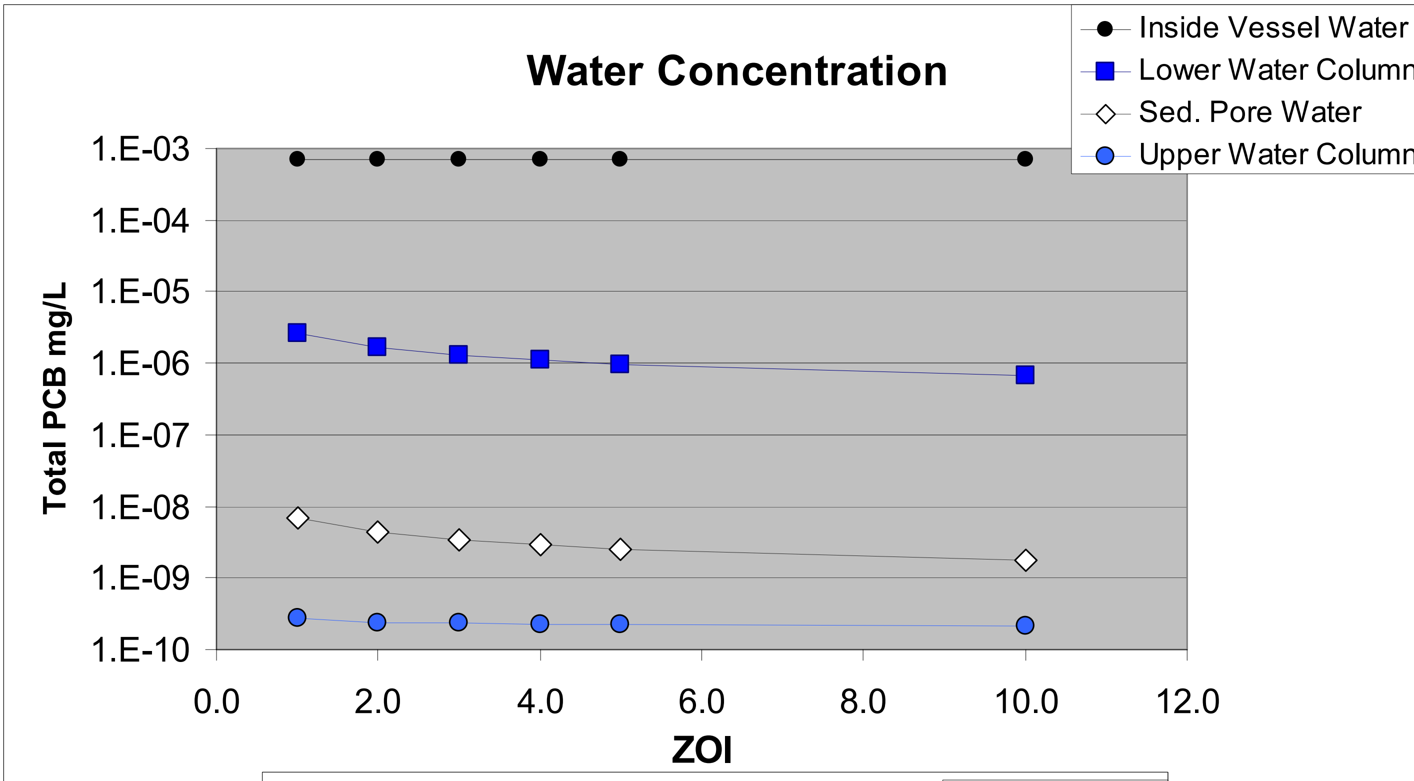
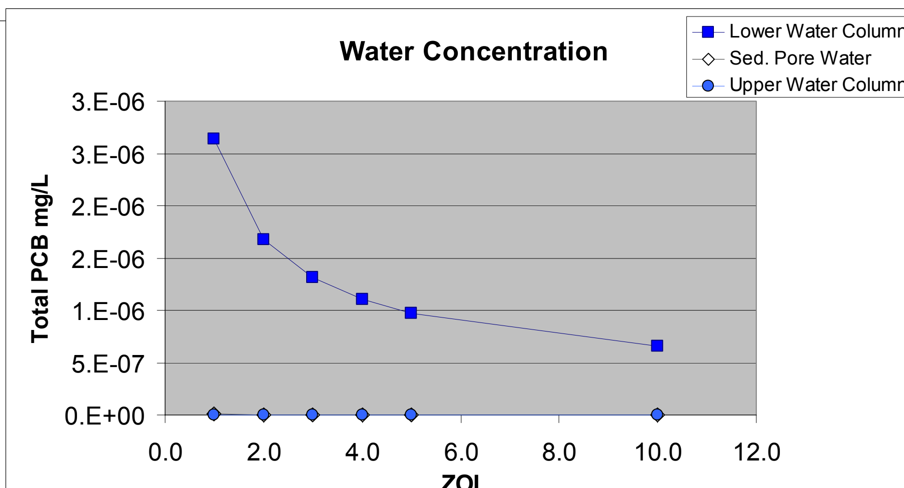



Fig. K-1. The change in physical dimensions of PRAM as a function of ZOI for distance from ship (A), the volumes of the upper and lower water columns (B), and the sediment bed (C). The interior vessel volume remains constant at $5.38 \times 10^4$ $m^3$.



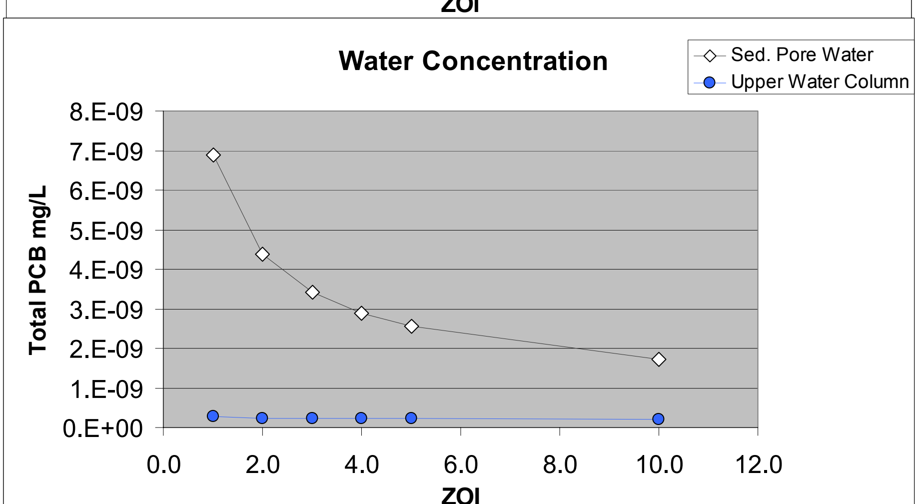
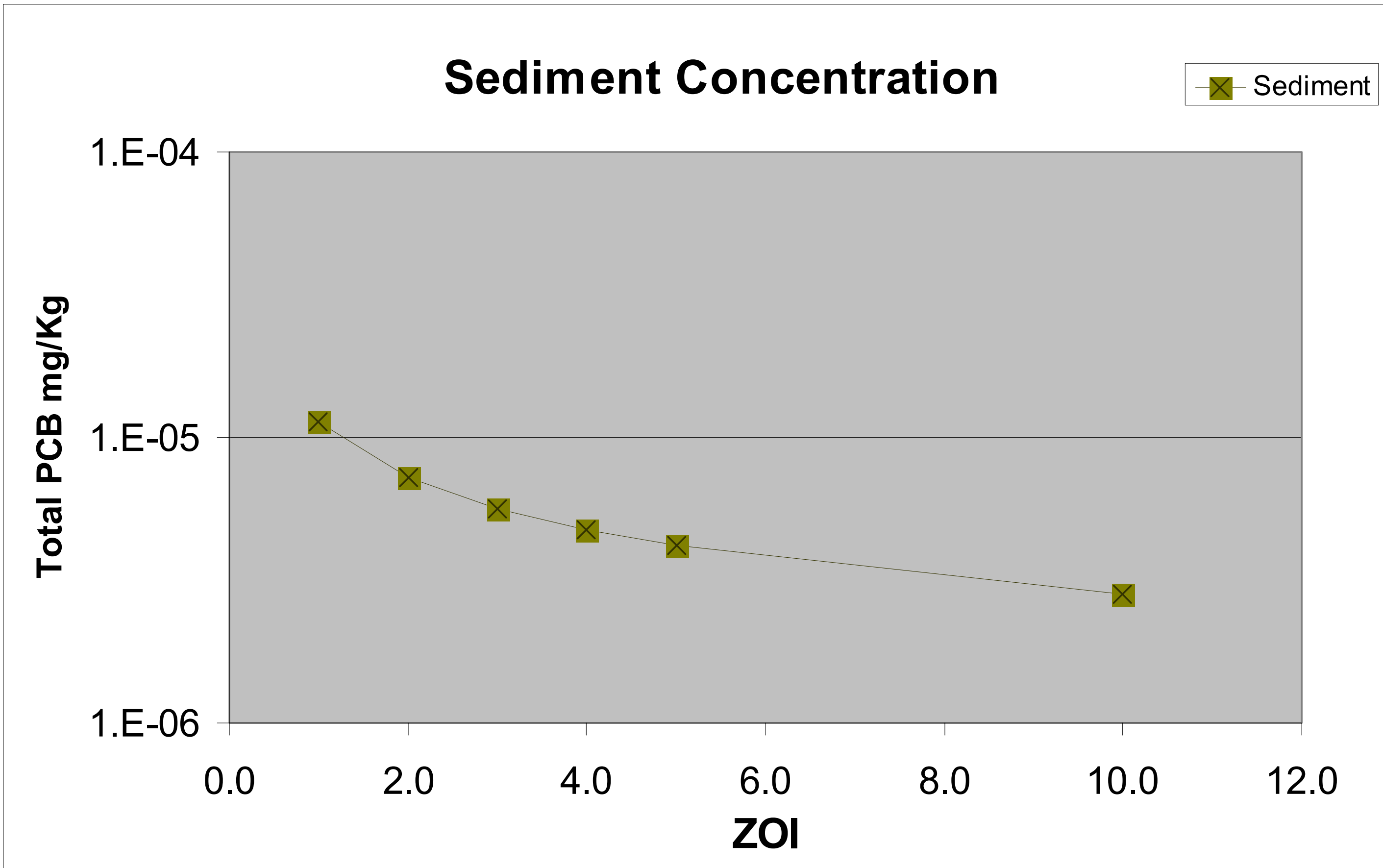




Fig. K-2. Changes in Total PCB concentration in bulk water compartments in PRAM as a function of changing ZOI. Note that the concentration of Total PCB inside the vessel did not change as a function of ZOI.



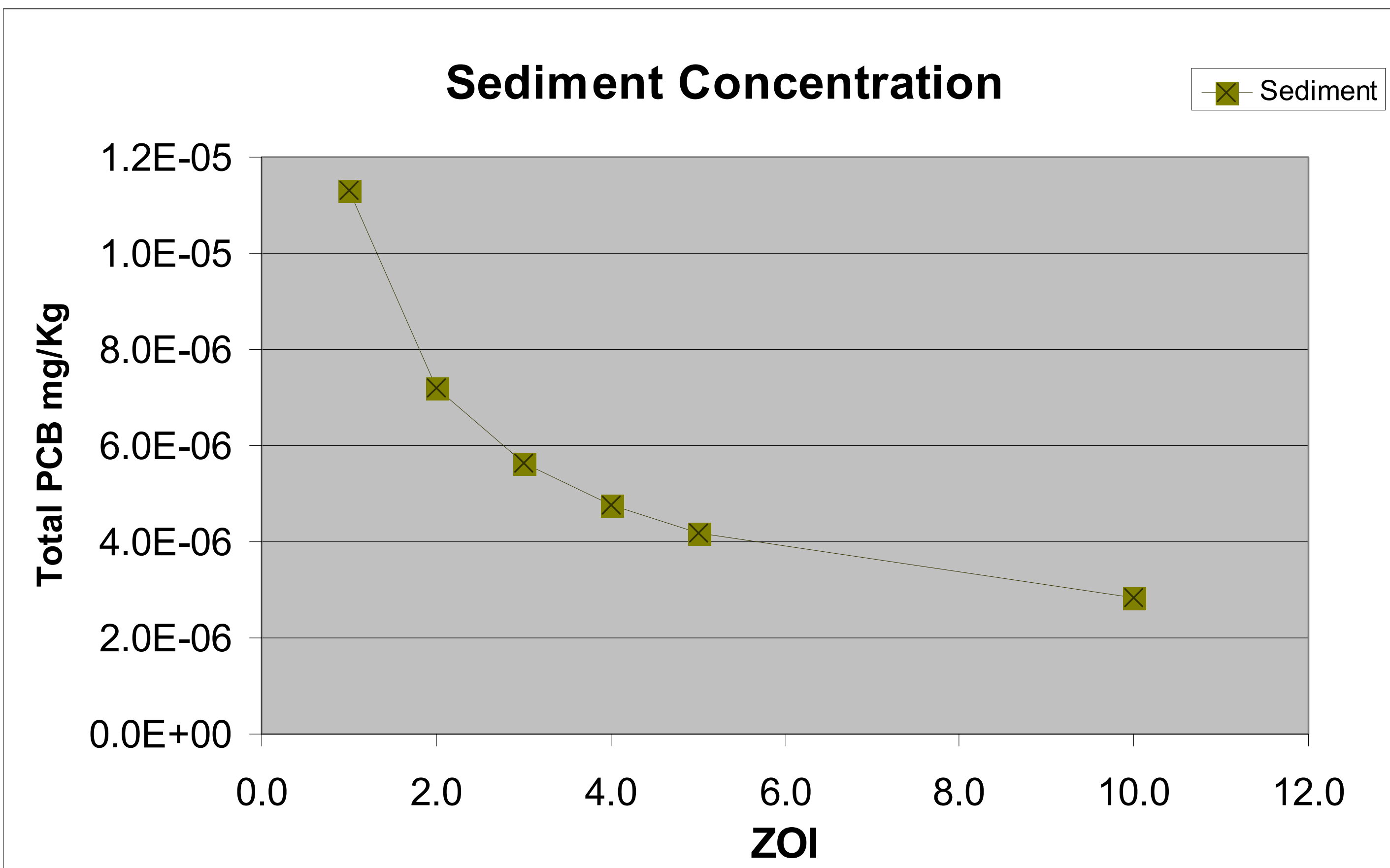
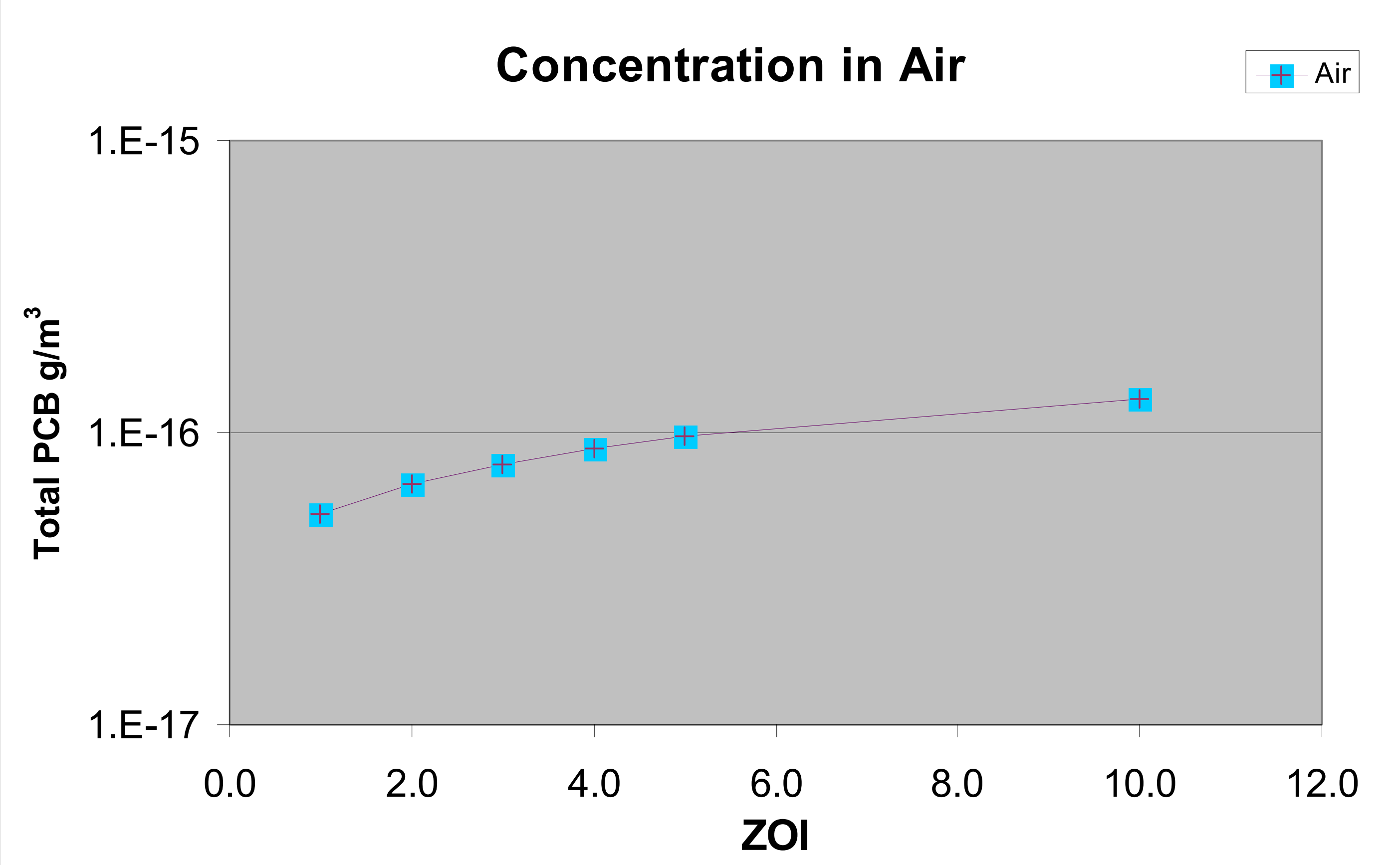




Fig. K-3. Concentrations of Total PCB in the bulk sediment compartment of PRAM as a function of ZOI.



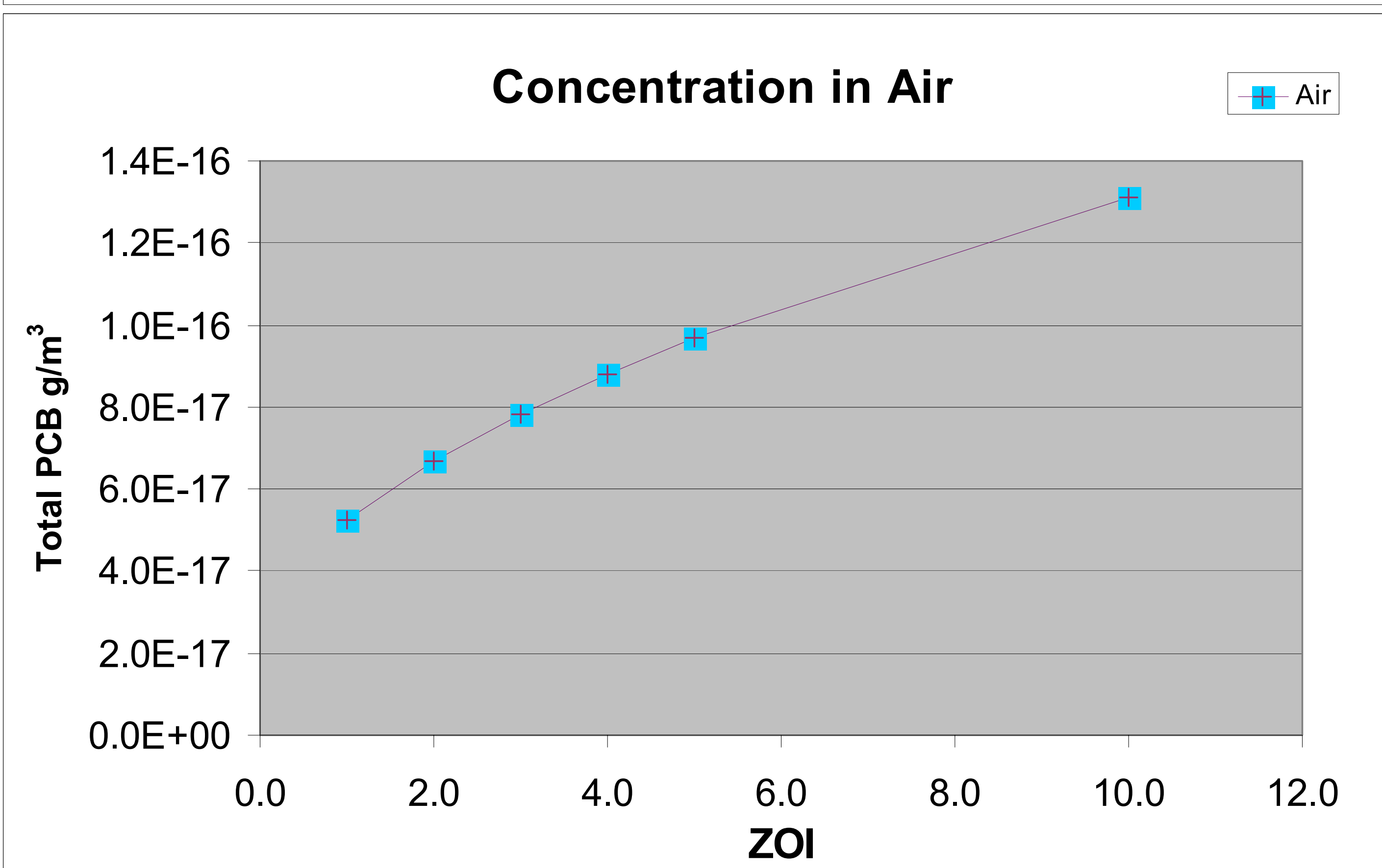




Fig. K-4. The concentration of Total PCB in the air compartment of PRAM as a function of ZOI.

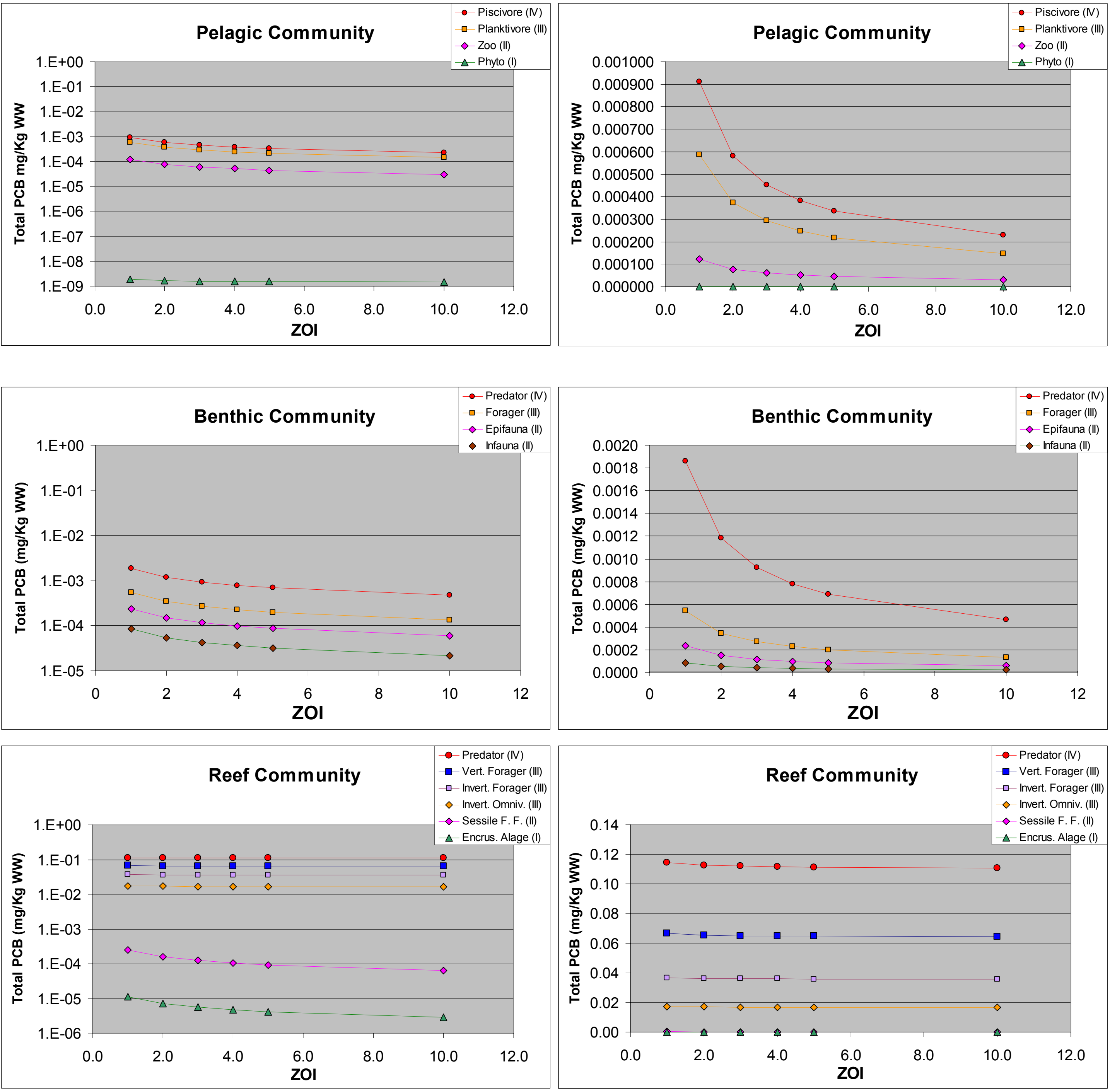



Fig. K-5. Change in concentration of Total PCB in food chains of pelagic, benthic, and reef communities modeled by PRAM as a function of changes in the ZOI. Data are ploted on log (left panels) and linear (right panels) y-axes.

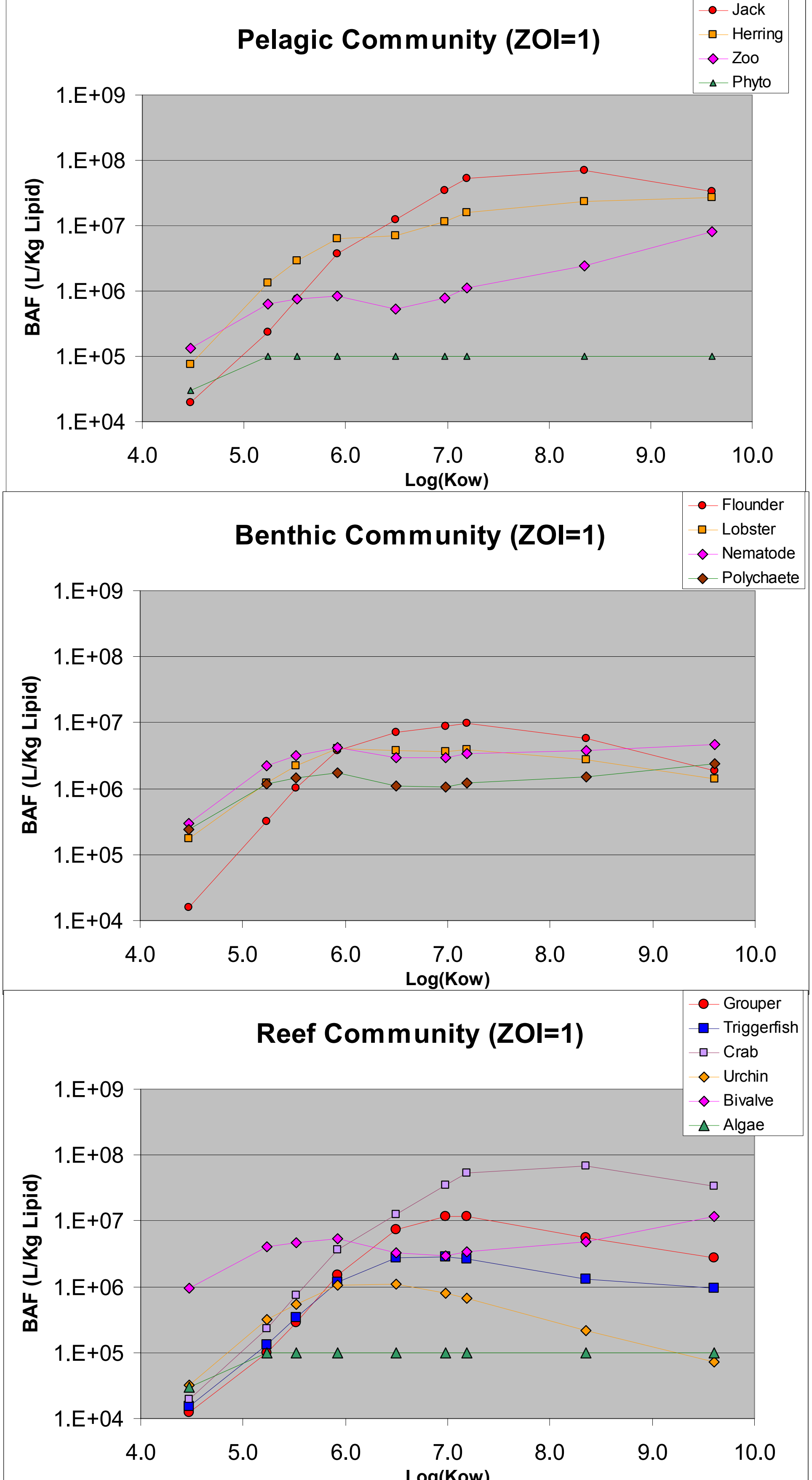



Fig. K-6. The $BAF_{LIPID}$ obtained from PRAM with a ZOI=1 for the components of the pelagic, benthic, and reef communities as a function of Log(Kow).

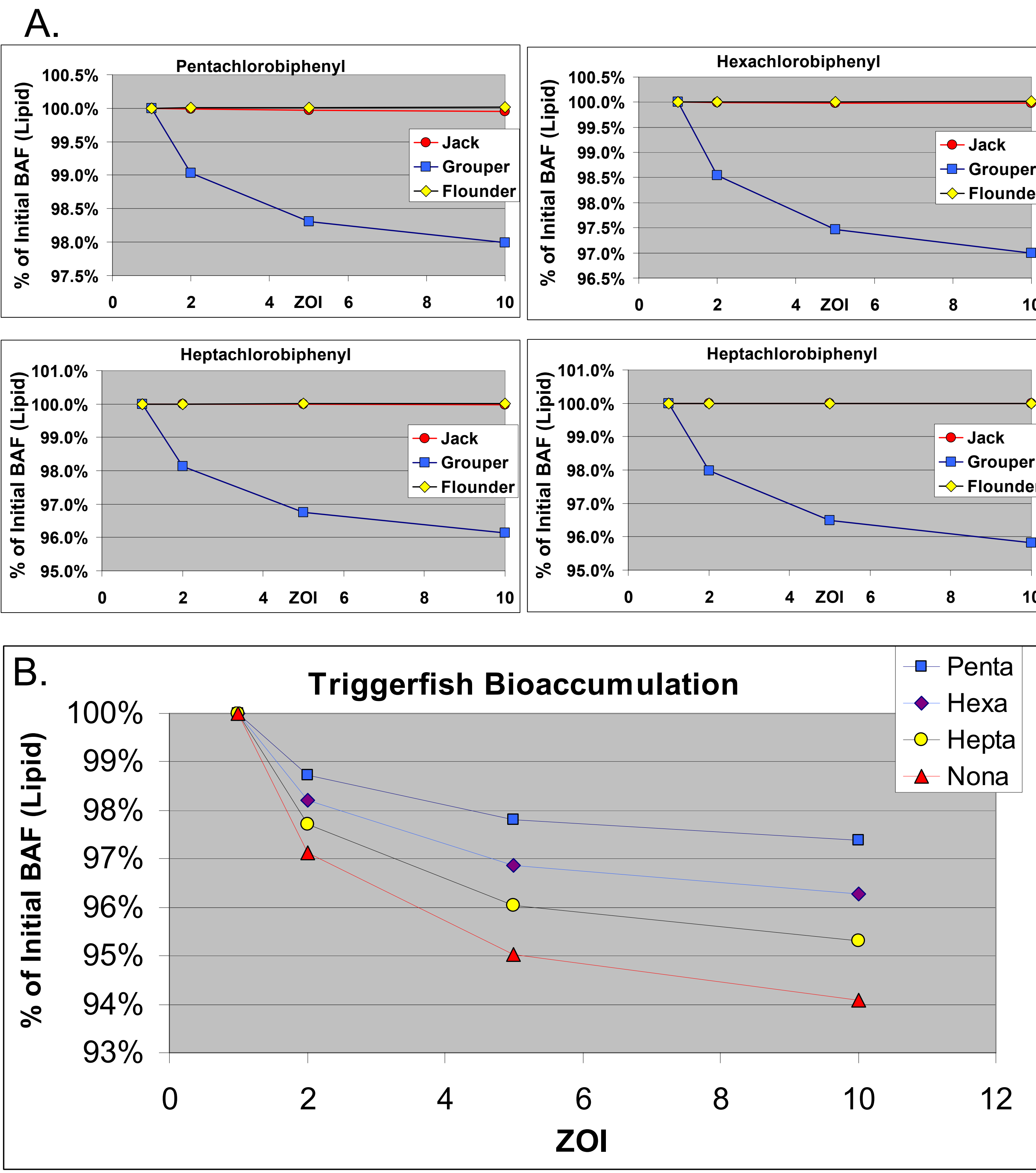



Fig. K-7. Changes in the $BAF_{LIPID}$ for the upper trophic level (TL=IV) fishes (A) and for triggerfish (TL=3, B) as a function of ZOI and homolog.

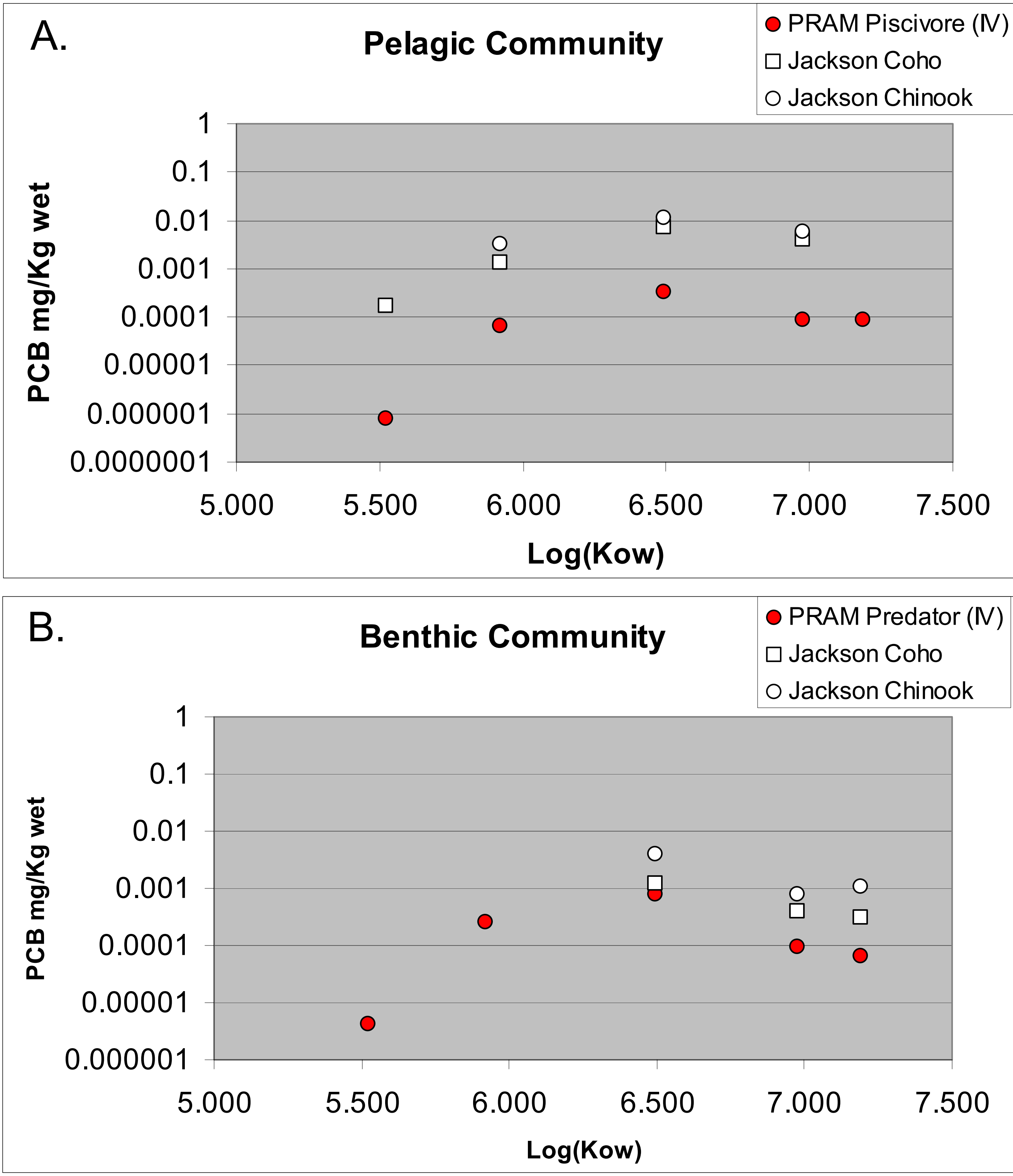



Fig. K-8. PCB homolog concentrations in top predators in the pelagic and benthic food chains predicted by PRAM compared to the concentrations predicted for Coho and Chinook salmon using the slope and intercept of the regressions reported by Jackson et al. 2001.

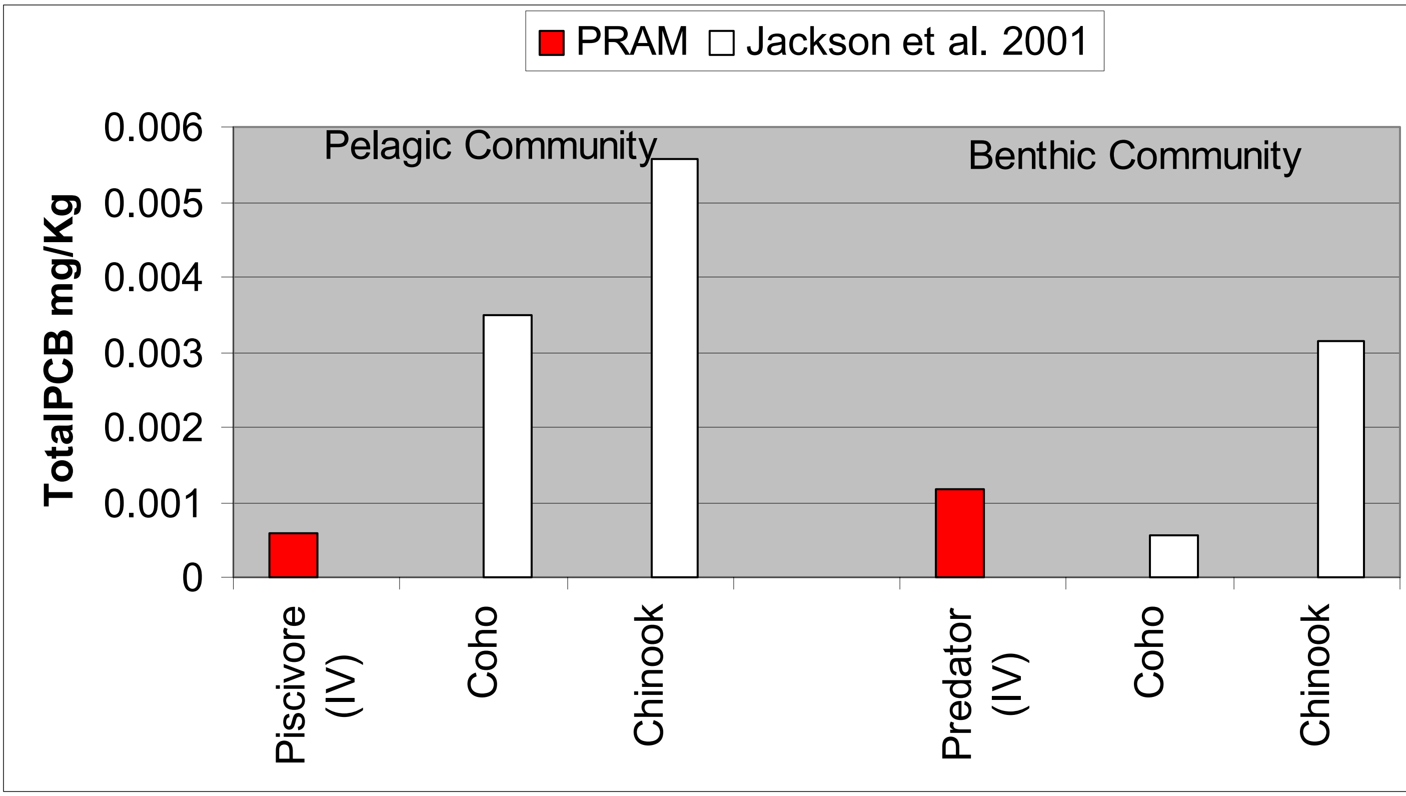
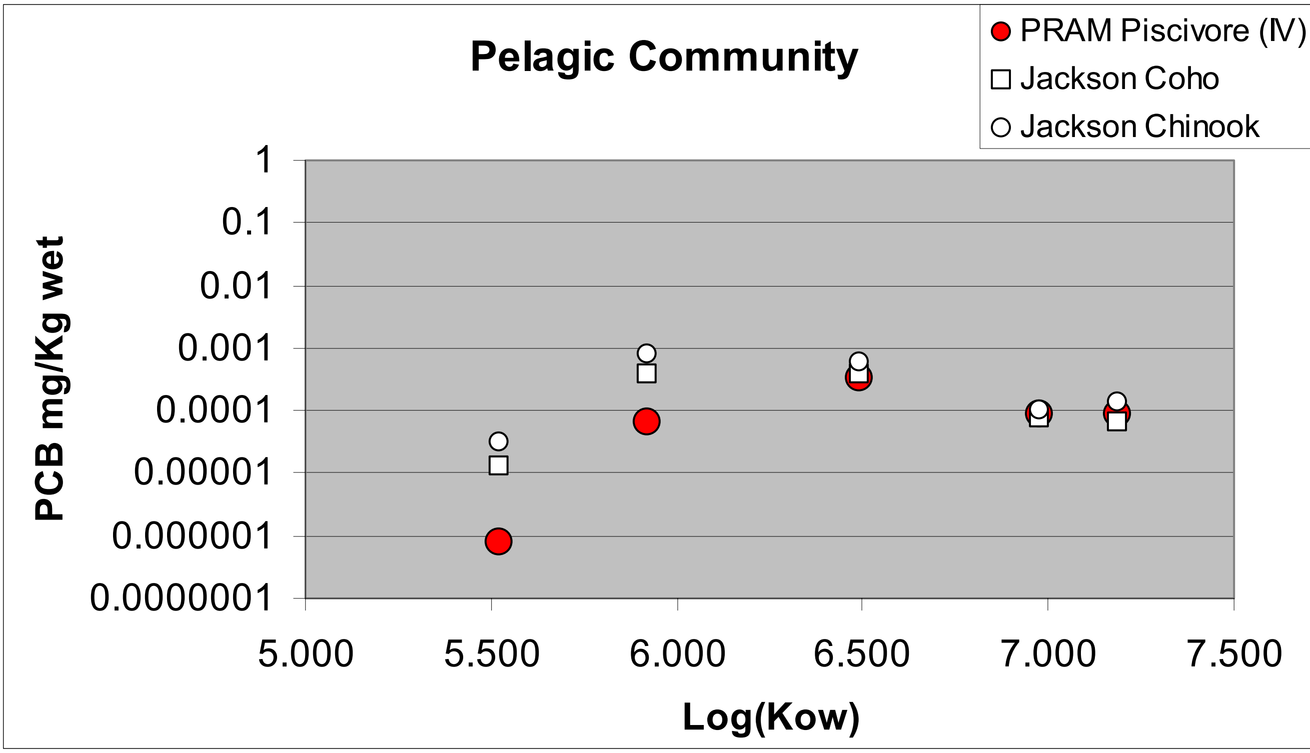



Fig. K-9. Total PCB concentrations in top predators in the Pelagic and Benthic food chains predicted by PRAM compared to the concentrations predicted for Coho and Chinook salmon using the slope and intercept of the regressions reported by Jackson et al. 2001.



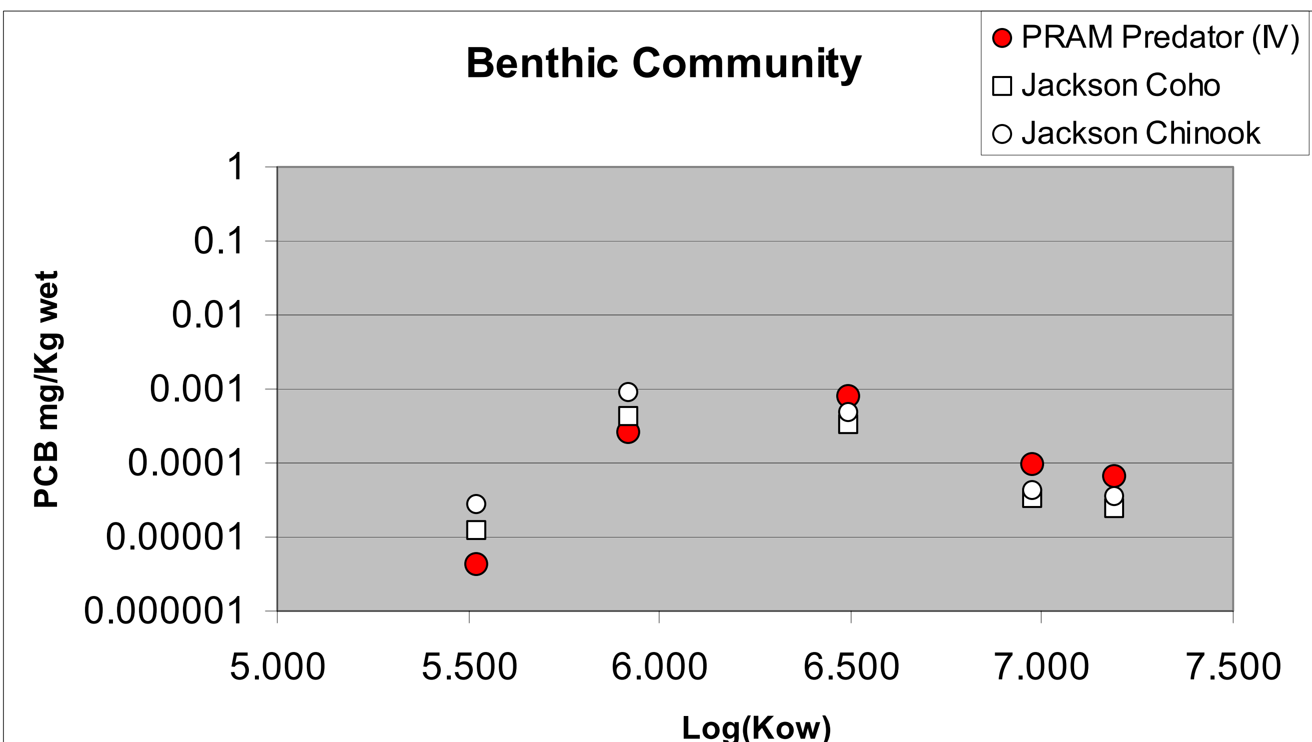




Fig. K-10. PCB homolog concentrations in top predators in the Pelagic and Benthic food chains predicted by PRAM compared to the concentrations predicted for Coho and Chinook salmon using <u>just the slope</u> of the regressions reported by Jackson et al. 2001.

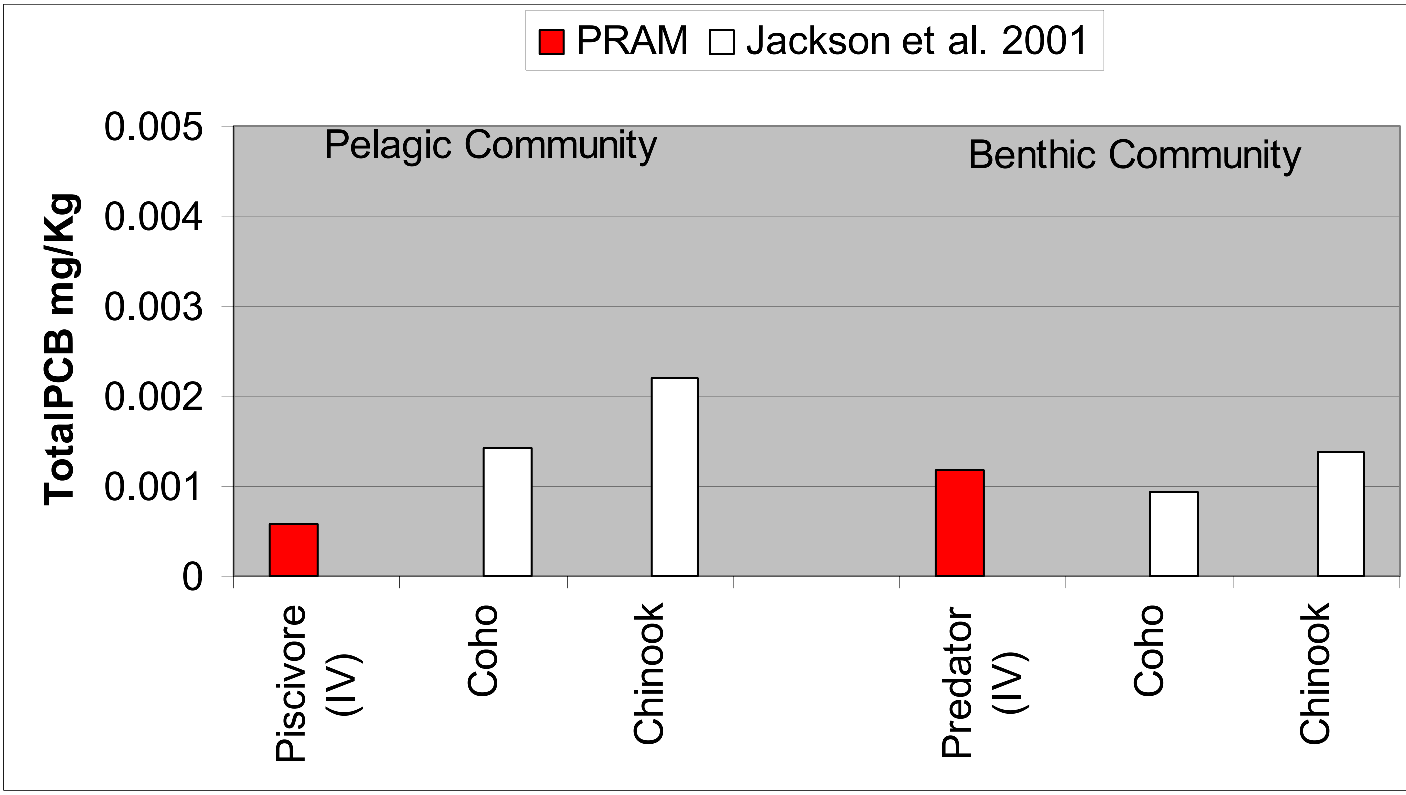



Fig. K-11. Total PCB concentrations in top predators in the Pelagic and Benthic food chains predicted by PRAM compared to the concentrations predicted for Coho and Chinook salmon using just the slope of the regressions reported by Jackson et al. 2001.

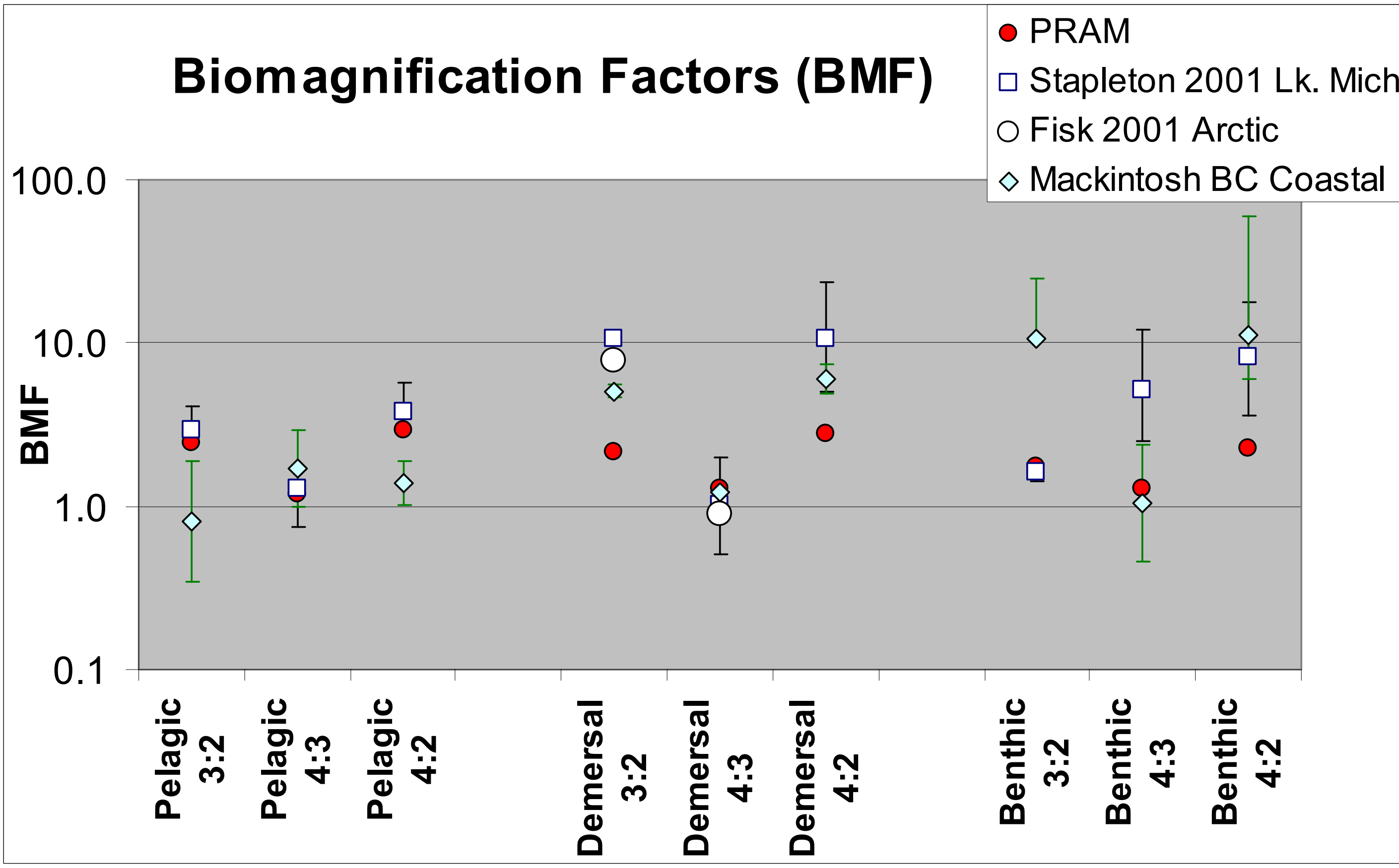


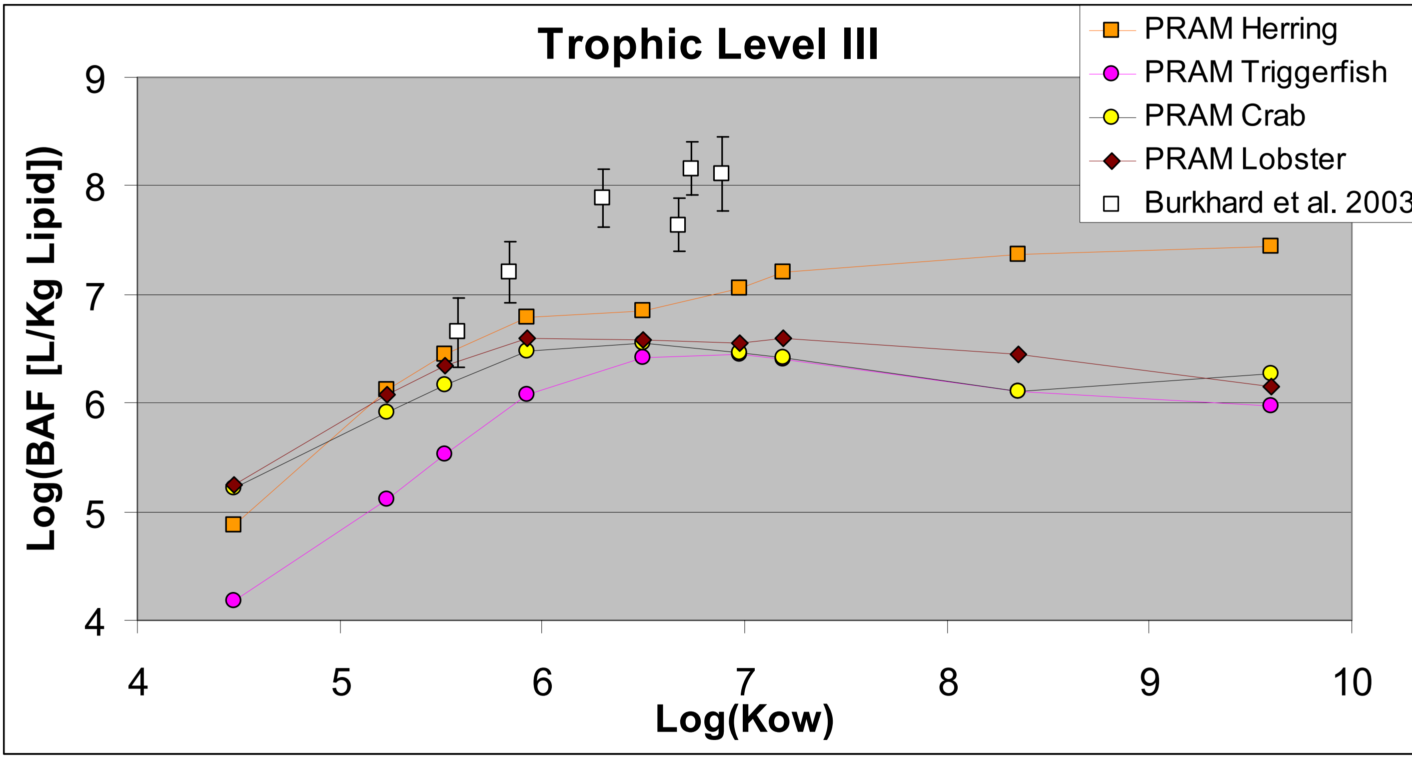

Fig. K-12. Comparison of PCB biomagnification factors ($BMF_{TLC}$) for trophic levels 3:2, 4:3, and 4:2 predicted by PRAM and observed in pelagic, demersal, and benthic food webs from Grand Traverse Bay, Lake Michigan (Stapleton et al. 2001), False Creek Harbor, Vancouver, BC Canada (Mackintosh et al. 2004), and a demersal food web from the Northwater Polynya, Arctic (Fisk, Hobson, & Norstrom 2001).

**TABLE 3. Coefficients of Variation (CV) and Average Log $BAF_L^{fd}$ Values and Log $BAF_T^t$ Values Across 13 Fish Species and Three Ecosystems for Six PCB Congeners**

| PCB congener | log $K_{ow}$ | log $BAF_L^{fd}$ | CV (%)[a] | log $BAF_T^t$ | CV (%)[a] |
|---|---|---|---|---|---|
| | | Trophic Level 3 (9 Fish Species) | | | |
| PCB 22 | 5.58 | 6.65 ± 0.32 (48)[b] | 85 | 4.98 ± 0.40 (46) | 116 |
| PCB 52 | 5.84 | 7.20 ± 0.28 (45) | 73 | 5.52 ± 0.35 (45) | 97 |
| PCB 85 | 6.30 | 7.89 ± 0.27 (44) | 70 | 5.81 ± 0.37 (44) | 104 |
| PCB 118 | 6.74 | 8.16 ± 0.25 (41) | 61 | 5.80 ± 0.37 (44) | 104 |
| PCB 146 | 6.89 | 8.11 ± 0.34 (41) | 92 | 6.05 ± 0.83 (28) | 615 |
| PCB 149 | 6.67 | 7.64 ± 0.24 (38) | 59 | 5.54 ± 0.27 (41) | 68 |
| | | Trophic Level 4 (4 Fish Species) | | | |
| PCB 22 | 5.58 | 6.74 ± 0.32 (24) | 86 | 5.32 ± 0.38 (23) | 109 |
| PCB 52 | 5.84 | 7.39 ± 0.28 (23) | 73 | 5.91 ± 0.34 (23) | 92 |
| PCB 85 | 6.30 | 8.16 ± 0.27 (22) | 70 | 6.31 ± 0.37 (22) | 102 |
| PCB 118 | 6.74 | 8.42 ± 0.24 (21) | 61 | 6.28 ± 0.36 (22) | 101 |
| PCB 146 | 6.89 | 8.44 ± 0.36 (21) | 99 | 6.74 ± 0.87 (15) | 752 |
| PCB 149 | 6.67 | 7.94 ± 0.26 (20) | 66 | 6.07 ± 0.29 (21) | 74 |

[a] Arithmetic. [b] Average ± standard deviation (number of data points).

Fig. K-13. $BAF_{LIPID}$ s reported for PCB congeners in Burkhard et al. (2003).



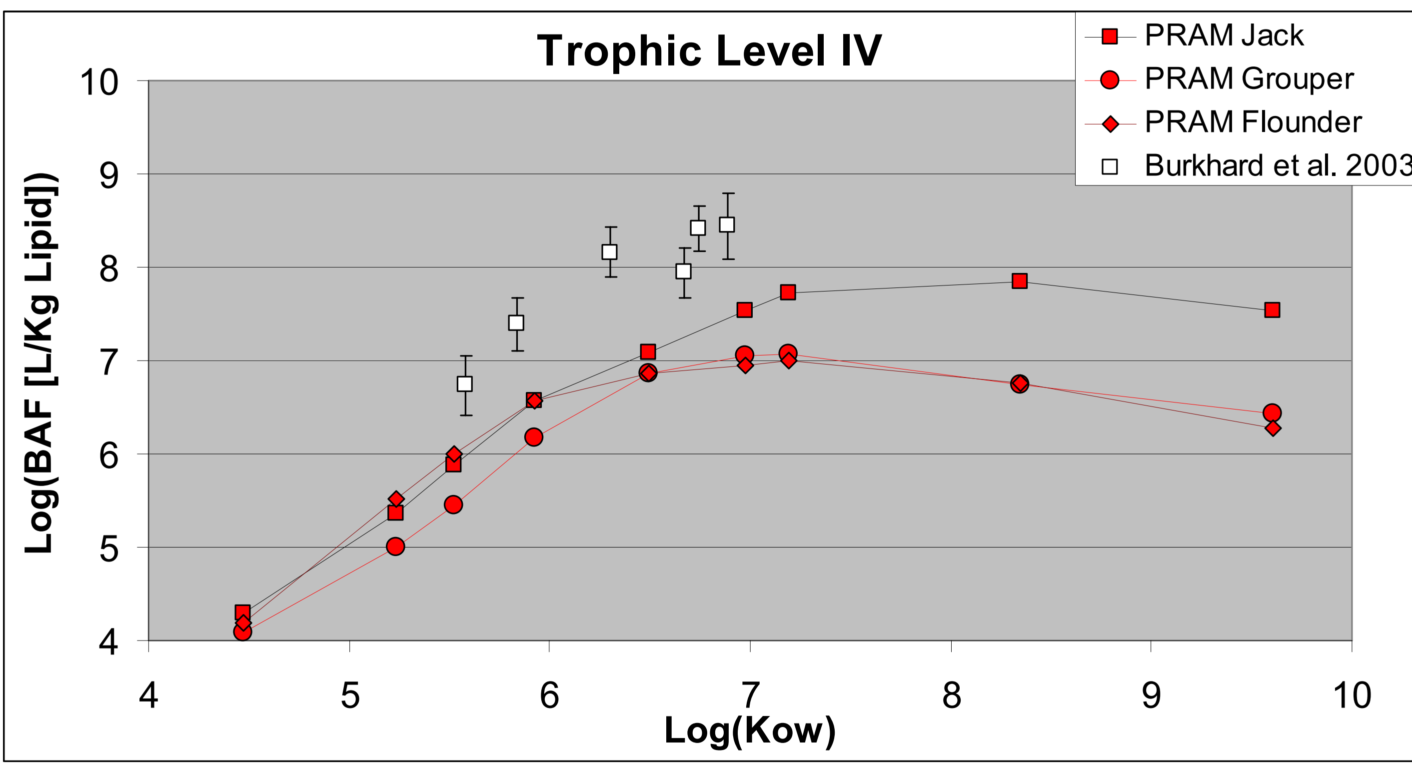




Fig. K-14. Comparison of the lipid-based bioaccumulation factors ($BAF_{LIPID}$ s) predicted by PRAM and BAFs reported in the literature from Green Bay Lake Michigan, the Hudson River, and Lake Ontario for Trophic Level III (A) and Trophic Level IV (B) predators.

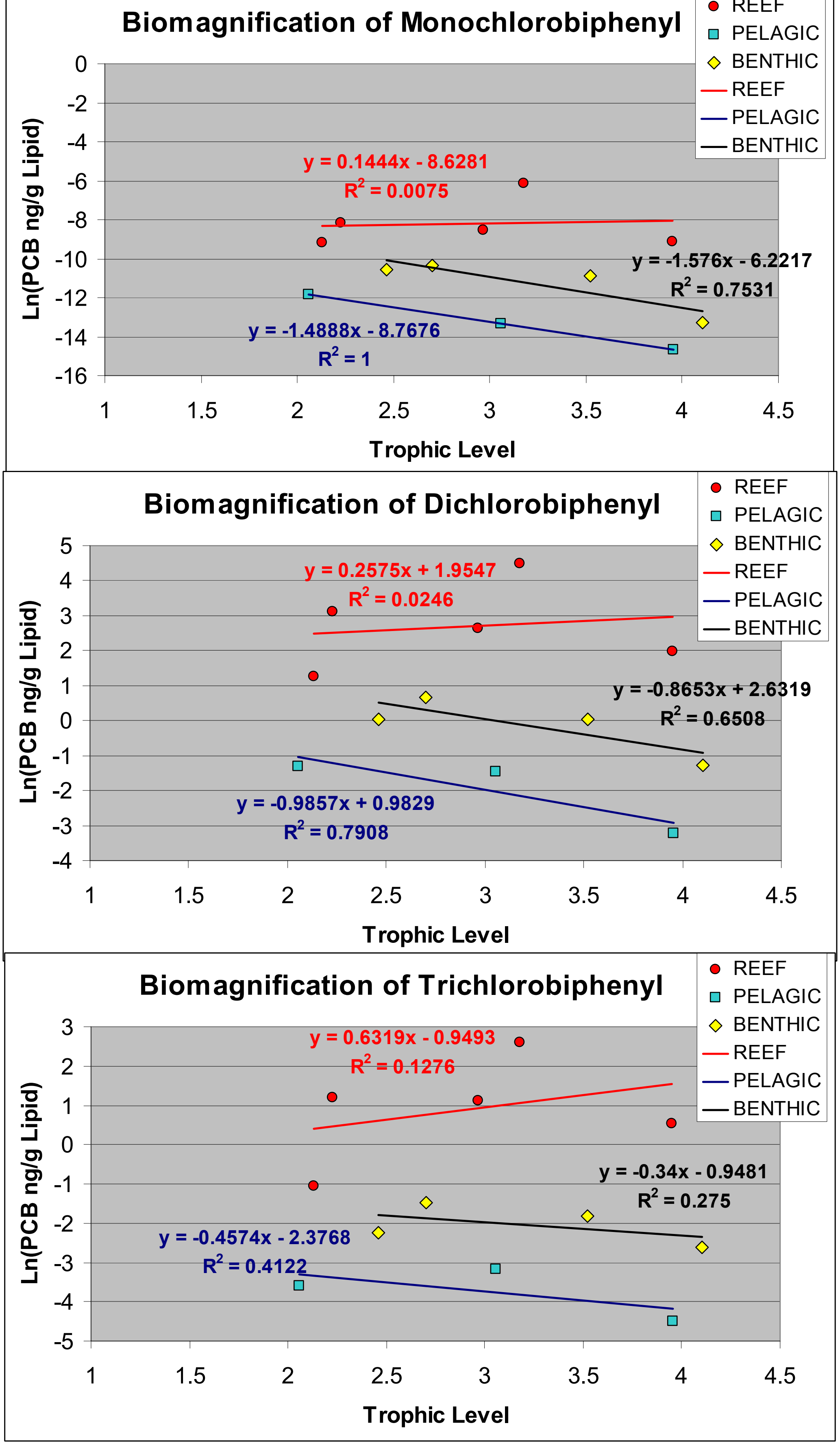



Fig. K-15. Biomagnification of mono-, di-, and trichlorobiphenyl predicted by PRAM.

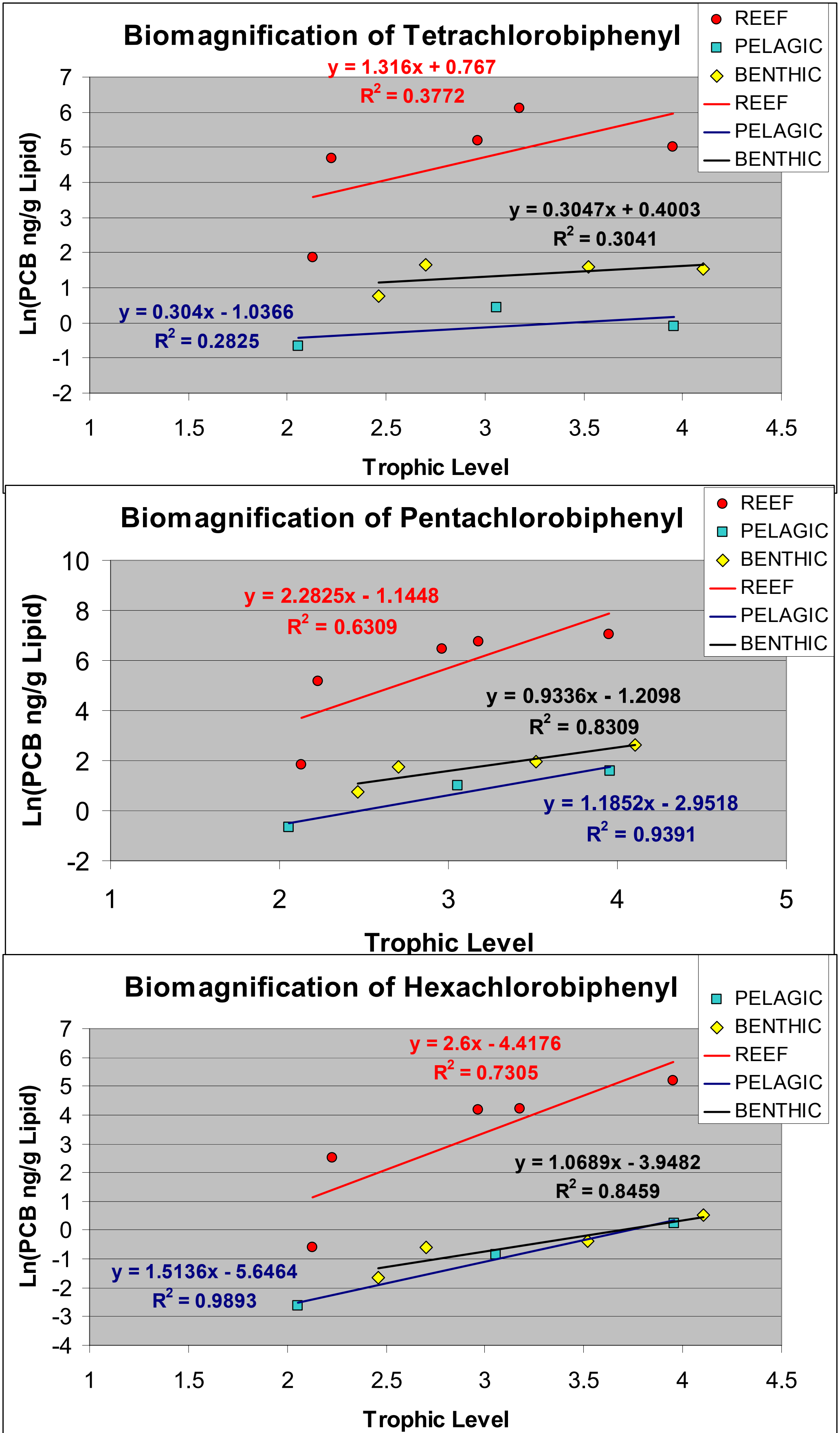



Fig. K-16. Biomagnification of tetra-, penta-, and hexachlorobiphenyl predicted by PRAM.

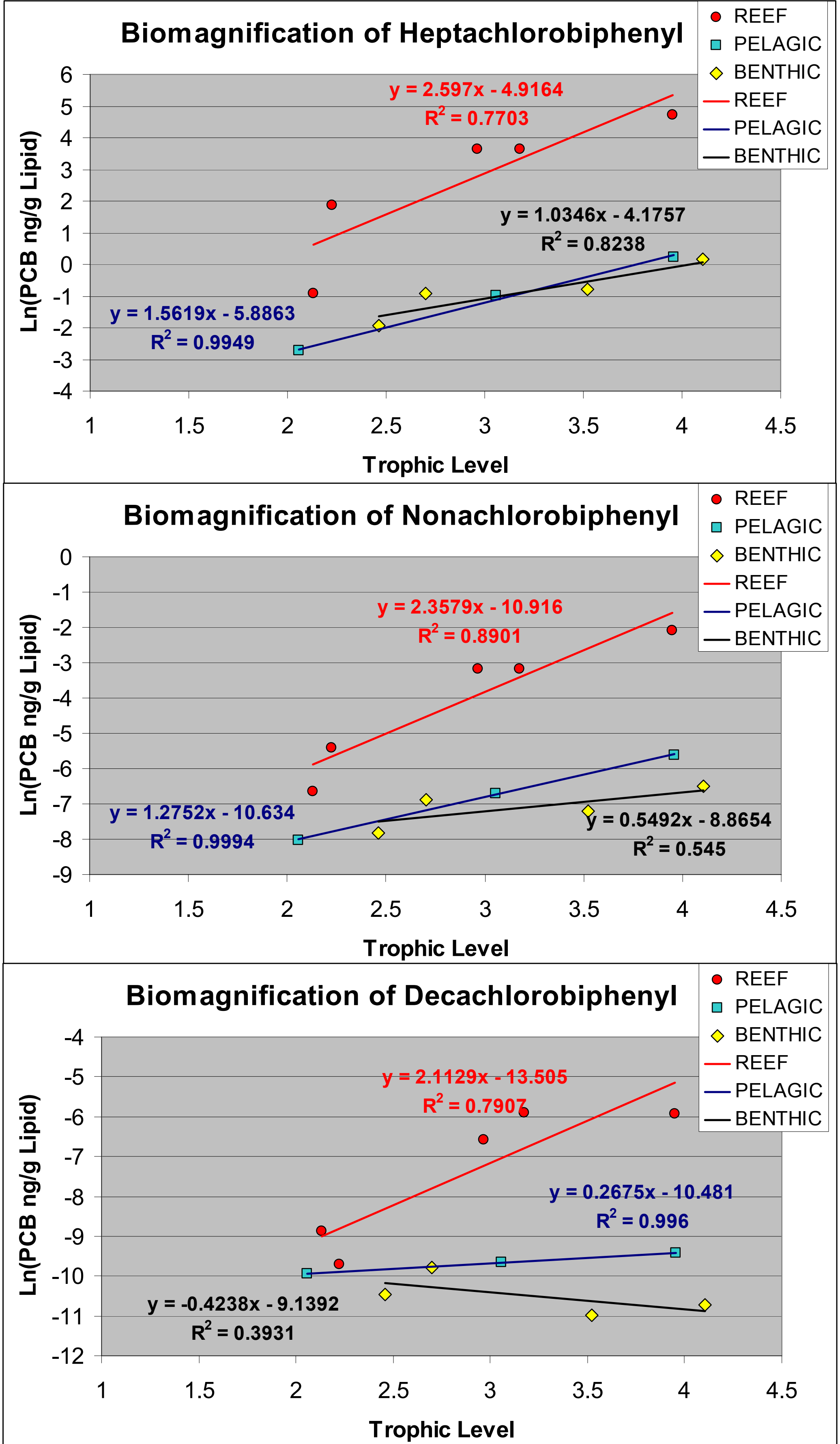
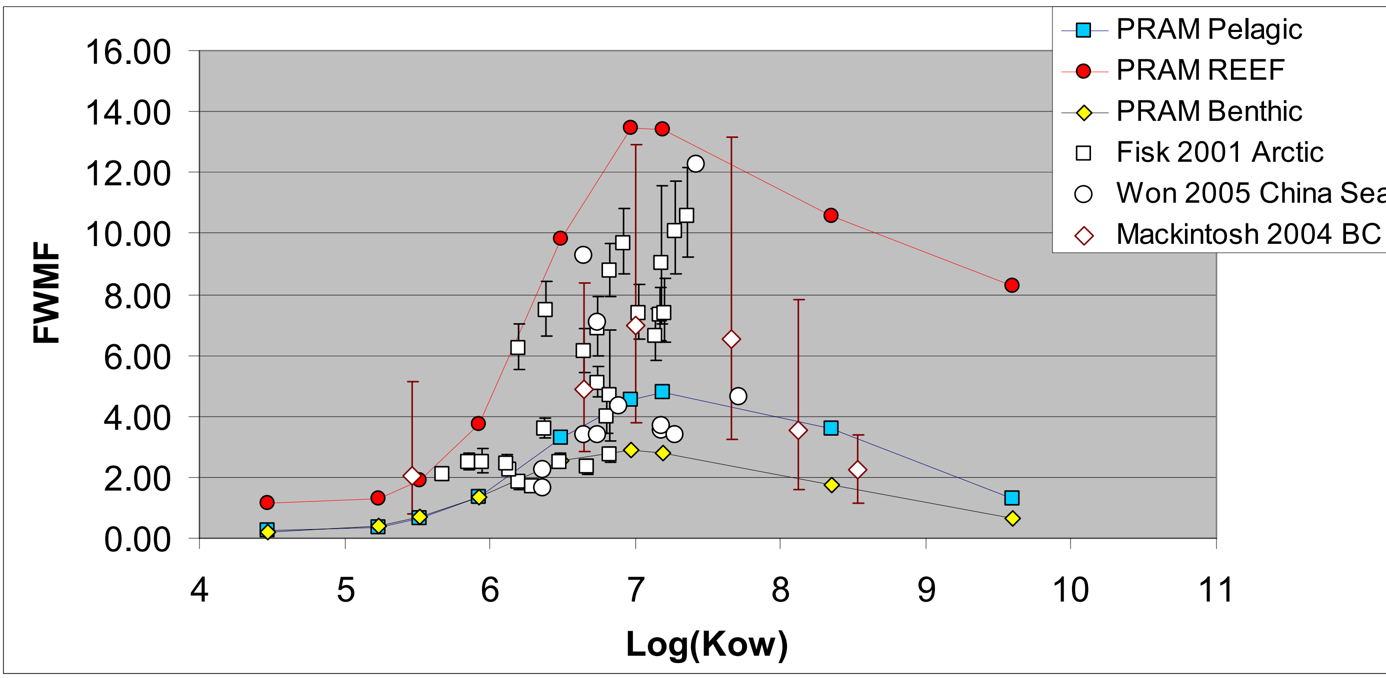



Fig. K-17. Biomagnification of hepta-, nona-, and decachlorobiphenyl predicted by PRAM.




error bars on Mackintosh 2004 are 95th% CL
error bars on Fisk 2001 are +/- 1 Std error

Fig. K-18. Comparison of the food web magnification factor (FWMF) predicted by PRAM for the pelagic, reef, and benthic communities and the FWMF reported in the literature for food webs from the Arctic (Fisk et al. 2001), China Sea (Wan et al. 2005), and coastal British Columbia (Mackintosh et al. 2004).

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## Appendix K.2 PRAM Output for Varying ZOI

### K.2.1 PRAM Output ZOI = 1

**Risk Estimate**

**Supplemental Information**

### K.2.2 PRAM Default Parameters (ZOI =2 )

**Risk Estimate**

**Supplemental Information**

### K.2.3 PRAM Output ZOI = 3

**Risk Estimate**

**Supplemental Information**

### K.2.4 PRAM Output ZOI = 4

**Risk Estimate**

**Supplemental Information**

### K.2.5 PRAM Output ZOI = 5

**Risk Estimate**

**Supplemental Information**

### K.2.6 PRAM Output ZOI = 10

**Risk Estimate**

**Supplemental Information**

### K.2.7 Summary of Total PCBs concentrations modeled for biological and abiotic compartments as a function of ZOI.

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION

***RISK ESTIMATES FOR Ex-Oriskany CV34***

| ZOI = 1 | Cancer Risk Adult & Child | | Hazard Adult & Child | | Cancer Risk Child | | Hazard Child | |
|---|---|---|---|---|---|---|---|---|
| ***RISK ESTIMATES*** | RME | CTE | RME | CTE | RME | CTE | RME | CTE |
| Benthic fish (flounder) | 1.15E-07 | 8.88E-09 | 6.69E-03 | 1.53E-03 | 3.36E-08 | 6.82E-09 | 9.81E-03 | 1.77E-03 |
| Benthic shellfish (lobster) | 3.33E-08 | 2.58E-09 | 1.95E-03 | 4.46E-04 | 9.79E-09 | 1.98E-09 | 2.85E-03 | 5.15E-04 |
| Pelagic fish (jack) | 5.61E-08 | 4.35E-09 | 3.28E-03 | 7.51E-04 | 1.65E-08 | 3.34E-09 | 4.81E-03 | 8.66E-04 |
| Reef fish TL-IV (grouper) | 7.05E-06 | 5.46E-07 | 4.11E-01 | 9.44E-02 | 2.07E-06 | 4.20E-07 | 6.04E-01 | 1.09E-01 |
| Reef fish TL-III (triggerfish) | 4.10E-06 | 3.17E-07 | 2.39E-01 | 5.48E-02 | 1.20E-06 | 2.44E-07 | 3.51E-01 | 6.32E-02 |
| Reef shellfish (crab) | 2.26E-06 | 1.75E-07 | 1.32E-01 | 3.02E-02 | 6.63E-07 | 1.35E-07 | 1.93E-01 | 3.49E-02 |

| ***PREDICTED EXPOSURE CONCENTRATIONS (mg/kg in fresh weight)*** | |
|---|---|
| Benthic fish (flounder) | 1.86E-03 |
| Benthic shellfish (lobster) | 5.42E-04 |
| Pelagic fish (jack) | 9.13E-04 |
| Reef fish TL-IV (grouper) | 1.15E-01 |
| Reef fish TL-III (triggerfish) | 6.66E-02 |
| Reef shellfish (crab) | 3.67E-02 |

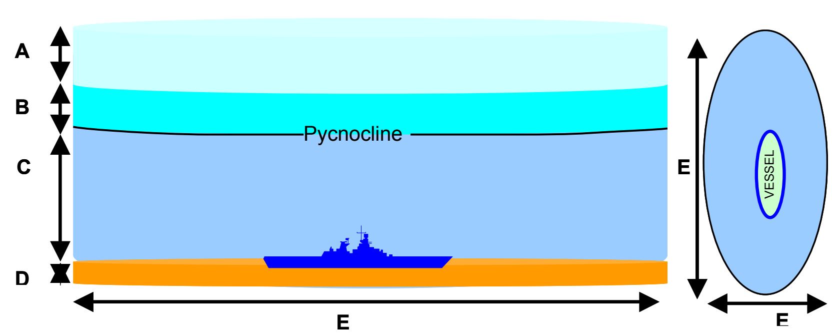
| ***RISK INPUTS - Adult*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 70 | 70 |
| Ingestion Rate (IRc) (kg/day) | 0.0261 | 0.0072 |
| Exposure Duration (EDc) (years) | 24 | 3 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 0.00002 | 0.000045 |
| Averaging Time for noncancer (ATnc-child) | 8.76E+03 | 1.10E+03 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |

| ***RISK INPUTS - Child*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 15 | 15 |
| Ingestion Rate (IRc) (kg/day) | 0.0092916 | 0.0025632 |
| Exposure Duration (EDc) (years) | 6 | 6 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 0.00002 | 0.000045 |
| Averaging Time for noncancer (ATnc-child) | 2.19E+03 | 2.19E+03 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |
| Child - Adult IR scaling factor | 0.356 | |

| | |
|---|---|
| Zone of Influence Multiplier | 1 |
| Scenario run on | 5/31/05 14:31 |

| ***PCB-LADEN MATERIAL INPUTS*** | Fraction PCB | Release Rate (ng/g-d) | kg Material Onboard | PCB Release (ng/day) |
|---|---|---|---|---|
| Ventilation Gaskets | 3.14E-05 | 1.58E+03 | 1.46E+03 | 7.23E+04 |
| Lubricants | 1.03E-04 | 2.20E+03 | 0.00E+00 | 0.00E+00 |
| Foam Rubber Material | 0.76% | 2.62E+00 | 0.00E+00 | 0.00E+00 |
| Black Rubber Material | 5.29E-05 | 1.58E+03 | 5.40E+03 | 4.50E+05 |
| Electrical Cable | 1.85E-03 | 2.79E+02 | 2.96E+05 | 1.53E+08 |
| Bulkhead Insulation Material | 5.37E-04 | 6.76E+04 | 1.44E+04 | 5.22E+08 |
| Aluminum Paint | 2.00E-05 | 1.11E+04 | 3.87E+05 | 8.62E+07 |
| Total | | | | 7.62E+08 |

| Ex-Oriskany CV34 | |
|---|---|
| Ex-Oriskany CV34 | 27100 |
| Length (ft) | 888 |
| Beam (ft) | 120 |




| ZOI = | 1 | |
|---|---|---|
| Spatial Footprint on Ocean Floor | | |
| | 7.78E+03 | m2 |
| | 3.00E-03 | mile2 |
| Modeled Dimensions Outside the Vessel | | |
| A | 1.00E+01 | m |
| B | 1.50E+01 | m |
| C | 5.00E+01 | m |
| D | 1.00E-01 | m |
| E | 2.71E+02 | m |
| F | 3.66E+01 | m |
| Volumes | | |
| Air Column | | |
| Air | 7.78E+04 | m3 |
| Upper Water Column | | |
| Water | 1.17E+05 | m3 |
| TSS | 7.78E-01 | m3 |
| Lower Water Column | | |
| Water | 3.35E+05 | m3 |
| TSS | 2.23E+00 | m3 |
| Inside Vessel | | |
| Water | 5.38E+04 | m3 |
| TSS | 3.59E-01 | m3 |
| Sediment Bed | | |
| Sediment | 0.00E+00 | m3 |

| Abiotic Inputs | |
|---|---|
| Air Column | |
| Active air space height above water column (m) | 10 |
| Air current (m/h) | 13677 |
| Upper Water Column | |
| Temperature (oC) | 24.5 |
| Water depth (m) | 15 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 6.12 |
| Lower Water Column | |
| Temperature (oC) | 19.5 |
| Water depth (m) | 50 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Inside Vessel | |
| Temperature (oC) | 19.5 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Sediment Bed | |
| Sediment density (g/cm3) | 1.5 |
| Active sediment depth (m) | 0.1 |
| Sediment fraction organic carbon | 0.01 |
| All Regions | |
| Suspended solids density (g/cm3) | 1.5 |
| Suspended solids fraction organic carbon | 0.15 |
| Dissolved organic carbon density (g/cm3) | 1 |
| Water current - to out of the ZOI (m/h) | 926 |
| Water current - inside to outside the vessel (m/h) | 9.26 |

| Total PCB concentrations | | |
|---|---|---|
| Air Column | | |
| Air | 5.26E-17 | g/m3 |
| Upper Water Column | | |
| Freely dissolved in water | 1.13E-12 | mg/L |
| Suspended solids | 1.48E-08 | mg/kg |
| Dissolved organic carbon | 1.98E-07 | mg/kg |
| Lower Water Column | | |
| Freely dissolved in water | 6.90E-09 | mg/L |
| Suspended solids | 1.70E-04 | mg/kg |
| Dissolved organic carbon | 1.55E-03 | mg/kg |
| Inside Vessel | | |
| Freely dissolved in water | 1.80E-06 | mg/L |
| Suspended solids | 4.44E-02 | mg/kg |
| Dissolved organic carbon | 4.06E-01 | mg/kg |
| Sediment Bed | | |
| Freely dissolved in pore water | 6.90E-09 | mg/L |
| Bedded sediment | 1.13E-05 | mg/kg |
| Dissolved organic carbon in pore water | 1.55E-03 | mg/kg |

| Total PCB concentrations in biota | | | Percent Exposures | |
|---|---|---|---|---|
| Pelagic Community | | | Upper WC | Lower WC |
| Phytoplankton (TL-I) | 1.86E-09 | mg/kg | 100% | 0% |
| Zooplankton (TL-II) | 1.21E-04 | mg/kg | 50% | 50% |
| Planktivore (TL-III) | 5.88E-04 | mg/kg | 80% | 20% |
| Piscivore (TL-IV) | 9.13E-04 | mg/kg | 80% | 20% |
| Reef / Vessel Community | | | Lower WC | Vessel Int. |
| Attached Algae (TL-I) | 1.14E-05 | mg/kg | 100% | 0% |
| Sessile filter feeder (TL-II) | 2.49E-04 | mg/kg | 100% | 0% |
| Invertebrate Omnivore (TL-II) | 1.72E-02 | mg/kg | 80% | 20% |
| Invertebrate Forager (TL-III) | 3.67E-02 | mg/kg | 70% | 30% |
| Vertebrate Forager (TL-III) | 6.66E-02 | mg/kg | 70% | 30% |
| Predator (TL-IV) | 1.15E-01 | mg/kg | 80% | 20% |
| Benthic Community | | | Lower WC | Pore Water |
| Infaunal invert. (TL-II) | 8.62E-05 | mg/kg | 20% | 80% |
| Epifaunal invert. (TL-II) | 2.37E-04 | mg/kg | 50% | 50% |
| Forager (TL-III) | 5.42E-04 | mg/kg | 75% | 25% |
| Predator (TL-IV) | 1.86E-03 | mg/kg | 90% | 10% |

**Scenario Run on** 5/31/05 14:31 **ZOI = 1**

| PCB Homolog | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Molecular Weight (g/mol) | 1.89E+02 | 2.23E+02 | 2.58E+02 | 2.92E+02 | 3.26E+02 | 3.61E+02 | 3.95E+02 | 4.30E+02 | 4.64E+02 | 4.99E+02 |
| Solubility (mg/L) | 2.91E+00 | 6.78E-01 | 8.14E-02 | 6.67E-02 | 2.61E-02 | 9.50E-04 | 2.30E-04 | 2.11E-08 | 4.02E-09 | 1.69E-10 |
| Solubility (mol/m$^3$) | 1.54E-02 | 3.04E-03 | 3.16E-04 | 2.28E-04 | 8.00E-05 | 2.63E-06 | 5.82E-07 | 4.91E-11 | 8.65E-12 | 3.38E-13 |
| Vapor Pressure (Pa) | 6.32E-01 | 1.41E-01 | 5.11E-02 | 2.08E-02 | 2.96E-03 | 3.43E-03 | 2.56E-04 | 8.65E-05 | 2.77E-05 | 1.41E-05 |
| Henry's (Pa-m$^3$/mol) | 4.10E+01 | 4.65E+01 | 1.62E+02 | 9.10E+01 | 3.70E+01 | 1.30E+03 | 4.40E+02 | 1.76E+06 | 3.20E+06 | 4.18E+07 |
| $\log_{10}K_{ow}$ = | 4.47 | 5.24 | 5.52 | 5.92 | 6.50 | 6.98 | 7.19 | 7.70 | 8.35 | 9.60 |
| $\log_{10}K_{oc}$ = | 3.66 | 4.06 | 4.63 | 4.65 | 4.94 | 6.08 | 6.34 | 6.46 | 6.97 | 7.94 |
| $\log_{10}K_{doc}$ = | 3.34 | 4.11 | 4.39 | 4.79 | 5.51 | 5.85 | 6.06 | 6.57 | 7.22 | 8.47 |
| Chemical emission rate (g/day) | 1.37E-05 | 1.12E-01 | 9.95E-03 | 1.69E-01 | 3.20E-01 | 7.57E-02 | 7.37E-02 | 0.00E+00 | 8.28E-04 | 4.62E-04 |
| Chemical emission rate (mol/hr) | 3.03E-09 | 2.09E-05 | 1.61E-06 | 2.42E-05 | 4.08E-05 | 8.74E-06 | 7.77E-06 | 0.00E+00 | 7.43E-08 | 3.86E-08 |
| Biodegradation in sediment (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Biodegradation in water (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Fraction PCB in Material (wt/wt) | 0.0000314 | 0.000103 | 0.76% | 0.0000529 | 0.00185 | 0.000537 | 0.00002 |
| Material Mass Onboard (kg) | 1459 | 0 | 0 | 5397 | 296419 | 14379 | 386528 |
| Total PCBs (kg) | 0.0458126 | 0 | 0 | 0.2855013 | 548.37515 | 7.721523 | 7.73056 |
| Total PCB Release rate (ng/g-PCB per day) | 1.58E+03 | 2.20E+03 | 2.62E+00 | 1.58E+03 | 2.79E+02 | 6.76E+04 | 1.11E+04 |

| Release Rates in nanograms PCB per gram of PCB within the Material | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 4.14E+01 | 3.47E+01 | 0.00E+00 | 4.14E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Dichlorobiphenyl | 1.27E+03 | 1.72E+02 | 3.08E-02 | 1.27E+03 | 2.03E+02 | 5.36E+00 | 0.00E+00 |
| Trichlorobiphenyl | 5.66E+01 | 8.97E+01 | 7.63E-02 | 5.66E+01 | 1.14E+00 | 9.44E+02 | 2.61E+02 |
| Tetrachlorobiphenyl | 1.44E+02 | 1.08E+03 | 1.29E+00 | 1.44E+02 | 1.57E+01 | 2.07E+04 | 1.23E+02 |
| Pentachlorobiphenyl | 6.31E+01 | 6.60E+02 | 3.90E-02 | 6.31E+01 | 1.80E+01 | 3.79E+04 | 2.24E+03 |
| Hexachlorobiphenyl | 0.00E+00 | 9.42E+01 | 5.34E-01 | 0.00E+00 | 2.41E+01 | 6.76E+03 | 1.33E+03 |
| Heptachlorobiphenyl | 5.04E+00 | 7.17E+01 | 6.46E-01 | 5.04E+00 | 1.47E+01 | 1.30E+03 | 7.19E+03 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 1.72E-03 | 0.00E+00 | 1.51E+00 | 0.00E+00 | 0.00E+00 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.43E-01 | 0.00E+00 | 0.00E+00 |
| **Total** | **1.58E+03** | **2.20E+03** | **2.62E+00** | **1.58E+03** | **2.79E+02** | **6.76E+04** | **1.11E+04** |

| Release Rates in nanograms PCB per Day | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint | Total |
|---|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 1.90E+03 | 0.00E+00 | 0.00E+00 | 1.18E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.37E+04 |
| Dichlorobiphenyl | 5.80E+04 | 0.00E+00 | 0.00E+00 | 3.62E+05 | 1.11E+08 | 4.14E+04 | 0.00E+00 | 1.12E+08 |
| Trichlorobiphenyl | 2.59E+03 | 0.00E+00 | 0.00E+00 | 1.62E+04 | 6.25E+05 | 7.29E+06 | 2.02E+06 | 9.95E+06 |
| Tetrachlorobiphenyl | 6.60E+03 | 0.00E+00 | 0.00E+00 | 4.11E+04 | 8.61E+06 | 1.60E+08 | 9.51E+05 | 1.69E+08 |
| Pentachlorobiphenyl | 2.89E+03 | 0.00E+00 | 0.00E+00 | 1.80E+04 | 9.87E+06 | 2.93E+08 | 1.73E+07 | 3.20E+08 |
| Hexachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.32E+07 | 5.22E+07 | 1.03E+07 | 7.57E+07 |
| Heptachlorobiphenyl | 2.31E+02 | 0.00E+00 | 0.00E+00 | 1.44E+03 | 8.06E+06 | 1.01E+07 | 5.56E+07 | 7.37E+07 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.28E+05 | 0.00E+00 | 0.00E+00 | 8.28E+05 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.62E+05 | 0.00E+00 | 0.00E+00 | 4.62E+05 |
| **Total** | 7.23E+04 | 0.00E+00 | 0.00E+00 | 4.50E+05 | 1.53E+08 | 5.22E+08 | 8.62E+07 | 7.62E+08 |

| Air | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 2.53E-20 | 1.56E-16 | 1.02E-17 | 1.37E-16 | 1.50E-16 | 5.28E-18 | 1.89E-18 | 0.00E+00 | 6.69E-22 | 2.15E-24 |
| Air concentration (g/m3) | 1.95E-21 | 1.42E-17 | 1.07E-18 | 1.63E-17 | 2.00E-17 | 7.77E-19 | 3.04E-19 | 0.00E+00 | 1.26E-22 | 4.37E-25 |

| Upper Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 7.42E-18 | 5.61E-14 | 1.36E-14 | 1.10E-13 | 5.24E-14 | 6.67E-14 | 8.42E-15 | 0.00E+00 | 2.34E-14 | 1.02E-15 |
| Water concentration (mg/L) | 3.41E-17 | 2.69E-13 | 2.17E-14 | 3.51E-13 | 4.62E-13 | 1.85E-14 | 7.56E-15 | 0.00E+00 | 3.41E-18 | 1.22E-20 |
| Suspended solids concentration (mg/kg) | 2.36E-14 | 4.61E-10 | 1.37E-10 | 2.38E-09 | 5.96E-09 | 3.33E-09 | 2.48E-09 | 0.00E+00 | 4.72E-12 | 1.60E-13 |
| Dissolved organic carbon (mg/kg) | 7.53E-14 | 3.43E-09 | 5.32E-10 | 2.17E-08 | 1.50E-07 | 1.29E-08 | 8.66E-09 | 0.00E+00 | 5.65E-11 | 3.62E-12 |

| Lower Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 3.70E-14 | 2.84E-10 | 7.24E-11 | 5.98E-10 | 3.43E-10 | 1.06E-09 | 2.07E-10 | 0.00E+00 | 2.87E-09 | 1.56E-09 |
| Water concentration (mg/L) | 1.70E-13 | 1.36E-09 | 1.15E-10 | 1.92E-09 | 3.02E-09 | 2.94E-10 | 1.85E-10 | 0.00E+00 | 4.17E-13 | 1.87E-14 |
| Suspended solids concentration (mg/kg) | 1.18E-10 | 2.34E-06 | 7.30E-07 | 1.30E-05 | 3.90E-05 | 5.30E-05 | 6.09E-05 | 0.00E+00 | 5.78E-07 | 2.44E-07 |
| Dissolved organic carbon (mg/kg) | 3.75E-10 | 1.74E-05 | 2.83E-06 | 1.19E-04 | 9.85E-04 | 2.06E-04 | 2.13E-04 | 0.00E+00 | 6.93E-06 | 5.53E-06 |

| Inside the Vessel | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 9.67E-12 | 7.43E-08 | 1.89E-08 | 1.56E-07 | 8.96E-08 | 2.77E-07 | 5.40E-08 | 0.00E+00 | 7.51E-07 | 4.09E-07 |
| Water concentration (mg/L) | 4.45E-11 | 3.57E-07 | 3.02E-08 | 5.02E-07 | 7.90E-07 | 7.68E-08 | 4.85E-08 | 0.00E+00 | 1.09E-10 | 4.88E-12 |
| Suspended solids concentration (mg/kg) | 3.07E-08 | 6.11E-04 | 1.91E-04 | 3.39E-03 | 1.02E-02 | 1.39E-02 | 1.59E-02 | 0.00E+00 | 1.51E-04 | 6.38E-05 |
| Dissolved organic carbon (mg/kg) | 9.80E-08 | 4.54E-03 | 7.41E-04 | 3.10E-02 | 2.57E-01 | 5.38E-02 | 5.56E-02 | 0.00E+00 | 1.81E-03 | 1.45E-03 |

| Sediment Bed | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 3.70E-14 | 2.84E-10 | 7.24E-11 | 5.98E-10 | 3.43E-10 | 1.06E-09 | 2.07E-10 | 0.00E+00 | 2.87E-09 | 1.56E-09 |
| Pore Water concentration (mg/L) | 1.70E-13 | 1.36E-09 | 1.15E-10 | 1.92E-09 | 3.02E-09 | 2.94E-10 | 1.85E-10 | 0.00E+00 | 4.17E-13 | 1.87E-14 |
| Sediment concentration (mg/kg) | 7.84E-12 | 1.56E-07 | 4.87E-08 | 8.65E-07 | 2.60E-06 | 3.53E-06 | 4.06E-06 | 0.00E+00 | 3.85E-08 | 1.63E-08 |

| Bioenergetic Inputs | Species | Body Weight | Lipid | Moisture | Caloric Density | GE to ME | Met Energy | Caloric Density | Production | Respiration | Excretion | Caloric Density | Met Energy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (kg) | (%-dw) | (%) | (kcal/g-dry weight) | Fraction | (kcal/kg-lipid) | (kcal/kg-lipid) | (% of total) | (% of total) | (% of total) | (kcal/g-wt weight) | (kcal/g-wt weight) |
| **Pelagic Community** | | | | | | | | | | | | | |
| Phytoplankton (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Zooplankton (TL-II) | copepods | 0.000005 | 22% | 76% | 3.6 | 0.65 | 10636 | 16364 | 18% | 24% | 58% | 0.864 | 0.5616 |
| Planktivore (TL-III) | herring | 0.05 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Piscivore (TL-IV) | jack | 0.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| **Reef / Vessel Community** | | | | | | | | | | | | | |
| Attached Algae (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.05 | 5% | 82% | 4.6 | 0.65 | 59800 | 92000 | 28% | 31% | 41% | 0.828 | 0.5382 |
| Invertebrate Omnivore (TL-II) | urchin | 0.05 | 29% | 82% | 4.6 | 0.65 | 10310 | 15862 | 7% | 25% | 68% | 0.828 | 0.5382 |
| Invertebrate Forager (TL-III) | crab | 1 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Vertebrate Forager (TL-III) | triggerfish | 1 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Predator (TL-IV) | grouper | 1.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 0.2 | 0.14 |
| **Benthic Community** | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.01 | 6% | 84% | 4.6 | 0.65 | 50000 | 76923 | 71% | 26% | 3% | 0.736 | 0.4784 |
| Epifaunal invert. (TL-II) | nematode | 0.01 | 6% | 82% | 4.6 | 0.65 | 50000 | 76923 | 31% | 19% | 50% | 0.828 | 0.5382 |
| Forager (TL-III) | lobster | 2 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Predator (TL-IV) | flounder | 3 | 22% | 75% | 4.9 | 0.7 | 15591 | 22273 | 20% | 60% | 20% | 1.225 | 0.8575 |

| Bioenergetic Inputs | | Respiration Rate Allometric Regression Parameters | | | Resp. Rate | Resp. Rate | Consumption | Growth Rate | Consumption | Consumption | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | a | b1 | b2 | 1 | gO2 | kcal | 1 | g-wt weight | kcal | As a % of |
| **Pelagic Community** | | | | | day | kg-lipid-day | kg-lipid-day | day | g-wt weight-d | wet weight-da | body weight |
| Phytoplankton (TL1) | Algae | | | | | | | | | | |
| Zooplankton (TL-II) | copepods | 0.006375522 | 0 | 0.039935335 | 0.015425453 | 84.24400867 | 1286.168071 | 0.014147849 | 0.32636028 | 0.06790967 | 32.6% |
| Planktivore (TL-III) | herring | 0.0033 | -0.227 | 0.0548 | 0.004949927 | 21.1649 | 129.2512977 | 0.001482433 | 0.01616792 | 0.0090799 | 1.6% |
| Piscivore (TL-IV) | jack | 0.001118602 | -0.55 | 0.12 | 0.000630951 | 2.697821256 | 16.47524431 | 0.000188961 | 0.00139796 | 0.00115739 | 0.1% |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | Algae | | | | | | | | | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.012 | 0 | 0.036 | 0.024213411 | 581.8482643 | 6877.300342 | 0.020930914 | 0.24377539 | 0.0618957 | 24.4% |
| Invertibrate Omnivore (TL-II) | urchin | 0.000675466 | 0 | 0.079181846 | 0.003163548 | 13.1069075 | 192.1012396 | 0.000847751 | 0.03471132 | 0.01002768 | 3.5% |
| Invertibrate Forager (TL-III) | crab | 0.001158234 | 0 | 0.071193202 | 0.004642088 | 60.75673491 | 377.3221989 | 0.003592107 | 0.01678102 | 0.00900593 | 1.7% |
| Vertibrate Forager (TL-III) | triggerfish | 0.015181024 | -0.415 | 0.061 | 0.002837229 | 12.13142452 | 74.08503521 | 0.00084971 | 0.00907693 | 0.00520447 | 0.9% |
| Predator (TL-IV) | grouper | 0.00279 | -0.355 | 0.0811 | 0.001011362 | 4.324384181 | 26.40845301 | 0.000302889 | 0.00264734 | 0.00185519 | 0.3% |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 1903.064429 | 0.017565285 | 0.09800757 | 0.01820852 | 9.8% |
| Epifaunal invert. (TL-II) | nematode | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 2604.19343 | 0.0104949 | 0.09262416 | 0.02803154 | 9.3% |
| Forager (TL-III) | lobster | 0.0035 | -0.13 | 0.066 | 0.00471923 | 61.76639253 | 383.5925529 | 0.003651801 | 0.01899736 | 0.00915559 | 1.9% |
| Predator (TL-IV) | flounder | 0.0046 | -0.24 | 0.067 | 0.002486878 | 13.58174479 | 82.94195291 | 0.000744785 | 0.00974341 | 0.00456181 | 1.0% |

| Dietary Preferences | Suspended Solids (Epilimnion) | Suspended Solids (Hypolimnion) | Sediment | Phytoplankton | Zooplankton | Pelagic Plankitivore | Attached Algae | Reef Sessile Filter Feeder | Invertebrate Omnivore | Reef Invertebrate Forager | Reef Vertebrate Forager | Infaunal Benthos | Epifaunal Benthos | Benthic Forager |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | | | | |
| Phytoplankton (TL1) | | | | | | | | | | | | | | |
| Zooplankton (TL-II) | 15% | 15% | | 70% | | | | | | | | | | |
| Planktivore (TL-III) | | | | | 100% | | | | | | | | | |
| Piscivore (TL-IV) | | | | | 10% | 90% | | | | | | | | |
| **Reef / Vessel Community** | | | | | | | | | | | | | | |
| Attached Algae | | | | | | | | | | | | | | |
| Sessile filter feeder (TL-II) | | 10% | | 80% | 10% | | | | | | | | | |
| Invertebrate Omnivore (TL-II) | | | | | | | 80% | 20% | | | | | | |
| Invertebrate Forager (TL-III) | | 5% | | | 5% | 5% | | 35% | 50% | | | | | |
| Vertebrate Forager (TL-III) | | | | | | 19% | | 19% | 15% | 22% | | 12.5% | 12.5% | |
| Predator (TL-IV) | | | | | | | | | | 15% | 60% | 8% | 8% | 8% |
| **Benthic Community** | | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | | | 50% | 30% | 20% | | | | | | | | | |
| Epifaunal invert. (TL-II) | | | 25% | 30% | 20% | | | | | | | 25% | | |
| Forager (TL-III) | | | 5% | | | | | | | | | 50% | 45% | |
| Predator (TL-IV) | | | 2% | | | | | | | | | 20% | 20% | 58% |

| Water Exposures | | Upper Water Column | Lower Water Column | Vessel Interior | Sediment Pore Water |
|---|---|---|---|---|---|
| **Pelagic Community** | | | | | |
| Phytoplankton (TL1) | Algae | 100% | | | |
| Zooplankton (TL-II) | copepods | 50% | 50% | | |
| Planktivore (TL-III) | herring | 80% | 20% | | |
| Piscivore (TL-IV) | jack | 80% | 20% | | |
| **Reef / Vessel Community** | | | | | |
| Attached Algae | Algae | | 100% | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | | 100% | | |
| Invertebrate Omnivore (TL-II) | urchin | | 80% | 20% | |
| Invertebrate Forager (TL-III) | crab | | 70% | 30% | |
| Vertebrate Forager (TL-III) | triggerfish | | 70% | 30% | |
| Predator (TL-IV) | grouper | | 80% | 20% | |
| **Benthic Community** | | | | | |
| Infaunal invert. (TL-II) | polychaete | | 20% | | 80% |
| Epifaunal invert. (TL-II) | nematode | | 50% | | 50% |
| Forager (TL-III) | lobster | | 75% | | 25% |
| Predator (TL-IV) | flounder | | 90% | | 10% |

| Energy Estimates for Suspended Sediment and Bedded Sediment | GE | ME | ME | as kcal/g-ww |
|---|---|---|---|---|
| Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.01099776 |
| Suspended Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.1649664 |

| Respiratory Efficiencies | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Low body weight (<100g) | 4.335E-01 | 8.000E-01 | 8.000E-01 | 8.000E-01 | 4.492E-01 | 2.582E-01 | 2.018E-01 | 1.127E-01 | 5.303E-02 | 1.255E-02 |
| High body weight (>100g) | 5.000E-01 | 5.000E-01 | 5.000E-01 | 5.000E-01 | 3.769E-01 | 2.857E-01 | 2.526E-01 | 1.888E-01 | 1.295E-01 | 6.299E-02 |
| Dietary Assimilation Efficiencies | 27% | 46% | 53% | 62% | 69% | 69% | 68% | 59% | 44% | 16% |

| Tissue Conc. (mg/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 1.017E-12 | 2.694E-08 | 2.167E-09 | 3.514E-08 | 4.615E-08 | 1.845E-09 | 7.559E-10 | 0.000E+00 | 3.406E-13 | 1.219E-15 |
| Zooplankton (TL-II) | 1.146E-08 | 4.254E-04 | 4.292E-05 | 8.101E-04 | 8.034E-04 | 1.150E-04 | 1.023E-04 | 0.000E+00 | 5.128E-07 | 7.581E-08 |
| Planktivore (TL-III) | 2.589E-09 | 3.603E-04 | 6.569E-05 | 2.403E-03 | 4.282E-03 | 6.738E-04 | 5.846E-04 | 0.000E+00 | 1.934E-06 | 1.018E-07 |
| Piscivore (TL-IV) | 6.768E-10 | 6.350E-05 | 1.744E-05 | 1.403E-03 | 7.505E-03 | 2.021E-03 | 1.976E-03 | 0.000E+00 | 5.773E-06 | 1.259E-07 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 5.066E-09 | 1.364E-04 | 1.154E-05 | 1.918E-04 | 3.020E-04 | 2.938E-05 | 1.855E-05 | 0.000E+00 | 4.173E-08 | 1.866E-09 |
| Sessile filter feeder (TL-II) | 1.631E-07 | 5.502E-03 | 5.434E-04 | 1.022E-02 | 9.893E-03 | 8.762E-04 | 6.344E-04 | 0.000E+00 | 2.031E-06 | 2.204E-07 |
| Invertebrate Omnivore (TL-II) | 2.918E-07 | 2.276E-02 | 3.368E-03 | 1.086E-01 | 1.760E-01 | 1.254E-02 | 6.618E-03 | 0.000E+00 | 4.840E-06 | 7.177E-08 |
| Invertebrate Forager (TL-III) | 2.200E-06 | 9.016E-02 | 1.346E-02 | 4.556E-01 | 8.720E-01 | 6.930E-02 | 3.861E-02 | 0.000E+00 | 4.273E-05 | 2.740E-06 |
| Vertebrate Forager (TL-III) | 2.023E-07 | 1.430E-02 | 3.082E-03 | 1.811E-01 | 6.449E-01 | 6.567E-02 | 3.856E-02 | 0.000E+00 | 4.352E-05 | 1.408E-06 |
| Predator (TL-IV) | 1.122E-07 | 7.313E-03 | 1.732E-03 | 1.518E-01 | 1.174E+00 | 1.808E-01 | 1.165E-01 | 0.000E+00 | 1.254E-04 | 2.713E-06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 4.132E-08 | 1.623E-03 | 1.687E-04 | 3.337E-03 | 3.350E-03 | 3.066E-04 | 2.241E-04 | 0.000E+00 | 6.254E-07 | 4.457E-08 |
| Epifaunal invert. (TL-II) | 5.125E-08 | 3.018E-03 | 3.600E-04 | 8.148E-03 | 8.978E-03 | 8.606E-04 | 6.353E-04 | 0.000E+00 | 1.596E-06 | 8.752E-08 |
| Forager (TL-III) | 2.992E-08 | 1.653E-03 | 2.527E-04 | 7.636E-03 | 1.138E-02 | 1.064E-03 | 7.249E-04 | 0.000E+00 | 1.156E-06 | 2.651E-08 |
| Predator (TL-IV) | 2.649E-09 | 4.406E-04 | 1.161E-04 | 7.193E-03 | 2.167E-02 | 2.608E-03 | 1.841E-03 | 0.000E+00 | 2.367E-06 | 3.480E-08 |

| Tissue Conc. (mg/kg-WW) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.676E-14 | 4.439E-10 | 3.571E-11 | 5.792E-10 | 7.606E-10 | 3.041E-11 | 1.246E-11 | 0.000E+00 | 5.612E-15 | 2.010E-17 | 1.862E-09 |
| Zooplankton (TL-II) | 6.050E-10 | 2.246E-05 | 2.266E-06 | 4.277E-05 | 4.242E-05 | 6.070E-06 | 5.400E-06 | 0.000E+00 | 2.708E-08 | 4.003E-09 | 1.214E-04 |
| Planktivore (TL-III) | 1.819E-10 | 2.531E-05 | 4.615E-06 | 1.688E-04 | 3.008E-04 | 4.733E-05 | 4.107E-05 | 0.000E+00 | 1.359E-07 | 7.152E-09 | 5.880E-04 |
| Piscivore (TL-IV) | 4.755E-11 | 4.461E-06 | 1.225E-06 | 9.859E-05 | 5.272E-04 | 1.420E-04 | 1.388E-04 | 0.000E+00 | 4.055E-07 | 8.845E-09 | 9.127E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 8.350E-11 | 2.248E-06 | 1.902E-07 | 3.161E-06 | 4.977E-06 | 4.841E-07 | 3.057E-07 | 0.000E+00 | 6.876E-10 | 3.074E-11 | 1.137E-05 |
| Sessile filter feeder (TL-II) | 1.468E-09 | 4.952E-05 | 4.891E-06 | 9.197E-05 | 8.903E-05 | 7.886E-06 | 5.710E-06 | 0.000E+00 | 1.828E-08 | 1.983E-09 | 2.490E-04 |
| Invertebrate Omnivore (TL-II) | 1.523E-08 | 1.188E-03 | 1.758E-04 | 5.668E-03 | 9.186E-03 | 6.545E-04 | 3.455E-04 | 0.000E+00 | 2.527E-07 | 3.746E-09 | 1.722E-02 |
| Invertebrate Forager (TL-III) | 5.250E-08 | 2.152E-03 | 3.213E-04 | 1.087E-02 | 2.081E-02 | 1.654E-03 | 9.215E-04 | 0.000E+00 | 1.020E-06 | 6.540E-08 | 3.674E-02 |
| Vertebrate Forager (TL-III) | 1.421E-08 | 1.004E-03 | 2.165E-04 | 1.272E-02 | 4.530E-02 | 4.613E-03 | 2.709E-03 | 0.000E+00 | 3.057E-06 | 9.893E-08 | 6.657E-02 |
| Predator (TL-IV) | 7.885E-09 | 5.138E-04 | 1.217E-04 | 1.066E-02 | 8.247E-02 | 1.270E-02 | 8.181E-03 | 0.000E+00 | 8.810E-06 | 1.906E-07 | 1.147E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 3.954E-10 | 1.553E-05 | 1.614E-06 | 3.193E-05 | 3.205E-05 | 2.934E-06 | 2.144E-06 | 0.000E+00 | 5.984E-09 | 4.264E-10 | 8.621E-05 |
| Epifaunal invert. (TL-II) | 5.517E-10 | 3.249E-05 | 3.875E-06 | 8.770E-05 | 9.664E-05 | 9.264E-06 | 6.838E-06 | 0.000E+00 | 1.718E-08 | 9.420E-10 | 2.368E-04 |
| Forager (TL-III) | 7.142E-10 | 3.944E-05 | 6.031E-06 | 1.823E-04 | 2.716E-04 | 2.539E-05 | 1.730E-05 | 0.000E+00 | 2.758E-08 | 6.328E-10 | 5.421E-04 |
| Predator (TL-IV) | 1.457E-10 | 2.423E-05 | 6.388E-06 | 3.956E-04 | 1.192E-03 | 1.434E-04 | 1.013E-04 | 0.000E+00 | 1.302E-07 | 1.914E-09 | 1.863E-03 |

| BAFs (L/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Zooplankton (TL-II) | 1.347E+05 | 6.237E+05 | 7.436E+05 | 8.445E+05 | 5.319E+05 | 7.826E+05 | 1.103E+06 | 0.000E+00 | 2.458E+06 | 8.127E+06 |
| Planktivore (TL-III) | 7.604E+04 | 1.320E+06 | 2.844E+06 | 6.259E+06 | 7.084E+06 | 1.147E+07 | 1.576E+07 | 0.000E+00 | 2.317E+07 | 2.729E+07 |
| Piscivore (TL-IV) | 1.988E+04 | 2.326E+05 | 7.549E+05 | 3.656E+06 | 1.242E+07 | 3.439E+07 | 5.326E+07 | 0.000E+00 | 6.917E+07 | 3.375E+07 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Sessile filter feeder (TL-II) | 9.590E+05 | 4.034E+06 | 4.709E+06 | 5.328E+06 | 3.275E+06 | 2.983E+06 | 3.420E+06 | 0.000E+00 | 4.867E+06 | 1.181E+07 |
| Invertebrate Omnivore (TL-II) | 3.231E+04 | 3.143E+05 | 5.495E+05 | 1.066E+06 | 1.097E+06 | 8.039E+05 | 6.721E+05 | 0.000E+00 | 2.185E+05 | 7.246E+04 |
| Invertebrate Forager (TL-III) | 1.634E+05 | 8.353E+05 | 1.474E+06 | 3.001E+06 | 3.648E+06 | 2.981E+06 | 2.630E+06 | 0.000E+00 | 1.294E+06 | 1.856E+06 |
| Vertebrate Forager (TL-III) | 1.502E+04 | 1.324E+05 | 3.373E+05 | 1.193E+06 | 2.698E+06 | 2.825E+06 | 2.627E+06 | 0.000E+00 | 1.318E+06 | 9.538E+05 |
| Predator (TL-IV) | 1.243E+04 | 1.010E+05 | 2.827E+05 | 1.490E+06 | 7.321E+06 | 1.159E+07 | 1.183E+07 | 0.000E+00 | 5.661E+06 | 2.739E+06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.429E+05 | 1.190E+06 | 1.462E+06 | 1.740E+06 | 1.109E+06 | 1.044E+06 | 1.208E+06 | 0.000E+00 | 1.499E+06 | 2.389E+06 |
| Epifaunal invert. (TL-II) | 3.013E+05 | 2.213E+06 | 3.119E+06 | 4.248E+06 | 2.973E+06 | 2.930E+06 | 3.425E+06 | 0.000E+00 | 3.825E+06 | 4.691E+06 |
| Forager (TL-III) | 1.759E+05 | 1.212E+06 | 2.189E+06 | 3.981E+06 | 3.768E+06 | 3.622E+06 | 3.908E+06 | 0.000E+00 | 2.770E+06 | 1.421E+06 |
| Predator (TL-IV) | 1.557E+04 | 3.231E+05 | 1.006E+06 | 3.750E+06 | 7.176E+06 | 8.877E+06 | 9.928E+06 | 0.000E+00 | 5.673E+06 | 1.865E+06 |

Notes:
Kow = octanol to water partitioning coefficient, Koc = organic carbon partitioning coefficient, Kdoc = dissolved organic carbon partitioning coefficient
TL = trophic level, ww = wet weight

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION

### *RISK ESTIMATES FOR Ex-Oriskany CV34*

| ZOI = 2 | Cancer Risk Adult & Child | | Hazard Adult & Child | | Cancer Risk Child | | Hazard Child | |
|---|---|---|---|---|---|---|---|---|
| ***RISK ESTIMATES*** | RME | CTE | RME | CTE | RME | CTE | RME | CTE |
| Benthic fish (flounder) | 7.29E-08 | 5.64E-09 | 4.25E-03 | 9.75E-04 | 2.14E-08 | 4.34E-09 | 6.24E-03 | 1.12E-03 |
| Benthic shellfish (lobster) | 2.12E-08 | 1.64E-09 | 1.24E-03 | 2.84E-04 | 6.22E-09 | 1.26E-09 | 1.81E-03 | 3.27E-04 |
| Pelagic fish (jack) | 3.57E-08 | 2.77E-09 | 2.08E-03 | 4.78E-04 | 1.05E-08 | 2.13E-09 | 3.06E-03 | 5.51E-04 |
| Reef fish TL-IV (grouper) | 6.94E-06 | 5.37E-07 | 4.05E-01 | 9.29E-02 | 2.04E-06 | 4.13E-07 | 5.94E-01 | 1.07E-01 |
| Reef fish TL-III (triggerfish) | 4.03E-06 | 3.12E-07 | 2.35E-01 | 5.39E-02 | 1.18E-06 | 2.40E-07 | 3.45E-01 | 6.22E-02 |
| Reef shellfish (crab) | 2.23E-06 | 1.73E-07 | 1.30E-01 | 2.98E-02 | 6.54E-07 | 1.33E-07 | 1.91E-01 | 3.44E-02 |

| ***PREDICTED EXPOSURE CONCENTRATIONS (mg/kg in fresh weight)*** | |
|---|---|
| Benthic fish (flounder) | 1.18E-03 |
| Benthic shellfish (lobster) | 3.45E-04 |
| Pelagic fish (jack) | 5.80E-04 |
| Reef fish TL-IV (grouper) | 1.13E-01 |
| Reef fish TL-III (triggerfish) | 6.55E-02 |
| Reef shellfish (crab) | 3.62E-02 |

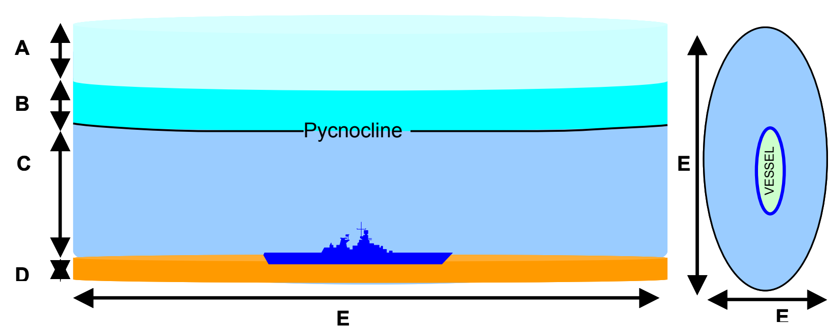
| ***RISK INPUTS - Adult*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 70 | 70 |
| Ingestion Rate (IRc) (kg/day) | 0.0261 | 0.0072 |
| Exposure Duration (EDc) (years) | 24 | 3 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 0.00002 | 0.000045 |
| Averaging Time for noncancer (ATnc-child) | 8.76E+03 | 1.10E+03 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |

| ***RISK INPUTS - Child*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 15 | 15 |
| Ingestion Rate (IRc) (kg/day) | 0.0092916 | 0.0025632 |
| Exposure Duration (EDc) (years) | 6 | 6 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 0.00002 | 0.000045 |
| Averaging Time for noncancer (ATnc-child) | 2.19E+03 | 2.19E+03 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |
| Child - Adult IR scaling factor | 0.356 | |

| | |
|---|---|
| Zone of Influence Multiplier | 2 |
| Scenario run on | 5/26/05 8:46 |

| ***PCB-LADEN MATERIAL INPUTS*** | Fraction PCB | Release Rate (ng/g-d) | kg Material Onboard | PCB Release (ng/day) |
|---|---|---|---|---|
| Ventilation Gaskets | 3.14E-05 | 1.58E+03 | 1.46E+03 | 7.23E+04 |
| Lubricants | 1.03E-04 | 2.20E+03 | 0.00E+00 | 0.00E+00 |
| Foam Rubber Material | 0.76% | 2.62E+00 | 0.00E+00 | 0.00E+00 |
| Black Rubber Material | 5.29E-05 | 1.58E+03 | 5.40E+03 | 4.50E+05 |
| Electrical Cable | 1.85E-03 | 2.79E+02 | 2.96E+05 | 1.53E+08 |
| Bulkhead Insulation Material | 5.37E-04 | 6.76E+04 | 1.44E+04 | 5.22E+08 |
| Aluminum Paint | 2.00E-05 | 1.11E+04 | 3.87E+05 | 8.62E+07 |
| Total | | | | 7.62E+08 |

| **Ex-Oriskany CV34** | |
|---|---|
| Ex-Oriskany CV34 | 27100 |
| Length (ft) | 888 |
| Beam (ft) | 120 |




| ZOI = | 2 | |
|---|---|---|
| **Spatial Footprint on Ocean Floor** | | |
| | 1.56E+04 | m2 |
| | 6.00E-03 | mile2 |
| **Modeled Dimensions Outside the Vessel** | | |
| A | 1.00E+01 | m |
| B | 1.50E+01 | m |
| C | 5.00E+01 | m |
| D | 1.00E-01 | m |
| E | 3.00E+02 | m |
| F | 6.60E+01 | m |
| **Volumes** | | |
| Air Column | | |
| Air | 1.56E+05 | m3 |
| Upper Water Column | | |
| Water | 2.33E+05 | m3 |
| TSS | 1.56E+00 | m3 |
| Lower Water Column | | |
| Water | 7.24E+05 | m3 |
| TSS | 4.82E+00 | m3 |
| Inside Vessel | | |
| Water | 5.38E+04 | m3 |
| TSS | 3.59E-01 | m3 |
| Sediment Bed | | |
| Sediment | 7.78E+02 | m3 |

| **Abiotic Inputs** | |
|---|---|
| Air Column | |
| Active air space height above water column (m) | 10 |
| Air current (m/h) | 13677 |
| Upper Water Column | |
| Temperature (oC) | 24.5 |
| Water depth (m) | 15 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 6.12 |
| Lower Water Column | |
| Temperature (oC) | 19.5 |
| Water depth (m) | 50 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Inside Vessel | |
| Temperature (oC) | 19.5 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Sediment Bed | |
| Sediment density (g/cm3) | 1.5 |
| Active sediment depth (m) | 0.1 |
| Sediment fraction organic carbon | 0.01 |
| All Regions | |
| Suspended solids density (g/cm3) | 1.5 |
| Suspended solids fraction organic carbon | 0.15 |
| Dissolved organic carbon density (g/cm3) | 1 |
| Water current - to out of the ZOI (m/h) | 926 |
| Water current - inside to outside the vessel (m/h) | 9.26 |

| **Total PCB concentrations** | | |
|---|---|---|
| Air Column | | |
| Air | 6.68E-17 | g/m3 |
| Upper Water Column | | |
| Freely dissolved in water | 1.02E-12 | mg/L |
| Suspended solids | 1.33E-08 | mg/kg |
| Dissolved organic carbon | 1.78E-07 | mg/kg |
| Lower Water Column | | |
| Freely dissolved in water | 4.39E-09 | mg/L |
| Suspended solids | 1.08E-04 | mg/kg |
| Dissolved organic carbon | 9.88E-04 | mg/kg |
| Inside Vessel | | |
| Freely dissolved in water | 1.80E-06 | mg/L |
| Suspended solids | 4.44E-02 | mg/kg |
| Dissolved organic carbon | 4.06E-01 | mg/kg |
| Sediment Bed | | |
| Freely dissolved in pore water | 4.39E-09 | mg/L |
| Bedded sediment | 7.19E-06 | mg/kg |
| Dissolved organic carbon in pore water | 9.88E-04 | mg/kg |

| **Total PCB concentrations in biota** | | | **Percent Exposures** | |
|---|---|---|---|---|
| Pelagic Community | | | Upper WC | Lower WC |
| Phytoplankton (TL-I) | 1.67E-09 | mg/kg | 100% | 0% |
| Zooplankton (TL-II) | 7.72E-05 | mg/kg | 50% | 50% |
| Planktivore (TL-III) | 3.74E-04 | mg/kg | 80% | 20% |
| Piscivore (TL-IV) | 5.80E-04 | mg/kg | 80% | 20% |
| Reef / Vessel Community | | | Lower WC | Vessel Int. |
| Attached Algae (TL-I) | 7.23E-06 | mg/kg | 100% | 0% |
| Sessile filter feeder (TL-II) | 1.58E-04 | mg/kg | 100% | 0% |
| Invertebrate Omnivore (TL-III) | 1.69E-02 | mg/kg | 80% | 20% |
| Invertebrate Forager (TL-III) | 3.62E-02 | mg/kg | 70% | 30% |
| Vertebrate Forager (TL-III) | 6.55E-02 | mg/kg | 70% | 30% |
| Predator (TL-IV) | 1.13E-01 | mg/kg | 80% | 20% |
| Benthic Community | | | Lower WC | Pore Water |
| Infaunal invert. (TL-II) | 5.48E-05 | mg/kg | 20% | 80% |
| Epifaunal invert. (TL-II) | 1.51E-04 | mg/kg | 50% | 50% |
| Forager (TL-III) | 3.45E-04 | mg/kg | 75% | 25% |
| Predator (TL-IV) | 1.18E-03 | mg/kg | 90% | 10% |

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION
## RISK ESTIMATES FOR Ex-Oriskany CV34
### Supplemental Information

**Scenario Run on** 5/26/05 8:46 **ZOI=2**

| PCB Homolog | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Molecular Weight (g/mol) | 1.89E+02 | 2.23E+02 | 2.58E+02 | 2.92E+02 | 3.26E+02 | 3.61E+02 | 3.95E+02 | 4.30E+02 | 4.64E+02 | 4.99E+02 |
| Solubility (mg/L) | 2.91E+00 | 6.78E-01 | 8.14E-02 | 6.67E-02 | 2.61E-02 | 9.50E-04 | 2.30E-04 | 2.11E-08 | 4.02E-09 | 1.69E-10 |
| Solubility (mol/m$^3$) | 1.54E-02 | 3.04E-03 | 3.16E-04 | 2.28E-04 | 8.00E-05 | 2.63E-06 | 5.82E-07 | 4.91E-11 | 8.65E-12 | 3.38E-13 |
| Vapor Pressure (Pa) | 6.32E-01 | 1.41E-01 | 5.11E-02 | 2.08E-02 | 2.96E-03 | 3.43E-03 | 2.56E-04 | 8.65E-05 | 2.77E-05 | 1.41E-05 |
| Henry's (Pa-m$^3$/mol) | 4.10E+01 | 4.65E+01 | 1.62E+02 | 9.10E+01 | 3.70E+01 | 1.30E+03 | 4.40E+02 | 1.76E+06 | 3.20E+06 | 4.18E+07 |
| $\log_{10}K_{ow}$ = | 4.47 | 5.24 | 5.52 | 5.92 | 6.50 | 6.98 | 7.19 | 7.70 | 8.35 | 9.60 |
| $\log_{10}K_{oc}$ = | 3.66 | 4.06 | 4.63 | 4.65 | 4.94 | 6.08 | 6.34 | 6.46 | 6.97 | 7.94 |
| $\log_{10}K_{doc}$ = | 3.34 | 4.11 | 4.39 | 4.79 | 5.51 | 5.85 | 6.06 | 6.57 | 7.22 | 8.47 |
| Chemical emission rate (g/day) | 1.37E-05 | 1.12E-01 | 9.95E-03 | 1.69E-01 | 3.20E-01 | 7.57E-02 | 7.37E-02 | 0.00E+00 | 8.28E-04 | 4.62E-04 |
| Chemical emission rate (mol/hr) | 3.03E-09 | 2.09E-05 | 1.61E-06 | 2.42E-05 | 4.08E-05 | 8.74E-06 | 7.77E-06 | 0.00E+00 | 7.43E-08 | 3.86E-08 |
| Biodegradation in sediment (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Biodegradation in water (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Fraction PCB in Material (wt/wt) | 0.0000314 | 0.000103 | 0.76% | 0.0000529 | 0.00185 | 0.000537 | 0.00002 |
| Material Mass Onboard (kg) | 1459 | 0 | 0 | 5397 | 296419 | 14379 | 386528 |
| Total PCBs (kg) | 0.0458126 | 0 | 0 | 0.2855013 | 548.37515 | 7.721523 | 7.73056 |
| Total PCB Release rate (ng/g-PCB per day) | 1.58E+03 | 2.20E+03 | 2.62E+00 | 1.58E+03 | 2.79E+02 | 6.76E+04 | 1.11E+04 |

| Release Rates in nanograms PCB per gram of PCB within the Material | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 4.14E+01 | 3.47E+01 | 0.00E+00 | 4.14E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Dichlorobiphenyl | 1.27E+03 | 1.72E+02 | 3.08E-02 | 1.27E+03 | 2.03E+02 | 5.36E+00 | 0.00E+00 |
| Trichlorobiphenyl | 5.66E+01 | 8.97E+01 | 7.63E-02 | 5.66E+01 | 1.14E+00 | 9.44E+02 | 2.61E+02 |
| Tetrachlorobiphenyl | 1.44E+02 | 1.08E+03 | 1.29E+00 | 1.44E+02 | 1.57E+01 | 2.07E+04 | 1.23E+02 |
| Pentachlorobiphenyl | 6.31E+01 | 6.60E+02 | 3.90E-02 | 6.31E+01 | 1.80E+01 | 3.79E+04 | 2.24E+03 |
| Hexachlorobiphenyl | 0.00E+00 | 9.42E+01 | 5.34E-01 | 0.00E+00 | 2.41E+01 | 6.76E+03 | 1.33E+03 |
| Heptachlorobiphenyl | 5.04E+00 | 7.17E+01 | 6.46E-01 | 5.04E+00 | 1.47E+01 | 1.30E+03 | 7.19E+03 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 1.72E-03 | 0.00E+00 | 1.51E+00 | 0.00E+00 | 0.00E+00 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.43E-01 | 0.00E+00 | 0.00E+00 |
| **Total** | **1.58E+03** | **2.20E+03** | **2.62E+00** | **1.58E+03** | **2.79E+02** | **6.76E+04** | **1.11E+04** |

| Release Rates in nanograms PCB per Day | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint | Total |
|---|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 1.90E+03 | 0.00E+00 | 0.00E+00 | 1.18E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.37E+04 |
| Dichlorobiphenyl | 5.80E+04 | 0.00E+00 | 0.00E+00 | 3.62E+05 | 1.11E+08 | 4.14E+04 | 0.00E+00 | 1.12E+08 |
| Trichlorobiphenyl | 2.59E+03 | 0.00E+00 | 0.00E+00 | 1.62E+04 | 6.25E+05 | 7.29E+06 | 2.02E+06 | 9.95E+06 |
| Tetrachlorobiphenyl | 6.60E+03 | 0.00E+00 | 0.00E+00 | 4.11E+04 | 8.61E+06 | 1.60E+08 | 9.51E+05 | 1.69E+08 |
| Pentachlorobiphenyl | 2.89E+03 | 0.00E+00 | 0.00E+00 | 1.80E+04 | 9.87E+06 | 2.93E+08 | 1.73E+07 | 3.20E+08 |
| Hexachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.32E+07 | 5.22E+07 | 1.03E+07 | 7.57E+07 |
| Heptachlorobiphenyl | 2.31E+02 | 0.00E+00 | 0.00E+00 | 1.44E+03 | 8.06E+06 | 1.01E+07 | 5.56E+07 | 7.37E+07 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.28E+05 | 0.00E+00 | 0.00E+00 | 8.28E+05 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.62E+05 | 0.00E+00 | 0.00E+00 | 4.62E+05 |
| **Total** | 7.23E+04 | 0.00E+00 | 0.00E+00 | 4.50E+05 | 1.53E+08 | 5.22E+08 | 8.62E+07 | 7.62E+08 |

| Air | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 3.22E-20 | 1.98E-16 | 1.30E-17 | 1.74E-16 | 1.91E-16 | 6.72E-18 | 2.40E-18 | 0.00E+00 | 8.51E-22 | 2.74E-24 |
| Air concentration (g/m3) | 2.47E-21 | 1.80E-17 | 1.37E-18 | 2.07E-17 | 2.54E-17 | 9.88E-19 | 3.86E-19 | 0.00E+00 | 1.61E-22 | 5.56E-25 |

| Upper Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 6.67E-18 | 5.04E-14 | 1.22E-14 | 9.85E-14 | 4.71E-14 | 5.99E-14 | 7.57E-15 | 0.00E+00 | 2.11E-14 | 9.20E-16 |
| Water concentration (mg/L) | 3.07E-17 | 2.42E-13 | 1.95E-14 | 3.16E-13 | 4.15E-13 | 1.66E-14 | 6.80E-15 | 0.00E+00 | 3.06E-18 | 1.10E-20 |
| Suspended solids concentration (mg/kg) | 2.12E-14 | 4.15E-10 | 1.23E-10 | 2.14E-09 | 5.36E-09 | 2.99E-09 | 2.23E-09 | 0.00E+00 | 4.24E-12 | 1.44E-13 |
| Dissolved organic carbon (mg/kg) | 6.77E-14 | 3.09E-09 | 4.79E-10 | 1.95E-08 | 1.35E-07 | 1.16E-08 | 7.79E-09 | 0.00E+00 | 5.09E-11 | 3.25E-12 |

| Lower Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 2.35E-14 | 1.81E-10 | 4.61E-11 | 3.80E-10 | 2.18E-10 | 6.75E-10 | 1.31E-10 | 0.00E+00 | 1.83E-09 | 9.95E-10 |
| Water concentration (mg/L) | 1.08E-13 | 8.67E-10 | 7.34E-11 | 1.22E-09 | 1.92E-09 | 1.87E-10 | 1.18E-10 | 0.00E+00 | 2.65E-13 | 1.19E-14 |
| Suspended solids concentration (mg/kg) | 7.47E-11 | 1.48E-06 | 4.64E-07 | 8.25E-06 | 2.48E-05 | 3.37E-05 | 3.87E-05 | 0.00E+00 | 3.68E-07 | 1.55E-07 |
| Dissolved organic carbon (mg/kg) | 2.38E-10 | 1.11E-05 | 1.80E-06 | 7.54E-05 | 6.26E-04 | 1.31E-04 | 1.35E-04 | 0.00E+00 | 4.41E-06 | 3.52E-06 |

| Inside the Vessel | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 9.67E-12 | 7.43E-08 | 1.89E-08 | 1.56E-07 | 8.96E-08 | 2.77E-07 | 5.40E-08 | 0.00E+00 | 7.51E-07 | 4.09E-07 |
| Water concentration (mg/L) | 4.45E-11 | 3.57E-07 | 3.02E-08 | 5.02E-07 | 7.90E-07 | 7.68E-08 | 4.85E-08 | 0.00E+00 | 1.09E-10 | 4.88E-12 |
| Suspended solids concentration (mg/kg) | 3.07E-08 | 6.11E-04 | 1.91E-04 | 3.39E-03 | 1.02E-02 | 1.39E-02 | 1.59E-02 | 0.00E+00 | 1.51E-04 | 6.38E-05 |
| Dissolved organic carbon (mg/kg) | 9.80E-08 | 4.54E-03 | 7.41E-04 | 3.10E-02 | 2.57E-01 | 5.38E-02 | 5.56E-02 | 0.00E+00 | 1.81E-03 | 1.45E-03 |

| Sediment Bed | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 2.35E-14 | 1.81E-10 | 4.61E-11 | 3.80E-10 | 2.18E-10 | 6.75E-10 | 1.31E-10 | 0.00E+00 | 1.83E-09 | 9.95E-10 |
| Pore Water concentration (mg/L) | 1.08E-13 | 8.67E-10 | 7.34E-11 | 1.22E-09 | 1.92E-09 | 1.87E-10 | 1.18E-10 | 0.00E+00 | 2.65E-13 | 1.19E-14 |
| Sediment concentration (mg/kg) | 4.98E-12 | 9.90E-08 | 3.09E-08 | 5.50E-07 | 1.65E-06 | 2.25E-06 | 2.58E-06 | 0.00E+00 | 2.45E-08 | 1.03E-08 |

| Bioenergetic Inputs | Species | Body Weight | Lipid | Moisture | Caloric Density | GE to ME | Met Energy | Caloric Density | Production | Respiration | Excretion | Caloric Density | Met Energy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (kg) | (%-dw) | (%) | (kcal/g-dry weight) | Fraction | (kcal/kg-lipid) | (kcal/kg-lipid) | (% of total) | (% of total) | (% of total) | (kcal/g-wt weight) | (kcal/g-wt weight) |
| **Pelagic Community** | | | | | | | | | | | | | |
| Phytoplankton (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Zooplankton (TL-II) | copepods | 0.000005 | 22% | 76% | 3.6 | 0.65 | 10636 | 16364 | 18% | 24% | 58% | 0.864 | 0.5616 |
| Planktivore (TL-III) | herring | 0.05 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Piscivore (TL-IV) | jack | 0.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| **Reef / Vessel Community** | | | | | | | | | | | | | |
| Attached Algae (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.05 | 5% | 82% | 4.6 | 0.65 | 59800 | 92000 | 28% | 31% | 41% | 0.828 | 0.5382 |
| Invertebrate Omnivore (TL-II) | urchin | 0.05 | 29% | 82% | 4.6 | 0.65 | 10310 | 15862 | 7% | 25% | 68% | 0.828 | 0.5382 |
| Invertebrate Forager (TL-III) | crab | 1 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Vertebrate Forager (TL-III) | triggerfish | 1 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Predator (TL-IV) | grouper | 1.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 0.2 | 0.14 |
| **Benthic Community** | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.01 | 6% | 84% | 4.6 | 0.65 | 50000 | 76923 | 71% | 26% | 3% | 0.736 | 0.4784 |
| Epifaunal invert. (TL-II) | nematode | 0.01 | 6% | 82% | 4.6 | 0.65 | 50000 | 76923 | 31% | 19% | 50% | 0.828 | 0.5382 |
| Forager (TL-III) | lobster | 2 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Predator (TL-IV) | flounder | 3 | 22% | 75% | 4.9 | 0.7 | 15591 | 22273 | 20% | 60% | 20% | 1.225 | 0.8575 |

| Bioenergetic Inputs | Respiration Rate Allometric Regression Parameters | a | b1 | b2 | Resp. Rate | Resp. Rate | Consumption | Growth Rate | Consumption | Consumption | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | 1/day | gO2/kg-lipid-day | kcal/kg-lipid-day | 1/day | g-wt weight/g-wt weight-d | kcal/wet weight-da | As a % of body weight |
| Phytoplankton (TL1) | Algae | | | | | | | | | | |
| Zooplankton (TL-II) | copepods | 0.006375522 | 0 | 0.039935335 | 0.015425453 | 84.24400867 | 1286.168071 | 0.014147849 | 0.32636028 | 0.06790967 | 32.6% |
| Planktivore (TL-III) | herring | 0.0033 | -0.227 | 0.0548 | 0.004949927 | 21.1649 | 129.2512977 | 0.001482433 | 0.01616792 | 0.0090799 | 1.6% |
| Piscivore (TL-IV) | jack | 0.001118602 | -0.55 | 0.12 | 0.000630951 | 2.697821256 | 16.47524431 | 0.000188961 | 0.00139796 | 0.00115739 | 0.1% |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | Algae | | | | | | | | | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.012 | 0 | 0.036 | 0.024213411 | 581.8482643 | 6877.300342 | 0.020930914 | 0.24377539 | 0.0618957 | 24.4% |
| Invertibrate Omnivore (TL-II) | urchin | 0.000675466 | 0 | 0.079181846 | 0.003163548 | 13.1069075 | 192.1012396 | 0.000847751 | 0.03471132 | 0.01002768 | 3.5% |
| Invertibrate Forager (TL-III) | crab | 0.001158234 | 0 | 0.071193202 | 0.004642088 | 60.75673491 | 377.3221989 | 0.003592107 | 0.01678102 | 0.00900593 | 1.7% |
| Vertibrate Forager (TL-III) | triggerfish | 0.015181024 | -0.415 | 0.061 | 0.002837229 | 12.13142452 | 74.08503521 | 0.00084971 | 0.00907693 | 0.00520447 | 0.9% |
| Predator (TL-IV) | grouper | 0.00279 | -0.355 | 0.0811 | 0.001011362 | 4.324384181 | 26.40845301 | 0.000302889 | 0.00264734 | 0.00185519 | 0.3% |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 1903.064429 | 0.017565285 | 0.09800757 | 0.01820852 | 9.8% |
| Epifaunal invert. (TL-II) | nematode | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 2604.19343 | 0.0104949 | 0.09262416 | 0.02803154 | 9.3% |
| Forager (TL-III) | lobster | 0.0035 | -0.13 | 0.066 | 0.00471923 | 61.76639253 | 383.5925529 | 0.003651801 | 0.01899736 | 0.00915559 | 1.9% |
| Predator (TL-IV) | flounder | 0.0046 | -0.24 | 0.067 | 0.002486878 | 13.58174479 | 82.94195291 | 0.000744785 | 0.00974341 | 0.00456181 | 1.0% |

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION
## RISK ESTIMATES FOR Ex-Oriskany CV34
### Supplemental Information

| TROPHIC LEVEL BASED ON DIET | 1.125 | 1.25 | 1.5 | 1 | 2.05625 | 3.05625 | 1 | 2.130625 | 2.226125 | 3.17690625 | 2.964776563 | 2.46125 | 2.7015625 | 3.521328125 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dietary Preferences** | Suspended Solids (Epilimnion) | Suspended Solids (Hypolimnion) | Sediment | Phytoplankton | Zooplankton | Pelagic Plankitivore | Attached Algae | Reef Sessile Filter Feeder | Invertebrate Omnivore | Reef Invertebrate Forager | Reef Vertebrate Forager | Infaunal Benthos | Epifaunal Benthos | Benthic Forager |
| **Pelagic Community** | | | | | | | | | | | | | | |
| Phytoplankton (TL1) | | | | | | | | | | | | | | |
| Zooplankton (TL-II) | 15% | 15% | | 70% | | | | | | | | | | |
| Planktivore (TL-III) | | | | | 100% | | | | | | | | | |
| Piscivore (TL-IV) | | | | | 10% | 90% | | | | | | | | |
| **Reef / Vessel Community** | | | | | | | | | | | | | | |
| Attached Algae | | | | | | | | | | | | | | |
| Sessile filter feeder (TL-II) | | 10% | | 80% | 10% | | | | | | | | | |
| Invertebrate Omnivore (TL-II) | | | | | | | 80% | 20% | | | | | | |
| Invertebrate Forager (TL-III) | | 5% | | | 5% | 5% | | 35% | 50% | | | | | |
| Vertebrate Forager (TL-III) | | | | | | 19% | | 19% | 15% | 22% | | 12.5% | 12.5% | |
| Predator (TL-IV) | | | | | | | | | | 15% | 60% | 8% | 8% | 8% |
| **Benthic Community** | | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | | | 50% | 30% | 20% | | | | | | | | | |
| Epifaunal invert. (TL-II) | | | 25% | 30% | 20% | | | | | | | 25% | | |
| Forager (TL-III) | | | 5% | | | | | | | | | 50% | 45% | |
| Predator (TL-IV) | | | 2% | | | | | | | | | 20% | 20% | 58% |

| **Water Exposures** | | Upper Water Column | Lower Water Column | Vessel Interior | Sediment Pore Water |
|---|---|---|---|---|---|
| **Pelagic Community** | | | | | |
| Phytoplankton (TL1) | Algae | 100% | | | |
| Zooplankton (TL-II) | copepods | 50% | 50% | | |
| Planktivore (TL-III) | herring | 80% | 20% | | |
| Piscivore (TL-IV) | jack | 80% | 20% | | |
| **Reef / Vessel Community** | | | | | |
| Attached Algae | Algae | | 100% | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | | 100% | | |
| Invertebrate Omnivore (TL-II) | urchin | | 80% | 20% | |
| Invertebrate Forager (TL-III) | crab | | 70% | 30% | |
| Vertebrate Forager (TL-III) | triggerfish | | 70% | 30% | |
| Predator (TL-IV) | grouper | | 80% | 20% | |
| **Benthic Community** | | | | | |
| Infaunal invert. (TL-II) | polychaete | | 20% | | 80% |
| Epifaunal invert. (TL-II) | nematode | | 50% | | 50% |
| Forager (TL-III) | lobster | | 75% | | 25% |
| Predator (TL-IV) | flounder | | 90% | | 10% |

| Energy Estimates for Suspended Sediment and Bedded Sediment | GE | ME | ME | as kcal/g-ww |
|---|---|---|---|---|
| Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.01099776 |
| Suspended Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.1649664 |

| **Respiratory Efficiencies** | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Low body weight (<100g) | 4.335E-01 | 8.000E-01 | 8.000E-01 | 8.000E-01 | 4.492E-01 | 2.582E-01 | 2.018E-01 | 1.127E-01 | 5.303E-02 | 1.255E-02 |
| High body weight (>100g) | 5.000E-01 | 5.000E-01 | 5.000E-01 | 5.000E-01 | 3.769E-01 | 2.857E-01 | 2.526E-01 | 1.888E-01 | 1.295E-01 | 6.299E-02 |
| **Dietary Assimilation Efficiencies** | 27% | 46% | 53% | 62% | 69% | 69% | 68% | 59% | 44% | 16% |

| **Tissue Conc. (mg/kg-lipid)** | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 9.143E-13 | 2.422E-08 | 1.948E-09 | 3.159E-08 | 4.150E-08 | 1.659E-09 | 6.797E-10 | 0.000E+00 | 3.062E-13 | 1.097E-15 |
| Zooplankton (TL-II) | 7.287E-09 | 2.706E-04 | 2.729E-05 | 5.151E-04 | 5.109E-04 | 7.310E-05 | 6.504E-05 | 0.000E+00 | 3.261E-07 | 4.821E-08 |
| Planktivore (TL-III) | 1.647E-09 | 2.291E-04 | 4.178E-05 | 1.528E-03 | 2.723E-03 | 4.285E-04 | 3.717E-04 | 0.000E+00 | 1.230E-06 | 6.474E-08 |
| Piscivore (TL-IV) | 4.305E-10 | 4.039E-05 | 1.109E-05 | 8.926E-04 | 4.773E-03 | 1.285E-03 | 1.257E-03 | 0.000E+00 | 3.671E-06 | 8.006E-08 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 3.222E-09 | 8.672E-05 | 7.339E-06 | 1.220E-04 | 1.920E-04 | 1.868E-05 | 1.179E-05 | 0.000E+00 | 2.653E-08 | 1.186E-09 |
| Sessile filter feeder (TL-II) | 1.037E-07 | 3.499E-03 | 3.456E-04 | 6.498E-03 | 6.291E-03 | 5.571E-04 | 4.034E-04 | 0.000E+00 | 1.291E-06 | 1.401E-07 |
| Invertebrate Omnivore (TL-II) | 2.898E-07 | 2.252E-02 | 3.328E-03 | 1.071E-01 | 1.730E-01 | 1.224E-02 | 6.420E-03 | 0.000E+00 | 4.488E-06 | 6.064E-08 |
| Invertebrate Forager (TL-III) | 2.192E-06 | 8.951E-02 | 1.334E-02 | 4.503E-01 | 8.597E-01 | 6.798E-02 | 3.772E-02 | 0.000E+00 | 4.148E-05 | 2.711E-06 |
| Vertebrate Forager (TL-III) | 2.015E-07 | 1.416E-02 | 3.046E-03 | 1.785E-01 | 6.347E-01 | 6.428E-02 | 3.756E-02 | 0.000E+00 | 4.214E-05 | 1.385E-06 |
| Predator (TL-IV) | 1.116E-07 | 7.257E-03 | 1.715E-03 | 1.498E-01 | 1.156E+00 | 1.771E-01 | 1.137E-01 | 0.000E+00 | 1.222E-04 | 2.685E-06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.628E-08 | 1.032E-03 | 1.073E-04 | 2.122E-03 | 2.130E-03 | 1.950E-04 | 1.425E-04 | 0.000E+00 | 3.977E-07 | 2.834E-08 |
| Epifaunal invert. (TL-II) | 3.259E-08 | 1.919E-03 | 2.289E-04 | 5.181E-03 | 5.709E-03 | 5.472E-04 | 4.040E-04 | 0.000E+00 | 1.015E-06 | 5.565E-08 |
| Forager (TL-III) | 1.903E-08 | 1.051E-03 | 1.607E-04 | 4.856E-03 | 7.236E-03 | 6.765E-04 | 4.610E-04 | 0.000E+00 | 7.349E-07 | 1.686E-08 |
| Predator (TL-IV) | 1.685E-09 | 2.802E-04 | 7.385E-05 | 4.574E-03 | 1.378E-02 | 1.658E-03 | 1.171E-03 | 0.000E+00 | 1.505E-06 | 2.213E-08 |

| **Tissue Conc. (mg/kg-WW)** | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.507E-14 | 3.991E-10 | 3.211E-11 | 5.207E-10 | 6.838E-10 | 2.735E-11 | 1.120E-11 | 0.000E+00 | 5.047E-15 | 1.807E-17 | 1.674E-09 |
| Zooplankton (TL-II) | 3.847E-10 | 1.429E-05 | 1.441E-06 | 2.720E-05 | 2.698E-05 | 3.860E-06 | 3.434E-06 | 0.000E+00 | 1.722E-08 | 2.545E-09 | 7.722E-05 |
| Planktivore (TL-III) | 1.157E-10 | 1.610E-05 | 2.935E-06 | 1.073E-04 | 1.913E-04 | 3.010E-05 | 2.611E-05 | 0.000E+00 | 8.639E-08 | 4.548E-09 | 3.740E-04 |
| Piscivore (TL-IV) | 3.024E-11 | 2.837E-06 | 7.791E-07 | 6.270E-05 | 3.353E-04 | 9.028E-05 | 8.828E-05 | 0.000E+00 | 2.579E-07 | 5.625E-09 | 5.804E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 5.309E-11 | 1.429E-06 | 1.209E-07 | 2.010E-06 | 3.165E-06 | 3.078E-07 | 1.944E-07 | 0.000E+00 | 4.372E-10 | 1.955E-11 | 7.228E-06 |
| Sessile filter feeder (TL-II) | 9.335E-10 | 3.149E-05 | 3.110E-06 | 5.848E-05 | 5.662E-05 | 5.014E-06 | 3.631E-06 | 0.000E+00 | 1.162E-08 | 1.261E-09 | 1.584E-04 |
| Invertebrate Omnivore (TL-II) | 1.513E-08 | 1.176E-03 | 1.737E-04 | 5.591E-03 | 9.032E-03 | 6.389E-04 | 3.351E-04 | 0.000E+00 | 2.343E-07 | 3.166E-09 | 1.695E-02 |
| Invertebrate Forager (TL-III) | 5.231E-08 | 2.136E-03 | 3.184E-04 | 1.075E-02 | 2.052E-02 | 1.623E-03 | 9.003E-04 | 0.000E+00 | 9.901E-07 | 6.469E-08 | 3.624E-02 |
| Vertebrate Forager (TL-III) | 1.415E-08 | 9.949E-04 | 2.140E-04 | 1.254E-02 | 4.459E-02 | 4.516E-03 | 2.638E-03 | 0.000E+00 | 2.960E-06 | 9.732E-08 | 6.550E-02 |
| Predator (TL-IV) | 7.841E-09 | 5.098E-04 | 1.205E-04 | 1.052E-02 | 8.122E-02 | 1.244E-02 | 7.984E-03 | 0.000E+00 | 8.585E-06 | 1.886E-07 | 1.128E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.514E-10 | 9.875E-06 | 1.026E-06 | 2.030E-05 | 2.038E-05 | 1.866E-06 | 1.363E-06 | 0.000E+00 | 3.805E-09 | 2.711E-10 | 5.482E-05 |
| Epifaunal invert. (TL-II) | 3.508E-10 | 2.066E-05 | 2.464E-06 | 5.577E-05 | 6.146E-05 | 5.891E-06 | 4.348E-06 | 0.000E+00 | 1.092E-08 | 5.990E-10 | 1.506E-04 |
| Forager (TL-III) | 4.541E-10 | 2.508E-05 | 3.835E-06 | 1.159E-04 | 1.727E-04 | 1.615E-05 | 1.100E-05 | 0.000E+00 | 1.754E-08 | 4.024E-10 | 3.447E-04 |
| Predator (TL-IV) | 9.265E-11 | 1.541E-05 | 4.062E-06 | 2.516E-04 | 7.580E-04 | 9.120E-05 | 6.440E-05 | 0.000E+00 | 8.279E-08 | 1.217E-09 | 1.185E-03 |

| **BAFs (L/kg-lipid)** | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Zooplankton (TL-II) | 1.347E+05 | 6.238E+05 | 7.436E+05 | 8.445E+05 | 5.320E+05 | 7.826E+05 | 1.103E+06 | 0.000E+00 | 2.458E+06 | 8.127E+06 |
| Planktivore (TL-III) | 7.603E+04 | 1.320E+06 | 2.843E+06 | 6.258E+06 | 7.083E+06 | 1.146E+07 | 1.576E+07 | 0.000E+00 | 2.317E+07 | 2.729E+07 |
| Piscivore (TL-IV) | 1.988E+04 | 2.326E+05 | 7.548E+05 | 3.655E+06 | 1.242E+07 | 3.439E+07 | 5.326E+07 | 0.000E+00 | 6.917E+07 | 3.375E+07 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Sessile filter feeder (TL-II) | 9.590E+05 | 4.034E+06 | 4.709E+06 | 5.328E+06 | 3.276E+06 | 2.983E+06 | 3.420E+06 | 0.000E+00 | 4.867E+06 | 1.181E+07 |
| Invertebrate Omnivore (TL-II) | 3.226E+04 | 3.127E+05 | 5.460E+05 | 1.057E+06 | 1.085E+06 | 7.891E+05 | 6.556E+05 | 0.000E+00 | 2.037E+05 | 6.157E+04 |
| Invertebrate Forager (TL-III) | 1.633E+05 | 8.319E+05 | 1.465E+06 | 2.976E+06 | 3.608E+06 | 2.934E+06 | 2.578E+06 | 0.000E+00 | 1.260E+06 | 1.842E+06 |
| Vertebrate Forager (TL-III) | 1.501E+04 | 1.316E+05 | 3.345E+05 | 1.180E+06 | 2.664E+06 | 2.774E+06 | 2.567E+06 | 0.000E+00 | 1.280E+06 | 9.414E+05 |
| Predator (TL-IV) | 1.243E+04 | 1.008E+05 | 2.815E+05 | 1.479E+06 | 7.250E+06 | 1.142E+07 | 1.161E+07 | 0.000E+00 | 5.547E+06 | 2.726E+06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.429E+05 | 1.190E+06 | 1.462E+06 | 1.740E+06 | 1.109E+06 | 1.044E+06 | 1.208E+06 | 0.000E+00 | 1.499E+06 | 2.389E+06 |
| Epifaunal invert. (TL-II) | 3.013E+05 | 2.213E+06 | 3.119E+06 | 4.248E+06 | 2.973E+06 | 2.930E+06 | 3.425E+06 | 0.000E+00 | 3.825E+06 | 4.691E+06 |
| Forager (TL-III) | 1.759E+05 | 1.212E+06 | 2.189E+06 | 3.981E+06 | 3.768E+06 | 3.622E+06 | 3.909E+06 | 0.000E+00 | 2.770E+06 | 1.421E+06 |
| Predator (TL-IV) | 1.557E+04 | 3.231E+05 | 1.006E+06 | 3.750E+06 | 7.177E+06 | 8.877E+06 | 9.928E+06 | 0.000E+00 | 5.673E+06 | 1.865E+06 |

Notes:
Kow = octanol to water partitioning coefficient, Koc = organic carbon partitioning coefficient, Kdoc = dissolved organic carbon partitioning coefficient
TL = trophic level, ww = wet weight

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION

## *RISK ESTIMATES FOR Ex-Oriskany CV34*

| ZOI = 3 | Cancer Risk Adult & Child | | Hazard Adult & Child | | Cancer Risk Child | | Hazard Child | |
|---|---|---|---|---|---|---|---|---|
| ***RISK ESTIMATES*** | RME | CTE | RME | CTE | RME | CTE | RME | CTE |
| Benthic fish (flounder) | 5.70E-08 | 4.41E-09 | 3.32E-03 | 7.62E-04 | 1.67E-08 | 3.39E-09 | 4.88E-03 | 8.79E-04 |
| Benthic shellfish (lobster) | 1.66E-08 | 1.28E-09 | 9.67E-04 | 2.22E-04 | 4.86E-09 | 9.87E-10 | 1.42E-03 | 2.56E-04 |
| Pelagic fish (jack) | 2.79E-08 | 2.16E-09 | 1.63E-03 | 3.74E-04 | 8.19E-09 | 1.66E-09 | 2.39E-03 | 4.31E-04 |
| Reef fish TL-IV (grouper) | 6.90E-06 | 5.34E-07 | 4.02E-01 | 9.23E-02 | 2.02E-06 | 4.11E-07 | 5.90E-01 | 1.06E-01 |
| Reef fish TL-III (triggerfish) | 4.00E-06 | 3.10E-07 | 2.34E-01 | 5.36E-02 | 1.17E-06 | 2.38E-07 | 3.43E-01 | 6.18E-02 |
| Reef shellfish (crab) | 2.22E-06 | 1.72E-07 | 1.29E-01 | 2.97E-02 | 6.51E-07 | 1.32E-07 | 1.90E-01 | 3.42E-02 |

| ***PREDICTED EXPOSURE CONCENTRATIONS (mg/kg in fresh weight)*** | |
|---|---|
| Benthic fish (flounder) | 9.26E-04 |
| Benthic shellfish (lobster) | 2.69E-04 |
| Pelagic fish (jack) | 4.54E-04 |
| Reef fish TL-IV (grouper) | 1.12E-01 |
| Reef fish TL-III (triggerfish) | 6.51E-02 |
| Reef shellfish (crab) | 3.61E-02 |

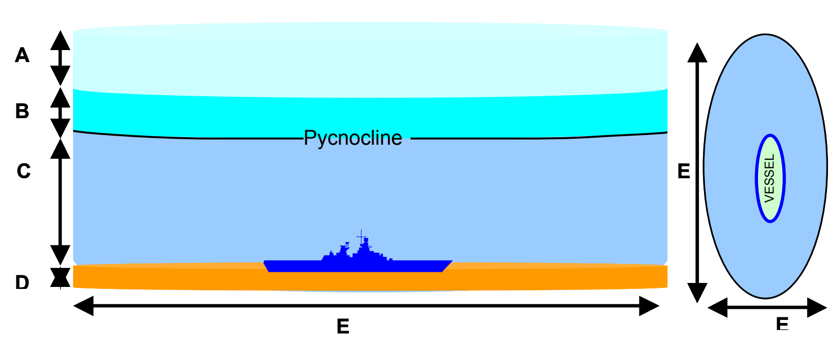
| ***RISK INPUTS - Adult*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 70 | 70 |
| Ingestion Rate (IRc) (kg/day) | 0.0261 | 0.0072 |
| Exposure Duration (EDc) (years) | 24 | 3 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 0.00002 | 0.000045 |
| Averaging Time for noncancer (ATnc-child) | 8.76E+03 | 1.10E+03 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |

| ***RISK INPUTS - Child*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 15 | 15 |
| Ingestion Rate (IRc) (kg/day) | 0.0092916 | 0.0025632 |
| Exposure Duration (EDc) (years) | 6 | 6 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 0.00002 | 0.000045 |
| Averaging Time for noncancer (ATnc-child) | 2.19E+03 | 2.19E+03 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |
| Child - Adult IR scaling factor | 0.356 | |

| | |
|---|---|
| Zone of Influence Multiplier | 3 |
| Scenario run on | 6/1/05 12:00 |

| ***PCB-LADEN MATERIAL INPUTS*** | Fraction PCB | Release Rate (ng/g-d) | kg Material Onboard | PCB Release (ng/day) |
|---|---|---|---|---|
| Ventilation Gaskets | 3.14E-05 | 1.58E+03 | 1.46E+03 | 7.23E+04 |
| Lubricants | 1.03E-04 | 2.20E+03 | 0.00E+00 | 0.00E+00 |
| Foam Rubber Material | 0.76% | 2.62E+00 | 0.00E+00 | 0.00E+00 |
| Black Rubber Material | 5.29E-05 | 1.58E+03 | 5.40E+03 | 4.50E+05 |
| Electrical Cable | 1.85E-03 | 2.79E+02 | 2.96E+05 | 1.53E+08 |
| Bulkhead Insulation Material | 5.37E-04 | 6.76E+04 | 1.44E+04 | 5.22E+08 |
| Aluminum Paint | 2.00E-05 | 1.11E+04 | 3.87E+05 | 8.62E+07 |
| Total | | | | 7.62E+08 |

| Ex-Oriskany CV34 | |
|---|---|
| Ex-Oriskany CV34 | 27100 |
| Length (ft) | 888 |
| Beam (ft) | 120 |




| ZOI = | 3 | |
|---|---|---|
| Spatial Footprint on Ocean Floor | | |
| | 2.33E+04 | m2 |
| | 9.01E-03 | mile2 |
| Modeled Dimensions Outside the Vessel | | |
| A | 1.00E+01 | m |
| B | 1.50E+01 | m |
| C | 5.00E+01 | m |
| D | 1.00E-01 | m |
| E | 3.25E+02 | m |
| F | 9.13E+01 | m |
| Volumes | | |
| Air Column | | |
| Air | 2.33E+05 | m3 |
| Upper Water Column | | |
| Water | 3.50E+05 | m3 |
| TSS | 2.33E+00 | m3 |
| Lower Water Column | | |
| Water | 1.11E+06 | m3 |
| TSS | 7.42E+00 | m3 |
| Inside Vessel | | |
| Water | 5.38E+04 | m3 |
| TSS | 3.59E-01 | m3 |
| Sediment Bed | | |
| Sediment | 1.56E+03 | m3 |

| Abiotic Inputs | |
|---|---|
| Air Column | |
| Active air space height above water column (m) | 10 |
| Air current (m/h) | 13677 |
| Upper Water Column | |
| Temperature (oC) | 24.5 |
| Water depth (m) | 15 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 6.12 |
| Lower Water Column | |
| Temperature (oC) | 19.5 |
| Water depth (m) | 50 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Inside Vessel | |
| Temperature (oC) | 19.5 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Sediment Bed | |
| Sediment density (g/cm3) | 1.5 |
| Active sediment depth (m) | 0.1 |
| Sediment fraction organic carbon | 0.01 |
| All Regions | |
| Suspended solids density (g/cm3) | 1.5 |
| Suspended solids fraction organic carbon | 0.15 |
| Dissolved organic carbon density (g/cm3) | 1 |
| Water current - to out of the ZOI (m/h) | 926 |
| Water current - inside to outside the vessel (m/h) | 9.26 |

| Total PCB concentrations | | |
|---|---|---|
| Air Column | | |
| Air | 7.83E-17 | g/m3 |
| Upper Water Column | | |
| Freely dissolved in water | 9.72E-13 | mg/L |
| Suspended solids | 1.27E-08 | mg/kg |
| Dissolved organic carbon | 1.70E-07 | mg/kg |
| Lower Water Column | | |
| Freely dissolved in water | 3.43E-09 | mg/L |
| Suspended solids | 8.43E-05 | mg/kg |
| Dissolved organic carbon | 7.72E-04 | mg/kg |
| Inside Vessel | | |
| Freely dissolved in water | 1.80E-06 | mg/L |
| Suspended solids | 4.44E-02 | mg/kg |
| Dissolved organic carbon | 4.06E-01 | mg/kg |
| Sediment Bed | | |
| Freely dissolved in pore water | 3.43E-09 | mg/L |
| Bedded sediment | 5.62E-06 | mg/kg |
| Dissolved organic carbon in pore water | 7.72E-04 | mg/kg |

| Total PCB concentrations in biota | | | Percent Exposures | |
|---|---|---|---|---|
| Pelagic Community | | | Upper WC | Lower WC |
| Phytoplankton (TL-I) | 1.60E-09 | mg/kg | 100% | 0% |
| Zooplankton (TL-II) | 6.04E-05 | mg/kg | 50% | 50% |
| Planktivore (TL-III) | 2.92E-04 | mg/kg | 80% | 20% |
| Piscivore (TL-IV) | 4.54E-04 | mg/kg | 80% | 20% |
| Reef / Vessel Community | | | Lower WC | Vessel Int. |
| Attached Algae (TL-I) | 5.65E-06 | mg/kg | 100% | 0% |
| Sessile filter feeder (TL-II) | 1.24E-04 | mg/kg | 100% | 0% |
| Invertebrate Omnivore (TL-III) | 1.68E-02 | mg/kg | 80% | 20% |
| Invertebrate Forager (TL-III) | 3.61E-02 | mg/kg | 70% | 30% |
| Vertebrate Forager (TL-III) | 6.51E-02 | mg/kg | 70% | 30% |
| Predator (TL-IV) | 1.12E-01 | mg/kg | 80% | 20% |
| Benthic Community | | | Lower WC | Pore Water |
| Infaunal invert. (TL-II) | 4.28E-05 | mg/kg | 20% | 80% |
| Epifaunal invert. (TL-II) | 1.18E-04 | mg/kg | 50% | 50% |
| Forager (TL-III) | 2.69E-04 | mg/kg | 75% | 25% |
| Predator (TL-IV) | 9.26E-04 | mg/kg | 90% | 10% |

**Scenario Run on** 6/1/05 12:00 ZOI = 3

| PCB Homolog | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Molecular Weight (g/mol) | 1.89E+02 | 2.23E+02 | 2.58E+02 | 2.92E+02 | 3.26E+02 | 3.61E+02 | 3.95E+02 | 4.30E+02 | 4.64E+02 | 4.99E+02 |
| Solubility (mg/L) | 2.91E+00 | 6.78E-01 | 8.14E-02 | 6.67E-02 | 2.61E-02 | 9.50E-04 | 2.30E-04 | 2.11E-08 | 4.02E-09 | 1.69E-10 |
| Solubility (mol/m$^3$) | 1.54E-02 | 3.04E-03 | 3.16E-04 | 2.28E-04 | 8.00E-05 | 2.63E-06 | 5.82E-07 | 4.91E-11 | 8.65E-12 | 3.38E-13 |
| Vapor Pressure (Pa) | 6.32E-01 | 1.41E-01 | 5.11E-02 | 2.08E-02 | 2.96E-03 | 3.43E-03 | 2.56E-04 | 8.65E-05 | 2.77E-05 | 1.41E-05 |
| Henry's (Pa-m$^3$/mol) | 4.10E+01 | 4.65E+01 | 1.62E+02 | 9.10E+01 | 3.70E+01 | 1.30E+03 | 4.40E+02 | 1.76E+06 | 3.20E+06 | 4.18E+07 |
| $\log_{10}K_{ow}$ = | 4.47 | 5.24 | 5.52 | 5.92 | 6.50 | 6.98 | 7.19 | 7.70 | 8.35 | 9.60 |
| $\log_{10}K_{oc}$ = | 3.66 | 4.06 | 4.63 | 4.65 | 4.94 | 6.08 | 6.34 | 6.46 | 6.97 | 7.94 |
| $\log_{10}K_{doc}$ = | 3.34 | 4.11 | 4.39 | 4.79 | 5.51 | 5.85 | 6.06 | 6.57 | 7.22 | 8.47 |
| Chemical emission rate (g/day) | 1.37E-05 | 1.12E-01 | 9.95E-03 | 1.69E-01 | 3.20E-01 | 7.57E-02 | 7.37E-02 | 0.00E+00 | 8.28E-04 | 4.62E-04 |
| Chemical emission rate (mol/hr) | 3.03E-09 | 2.09E-05 | 1.61E-06 | 2.42E-05 | 4.08E-05 | 8.74E-06 | 7.77E-06 | 0.00E+00 | 7.43E-08 | 3.86E-08 |
| Biodegradation in sediment (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Biodegradation in water (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Fraction PCB in Material (wt/wt) | 0.0000314 | 0.000103 | 0.76% | 0.0000529 | 0.00185 | 0.000537 | 0.00002 |
| Material Mass Onboard (kg) | 1459 | 0 | 0 | 5397 | 296419 | 14379 | 386528 |
| Total PCBs (kg) | 0.0458126 | 0 | 0 | 0.2855013 | 548.37515 | 7.721523 | 7.73056 |
| Total PCB Release rate (ng/g-PCB per day) | 1.58E+03 | 2.20E+03 | 2.62E+00 | 1.58E+03 | 2.79E+02 | 6.76E+04 | 1.11E+04 |

| Release Rates in nanograms PCB per gram of PCB within the Material | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 4.14E+01 | 3.47E+01 | 0.00E+00 | 4.14E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Dichlorobiphenyl | 1.27E+03 | 1.72E+02 | 3.08E-02 | 1.27E+03 | 2.03E+02 | 5.36E+00 | 0.00E+00 |
| Trichlorobiphenyl | 5.66E+01 | 8.97E+01 | 7.63E-02 | 5.66E+01 | 1.14E+00 | 9.44E+02 | 2.61E+02 |
| Tetrachlorobiphenyl | 1.44E+02 | 1.08E+03 | 1.29E+00 | 1.44E+02 | 1.57E+01 | 2.07E+04 | 1.23E+02 |
| Pentachlorobiphenyl | 6.31E+01 | 6.60E+02 | 3.90E-02 | 6.31E+01 | 1.80E+01 | 3.79E+04 | 2.24E+03 |
| Hexachlorobiphenyl | 0.00E+00 | 9.42E+01 | 5.34E-01 | 0.00E+00 | 2.41E+01 | 6.76E+03 | 1.33E+03 |
| Heptachlorobiphenyl | 5.04E+00 | 7.17E+01 | 6.46E-01 | 5.04E+00 | 1.47E+01 | 1.30E+03 | 7.19E+03 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 1.72E-03 | 0.00E+00 | 1.51E+00 | 0.00E+00 | 0.00E+00 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.43E-01 | 0.00E+00 | 0.00E+00 |
| **Total** | **1.58E+03** | **2.20E+03** | **2.62E+00** | **1.58E+03** | **2.79E+02** | **6.76E+04** | **1.11E+04** |

| Release Rates in nanograms PCB per Day | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint | Total |
|---|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 1.90E+03 | 0.00E+00 | 0.00E+00 | 1.18E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.37E+04 |
| Dichlorobiphenyl | 5.80E+04 | 0.00E+00 | 0.00E+00 | 3.62E+05 | 1.11E+08 | 4.14E+04 | 0.00E+00 | 1.12E+08 |
| Trichlorobiphenyl | 2.59E+03 | 0.00E+00 | 0.00E+00 | 1.62E+04 | 6.25E+05 | 7.29E+06 | 2.02E+06 | 9.95E+06 |
| Tetrachlorobiphenyl | 6.60E+03 | 0.00E+00 | 0.00E+00 | 4.11E+04 | 8.61E+06 | 1.60E+08 | 9.51E+05 | 1.69E+08 |
| Pentachlorobiphenyl | 2.89E+03 | 0.00E+00 | 0.00E+00 | 1.80E+04 | 9.87E+06 | 2.93E+08 | 1.73E+07 | 3.20E+08 |
| Hexachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.32E+07 | 5.22E+07 | 1.03E+07 | 7.57E+07 |
| Heptachlorobiphenyl | 2.31E+02 | 0.00E+00 | 0.00E+00 | 1.44E+03 | 8.06E+06 | 1.01E+07 | 5.56E+07 | 7.37E+07 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.28E+05 | 0.00E+00 | 0.00E+00 | 8.28E+05 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.62E+05 | 0.00E+00 | 0.00E+00 | 4.62E+05 |
| **Total** | 7.23E+04 | 0.00E+00 | 0.00E+00 | 4.50E+05 | 1.53E+08 | 5.22E+08 | 8.62E+07 | 7.62E+08 |

| Air | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 3.77E-20 | 2.32E-16 | 1.53E-17 | 2.04E-16 | 2.24E-16 | 7.88E-18 | 2.81E-18 | 0.00E+00 | 9.97E-22 | 3.21E-24 |
| Air concentration (g/m3) | 2.89E-21 | 2.11E-17 | 1.60E-18 | 2.43E-17 | 2.97E-17 | 1.16E-18 | 4.52E-19 | 0.00E+00 | 1.89E-22 | 6.51E-25 |

| Upper Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 6.39E-18 | 4.83E-14 | 1.17E-14 | 9.43E-14 | 4.51E-14 | 5.74E-14 | 7.25E-15 | 0.00E+00 | 2.02E-14 | 8.80E-16 |
| Water concentration (mg/L) | 2.94E-17 | 2.32E-13 | 1.86E-14 | 3.02E-13 | 3.97E-13 | 1.59E-14 | 6.51E-15 | 0.00E+00 | 2.93E-18 | 1.05E-20 |
| Suspended solids concentration (mg/kg) | 2.03E-14 | 3.97E-10 | 1.18E-10 | 2.05E-09 | 5.13E-09 | 2.86E-09 | 2.14E-09 | 0.00E+00 | 4.06E-12 | 1.37E-13 |
| Dissolved organic carbon (mg/kg) | 6.47E-14 | 2.95E-09 | 4.58E-10 | 1.87E-08 | 1.29E-07 | 1.11E-08 | 7.46E-09 | 0.00E+00 | 4.87E-11 | 3.11E-12 |

| Lower Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 1.84E-14 | 1.41E-10 | 3.60E-11 | 2.97E-10 | 1.70E-10 | 5.27E-10 | 1.03E-10 | 0.00E+00 | 1.43E-09 | 7.78E-10 |
| Water concentration (mg/L) | 8.45E-14 | 6.78E-10 | 5.74E-11 | 9.53E-10 | 1.50E-09 | 1.46E-10 | 9.22E-11 | 0.00E+00 | 2.07E-13 | 9.27E-15 |
| Suspended solids concentration (mg/kg) | 5.84E-11 | 1.16E-06 | 3.63E-07 | 6.45E-06 | 1.94E-05 | 2.63E-05 | 3.03E-05 | 0.00E+00 | 2.87E-07 | 1.21E-07 |
| Dissolved organic carbon (mg/kg) | 1.86E-10 | 8.64E-06 | 1.41E-06 | 5.89E-05 | 4.89E-04 | 1.02E-04 | 1.06E-04 | 0.00E+00 | 3.44E-06 | 2.75E-06 |

| Inside the Vessel | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 9.67E-12 | 7.43E-08 | 1.89E-08 | 1.56E-07 | 8.96E-08 | 2.77E-07 | 5.40E-08 | 0.00E+00 | 7.51E-07 | 4.09E-07 |
| Water concentration (mg/L) | 4.45E-11 | 3.57E-07 | 3.02E-08 | 5.02E-07 | 7.90E-07 | 7.68E-08 | 4.85E-08 | 0.00E+00 | 1.09E-10 | 4.88E-12 |
| Suspended solids concentration (mg/kg) | 3.07E-08 | 6.11E-04 | 1.91E-04 | 3.39E-03 | 1.02E-02 | 1.39E-02 | 1.59E-02 | 0.00E+00 | 1.51E-04 | 6.38E-05 |
| Dissolved organic carbon (mg/kg) | 9.80E-08 | 4.54E-03 | 7.41E-04 | 3.10E-02 | 2.57E-01 | 5.38E-02 | 5.56E-02 | 0.00E+00 | 1.81E-03 | 1.45E-03 |

| Sediment Bed | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 1.84E-14 | 1.41E-10 | 3.60E-11 | 2.97E-10 | 1.70E-10 | 5.27E-10 | 1.03E-10 | 0.00E+00 | 1.43E-09 | 7.78E-10 |
| Pore Water concentration (mg/L) | 8.45E-14 | 6.78E-10 | 5.74E-11 | 9.53E-10 | 1.50E-09 | 1.46E-10 | 9.22E-11 | 0.00E+00 | 2.07E-13 | 9.27E-15 |
| Sediment concentration (mg/kg) | 3.89E-12 | 7.74E-08 | 2.42E-08 | 4.30E-07 | 1.29E-06 | 1.76E-06 | 2.02E-06 | 0.00E+00 | 1.92E-08 | 8.09E-09 |

| Bioenergetic Inputs | Species | Body Weight | Lipid | Moisture | Caloric Density | GE to ME | Met Energy | Caloric Density | Production | Respiration | Excretion | Caloric Density | Met Energy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (kg) | (%-dw) | (%) | (kcal/g-dry weight) | Fraction | (kcal/kg-lipid) | (kcal/kg-lipid) | (% of total) | (% of total) | (% of total) | (kcal/g-wt weight) | (kcal/g-wt weight) |
| **Pelagic Community** | | | | | | | | | | | | | |
| Phytoplankton (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Zooplankton (TL-II) | copepods | 0.000005 | 22% | 76% | 3.6 | 0.65 | 10636 | 16364 | 18% | 24% | 58% | 0.864 | 0.5616 |
| Planktivore (TL-III) | herring | 0.05 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Piscivore (TL-IV) | jack | 0.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| **Reef / Vessel Community** | | | | | | | | | | | | | |
| Attached Algae (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.05 | 5% | 82% | 4.6 | 0.65 | 59800 | 92000 | 28% | 31% | 41% | 0.828 | 0.5382 |
| Invertebrate Omnivore (TL-II) | urchin | 0.05 | 29% | 82% | 4.6 | 0.65 | 10310 | 15862 | 7% | 25% | 68% | 0.828 | 0.5382 |
| Invertebrate Forager (TL-III) | crab | 1 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Vertebrate Forager (TL-III) | triggerfish | 1 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Predator (TL-IV) | grouper | 1.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 0.2 | 0.14 |
| **Benthic Community** | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.01 | 6% | 84% | 4.6 | 0.65 | 50000 | 76923 | 71% | 26% | 3% | 0.736 | 0.4784 |
| Epifaunal invert. (TL-II) | nematode | 0.01 | 6% | 82% | 4.6 | 0.65 | 50000 | 76923 | 31% | 19% | 50% | 0.828 | 0.5382 |
| Forager (TL-III) | lobster | 2 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Predator (TL-IV) | flounder | 3 | 22% | 75% | 4.9 | 0.7 | 15591 | 22273 | 20% | 60% | 20% | 1.225 | 0.8575 |

| Bioenergetic Inputs | | Respiration Rate Allometric Regression Parameters | | | Resp. Rate | Resp. Rate | Consumption | Growth Rate | Consumption | Consumption | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | a | b1 | b2 | 1 / day | gO2 / kg-lipid-day | kcal / kg-lipid-day | 1 / day | g-wt weight / g-wt weight-d | kcal / wet weight-da | As a % of body weight |
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | Algae | | | | | | | | | | |
| Zooplankton (TL-II) | copepods | 0.006375522 | 0 | 0.039935335 | 0.015425453 | 84.24400867 | 1286.168071 | 0.014147849 | 0.32636028 | 0.06790967 | 32.6% |
| Planktivore (TL-III) | herring | 0.0033 | -0.227 | 0.0548 | 0.004949927 | 21.1649 | 129.2512977 | 0.001482433 | 0.01616792 | 0.0090799 | 1.6% |
| Piscivore (TL-IV) | jack | 0.001118602 | -0.55 | 0.12 | 0.000630951 | 2.697821256 | 16.47524431 | 0.000188961 | 0.00139796 | 0.00115739 | 0.1% |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | Algae | | | | | | | | | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.012 | 0 | 0.036 | 0.024213411 | 581.8482643 | 6877.300342 | 0.020930914 | 0.24377539 | 0.0618957 | 24.4% |
| Invertibrate Omnivore (TL-II) | urchin | 0.000675466 | 0 | 0.079181846 | 0.003163548 | 13.1069075 | 192.1012396 | 0.00084751 | 0.03471132 | 0.01002768 | 3.5% |
| Invertibrate Forager (TL-III) | crab | 0.001158234 | 0 | 0.071193202 | 0.004642088 | 60.75673491 | 377.3221989 | 0.003592107 | 0.01678102 | 0.00900593 | 1.7% |
| Vertibrate Forager (TL-III) | triggerfish | 0.015181024 | -0.415 | 0.061 | 0.002837229 | 12.13142452 | 74.08503521 | 0.00084971 | 0.00907693 | 0.00520447 | 0.9% |
| Predator (TL-IV) | grouper | 0.00279 | -0.355 | 0.0811 | 0.001011362 | 4.324384181 | 26.40845301 | 0.000302889 | 0.00264734 | 0.00185519 | 0.3% |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 1903.064429 | 0.017565285 | 0.09800757 | 0.01820852 | 9.8% |
| Epifaunal invert. (TL-II) | nematode | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 2604.19343 | 0.0104949 | 0.09262416 | 0.02803154 | 9.3% |
| Forager (TL-III) | lobster | 0.0035 | -0.13 | 0.066 | 0.00471923 | 61.76639253 | 383.5925529 | 0.003651801 | 0.01899736 | 0.00915559 | 1.9% |
| Predator (TL-IV) | flounder | 0.0046 | -0.24 | 0.067 | 0.002486878 | 13.58174479 | 82.94195291 | 0.000744785 | 0.00974341 | 0.00456181 | 1.0% |

**Dietary Preferences**

| | Suspended Solids (Epilimnion) | Suspended Solids (Hypolimnion) | Sediment | Phytoplankton | Zooplankton | Pelagic Plankitivore | Attached Algae | Reef Sessile Filter Feeder | Invertebrate Omnivore | Reef Invertebrate Forager | Reef Vertebrate Forager | Infaunal Benthos | Epifaunal Benthos | Benthic Forager |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | | | | |
| Phytoplankton (TL1) | | | | | | | | | | | | | | |
| Zooplankton (TL-II) | 15% | 15% | | 70% | | | | | | | | | | |
| Planktivore (TL-III) | | | | | 100% | | | | | | | | | |
| Piscivore (TL-IV) | | | | | 10% | 90% | | | | | | | | |
| **Reef / Vessel Community** | | | | | | | | | | | | | | |
| Attached Algae | | | | | | | | | | | | | | |
| Sessile filter feeder (TL-II) | | 10% | | 80% | 10% | | | | | | | | | |
| Invertebrate Omnivore (TL-II) | | | | | | | 80% | 20% | | | | | | |
| Invertebrate Forager (TL-III) | | 5% | | | 5% | 5% | | 35% | 50% | | | | | |
| Vertebrate Forager (TL-III) | | | | | | 19% | | 19% | 15% | 22% | | 12.5% | 12.5% | |
| Predator (TL-IV) | | | | | | | | | | 15% | 60% | 8% | 8% | 8% |
| **Benthic Community** | | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | | | 50% | 30% | 20% | | | | | | | | | |
| Epifaunal invert. (TL-II) | | | 25% | 30% | 20% | | | | | | | 25% | | |
| Forager (TL-III) | | | 5% | | | | | | | | | 50% | 45% | |
| Predator (TL-IV) | | | 2% | | | | | | | | | 20% | 20% | 58% |

**Water Exposures**

| | | Upper Water Column | Lower Water Column | Vessel Interior | Sediment Pore Water |
|---|---|---|---|---|---|
| **Pelagic Community** | | | | | |
| Phytoplankton (TL1) | Algae | 100% | | | |
| Zooplankton (TL-II) | copepods | 50% | 50% | | |
| Planktivore (TL-III) | herring | 80% | 20% | | |
| Piscivore (TL-IV) | jack | 80% | 20% | | |
| **Reef / Vessel Community** | | | | | |
| Attached Algae | Algae | | 100% | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | | 100% | | |
| Invertebrate Omnivore (TL-II) | urchin | | 80% | 20% | |
| Invertebrate Forager (TL-III) | crab | | 70% | 30% | |
| Vertebrate Forager (TL-III) | triggerfish | | 70% | 30% | |
| Predator (TL-IV) | grouper | | 80% | 20% | |
| **Benthic Community** | | | | | |
| Infaunal invert. (TL-II) | polychaete | | 20% | | 80% |
| Epifaunal invert. (TL-II) | nematode | | 50% | | 50% |
| Forager (TL-III) | lobster | | 75% | | 25% |
| Predator (TL-IV) | flounder | | 90% | | 10% |

**Energy Estimates for Suspended Sediment and Bedded Sediment**

| | GE | ME | ME | as kcal/g-ww |
|---|---|---|---|---|
| Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.01099776 |
| Suspended Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.1649664 |

| Respiratory Efficiencies | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Low body weight (<100g) | 4.335E-01 | 8.000E-01 | 8.000E-01 | 8.000E-01 | 4.492E-01 | 2.582E-01 | 2.018E-01 | 1.127E-01 | 5.303E-02 | 1.255E-02 |
| High body weight (>100g) | 5.000E-01 | 5.000E-01 | 5.000E-01 | 5.000E-01 | 3.769E-01 | 2.857E-01 | 2.526E-01 | 1.888E-01 | 1.295E-01 | 6.299E-02 |
| Dietary Assimilation Efficiencies | 27% | 46% | 53% | 62% | 69% | 69% | 68% | 59% | 44% | 16% |

| Tissue Conc. (mg/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 8.750E-13 | 2.318E-08 | 1.865E-09 | 3.024E-08 | 3.972E-08 | 1.588E-09 | 6.506E-10 | 0.000E+00 | 2.932E-13 | 1.050E-15 |
| Zooplankton (TL-II) | 5.696E-09 | 2.115E-04 | 2.134E-05 | 4.027E-04 | 3.994E-04 | 5.714E-05 | 5.083E-05 | 0.000E+00 | 2.549E-07 | 3.768E-08 |
| Planktivore (TL-III) | 1.287E-09 | 1.791E-04 | 3.266E-05 | 1.194E-03 | 2.129E-03 | 3.349E-04 | 2.905E-04 | 0.000E+00 | 9.612E-07 | 5.060E-08 |
| Piscivore (TL-IV) | 3.366E-10 | 3.157E-05 | 8.670E-06 | 6.977E-04 | 3.731E-03 | 1.005E-03 | 9.822E-04 | 0.000E+00 | 2.869E-06 | 6.258E-08 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.518E-09 | 6.778E-05 | 5.736E-06 | 9.533E-05 | 1.501E-04 | 1.460E-05 | 9.218E-06 | 0.000E+00 | 2.074E-08 | 9.272E-10 |
| Sessile filter feeder (TL-II) | 8.107E-08 | 2.734E-03 | 2.701E-04 | 5.079E-03 | 4.917E-03 | 4.355E-04 | 3.153E-04 | 0.000E+00 | 1.009E-06 | 1.095E-07 |
| Invertebrate Omnivore (TL-II) | 2.890E-07 | 2.243E-02 | 3.312E-03 | 1.065E-01 | 1.719E-01 | 1.213E-02 | 6.345E-03 | 0.000E+00 | 4.354E-06 | 5.640E-08 |
| Invertebrate Forager (TL-III) | 2.189E-06 | 8.926E-02 | 1.329E-02 | 4.483E-01 | 8.549E-01 | 6.748E-02 | 3.738E-02 | 0.000E+00 | 4.100E-05 | 2.699E-06 |
| Vertebrate Forager (TL-III) | 2.011E-07 | 1.411E-02 | 3.032E-03 | 1.776E-01 | 6.308E-01 | 6.375E-02 | 3.718E-02 | 0.000E+00 | 4.161E-05 | 1.377E-06 |
| Predator (TL-IV) | 1.114E-07 | 7.236E-03 | 1.709E-03 | 1.490E-01 | 1.149E+00 | 1.758E-01 | 1.126E-01 | 0.000E+00 | 1.210E-04 | 2.674E-06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.054E-08 | 8.067E-04 | 8.384E-05 | 1.658E-03 | 1.665E-03 | 1.524E-04 | 1.114E-04 | 0.000E+00 | 3.108E-07 | 2.215E-08 |
| Epifaunal invert. (TL-II) | 2.547E-08 | 1.500E-03 | 1.789E-04 | 4.050E-03 | 4.463E-03 | 4.277E-04 | 3.158E-04 | 0.000E+00 | 7.933E-07 | 4.350E-08 |
| Forager (TL-III) | 1.487E-08 | 8.214E-04 | 1.256E-04 | 3.795E-03 | 5.656E-03 | 5.288E-04 | 3.603E-04 | 0.000E+00 | 5.744E-07 | 1.318E-08 |
| Predator (TL-IV) | 1.317E-09 | 2.190E-04 | 5.772E-05 | 3.575E-03 | 1.077E-02 | 1.296E-03 | 9.152E-04 | 0.000E+00 | 1.176E-06 | 1.729E-08 |

| Tissue Conc. (mg/kg-WW) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.442E-14 | 3.819E-10 | 3.073E-11 | 4.983E-10 | 6.545E-10 | 2.618E-11 | 1.072E-11 | 0.000E+00 | 4.831E-15 | 1.730E-17 | 1.602E-09 |
| Zooplankton (TL-II) | 3.007E-10 | 1.117E-05 | 1.127E-06 | 2.126E-05 | 2.109E-05 | 3.017E-06 | 2.684E-06 | 0.000E+00 | 1.346E-08 | 1.989E-09 | 6.036E-05 |
| Planktivore (TL-III) | 9.043E-11 | 1.258E-05 | 2.294E-06 | 8.391E-05 | 1.495E-04 | 2.353E-05 | 2.041E-05 | 0.000E+00 | 6.753E-08 | 3.555E-09 | 2.923E-04 |
| Piscivore (TL-IV) | 2.364E-11 | 2.218E-06 | 6.091E-07 | 4.901E-05 | 2.621E-04 | 7.057E-05 | 6.900E-05 | 0.000E+00 | 2.016E-07 | 4.396E-09 | 4.537E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 4.150E-11 | 1.117E-06 | 9.453E-08 | 1.571E-06 | 2.474E-06 | 2.406E-07 | 1.519E-07 | 0.000E+00 | 3.418E-10 | 1.528E-11 | 5.649E-06 |
| Sessile filter feeder (TL-II) | 7.297E-10 | 2.461E-05 | 2.431E-06 | 4.571E-05 | 4.425E-05 | 3.919E-06 | 2.838E-06 | 0.000E+00 | 9.084E-09 | 9.857E-10 | 1.238E-04 |
| Invertebrate Omnivore (TL-II) | 1.509E-08 | 1.171E-03 | 1.729E-04 | 5.561E-03 | 8.973E-03 | 6.330E-04 | 3.312E-04 | 0.000E+00 | 2.273E-07 | 2.944E-09 | 1.684E-02 |
| Invertebrate Forager (TL-III) | 5.224E-08 | 2.131E-03 | 3.173E-04 | 1.070E-02 | 2.041E-02 | 1.611E-03 | 8.923E-04 | 0.000E+00 | 9.787E-07 | 6.442E-08 | 3.606E-02 |
| Vertebrate Forager (TL-III) | 1.413E-08 | 9.913E-04 | 2.130E-04 | 1.247E-02 | 4.432E-02 | 4.478E-03 | 2.612E-03 | 0.000E+00 | 2.923E-06 | 9.671E-08 | 6.509E-02 |
| Predator (TL-IV) | 7.825E-09 | 5.083E-04 | 1.201E-04 | 1.047E-02 | 8.075E-02 | 1.235E-02 | 7.909E-03 | 0.000E+00 | 8.499E-06 | 1.879E-07 | 1.121E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 1.965E-10 | 7.718E-06 | 8.022E-07 | 1.587E-05 | 1.593E-05 | 1.458E-06 | 1.066E-06 | 0.000E+00 | 2.974E-09 | 2.119E-10 | 4.285E-05 |
| Epifaunal invert. (TL-II) | 2.742E-10 | 1.615E-05 | 1.926E-06 | 4.359E-05 | 4.804E-05 | 4.604E-06 | 3.399E-06 | 0.000E+00 | 8.539E-09 | 4.682E-10 | 1.177E-04 |
| Forager (TL-III) | 3.550E-10 | 1.960E-05 | 2.998E-06 | 9.058E-05 | 1.350E-04 | 1.262E-05 | 8.600E-06 | 0.000E+00 | 1.371E-08 | 3.145E-10 | 2.694E-04 |
| Predator (TL-IV) | 7.241E-11 | 1.204E-05 | 3.175E-06 | 1.966E-04 | 5.925E-04 | 7.128E-05 | 5.034E-05 | 0.000E+00 | 6.471E-08 | 9.512E-10 | 9.260E-04 |

| BAFs (L/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Zooplankton (TL-II) | 1.347E+05 | 6.238E+05 | 7.437E+05 | 8.446E+05 | 5.320E+05 | 7.827E+05 | 1.103E+06 | 0.000E+00 | 2.458E+06 | 8.127E+06 |
| Planktivore (TL-III) | 7.603E+04 | 1.319E+06 | 2.843E+06 | 6.257E+06 | 7.083E+06 | 1.146E+07 | 1.575E+07 | 0.000E+00 | 2.317E+07 | 2.729E+07 |
| Piscivore (TL-IV) | 1.988E+04 | 2.326E+05 | 7.548E+05 | 3.655E+06 | 1.242E+07 | 3.439E+07 | 5.326E+07 | 0.000E+00 | 6.917E+07 | 3.375E+07 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Sessile filter feeder (TL-II) | 9.590E+05 | 4.034E+06 | 4.709E+06 | 5.328E+06 | 3.276E+06 | 2.983E+06 | 3.420E+06 | 0.000E+00 | 4.867E+06 | 1.181E+07 |
| Invertebrate Omnivore (TL-II) | 3.225E+04 | 3.121E+05 | 5.447E+05 | 1.054E+06 | 1.080E+06 | 7.834E+05 | 6.492E+05 | 0.000E+00 | 1.981E+05 | 5.738E+04 |
| Invertebrate Forager (TL-III) | 1.633E+05 | 8.307E+05 | 1.462E+06 | 2.966E+06 | 3.593E+06 | 2.916E+06 | 2.558E+06 | 0.000E+00 | 1.247E+06 | 1.836E+06 |
| Vertebrate Forager (TL-III) | 1.501E+04 | 1.313E+05 | 3.334E+05 | 1.175E+06 | 2.651E+06 | 2.754E+06 | 2.544E+06 | 0.000E+00 | 1.266E+06 | 9.366E+05 |
| Predator (TL-IV) | 1.243E+04 | 1.007E+05 | 2.810E+05 | 1.474E+06 | 7.223E+06 | 1.136E+07 | 1.152E+07 | 0.000E+00 | 5.503E+06 | 2.721E+06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.429E+05 | 1.190E+06 | 1.462E+06 | 1.740E+06 | 1.109E+06 | 1.044E+06 | 1.208E+06 | 0.000E+00 | 1.499E+06 | 2.389E+06 |
| Epifaunal invert. (TL-II) | 3.013E+05 | 2.213E+06 | 3.119E+06 | 4.248E+06 | 2.973E+06 | 2.930E+06 | 3.425E+06 | 0.000E+00 | 3.825E+06 | 4.691E+06 |
| Forager (TL-III) | 1.759E+05 | 1.212E+06 | 2.189E+06 | 3.981E+06 | 3.768E+06 | 3.622E+06 | 3.909E+06 | 0.000E+00 | 2.770E+06 | 1.421E+06 |
| Predator (TL-IV) | 1.557E+04 | 3.231E+05 | 1.006E+06 | 3.750E+06 | 7.177E+06 | 8.877E+06 | 9.928E+06 | 0.000E+00 | 5.673E+06 | 1.865E+06 |

Notes:
Kow = octanol to water partitioning coefficient, Koc = organic carbon partitioning coefficient, Kdoc = dissolved organic carbon partitioning coefficient
TL = trophic level, ww = wet weight

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION

## *RISK ESTIMATES FOR Ex-Oriskany CV34*

| ZOI = 4 | Cancer Risk Adult & Child | | Hazard Adult & Child | | Cancer Risk Child | | Hazard Child | |
|---|---|---|---|---|---|---|---|---|
| ***RISK ESTIMATES*** | RME | CTE | RME | CTE | RME | CTE | RME | CTE |
| Benthic fish (flounder) | 4.81E-08 | 3.73E-09 | 2.81E-03 | 6.44E-04 | 1.41E-08 | 2.86E-09 | 4.12E-03 | 7.42E-04 |
| Benthic shellfish (lobster) | 1.40E-08 | 1.08E-09 | 8.16E-04 | 1.87E-04 | 4.11E-09 | 8.33E-10 | 1.20E-03 | 2.16E-04 |
| Pelagic fish (jack) | 2.36E-08 | 1.83E-09 | 1.38E-03 | 3.16E-04 | 6.92E-09 | 1.40E-09 | 2.02E-03 | 3.64E-04 |
| Reef fish TL-IV (grouper) | 6.87E-06 | 5.32E-07 | 4.01E-01 | 9.20E-02 | 2.02E-06 | 4.09E-07 | 5.88E-01 | 1.06E-01 |
| Reef fish TL-III (triggerfish) | 3.99E-06 | 3.09E-07 | 2.33E-01 | 5.34E-02 | 1.17E-06 | 2.37E-07 | 3.41E-01 | 6.16E-02 |
| Reef shellfish (crab) | 2.21E-06 | 1.71E-07 | 1.29E-01 | 2.96E-02 | 6.49E-07 | 1.32E-07 | 1.89E-01 | 3.41E-02 |

| ***PREDICTED EXPOSURE CONCENTRATIONS (mg/kg in fresh weight)*** | |
|---|---|
| Benthic fish (flounder) | 7.82E-04 |
| Benthic shellfish (lobster) | 2.28E-04 |
| Pelagic fish (jack) | 3.83E-04 |
| Reef fish TL-IV (grouper) | 1.12E-01 |
| Reef fish TL-III (triggerfish) | 6.49E-02 |
| Reef shellfish (crab) | 3.60E-02 |

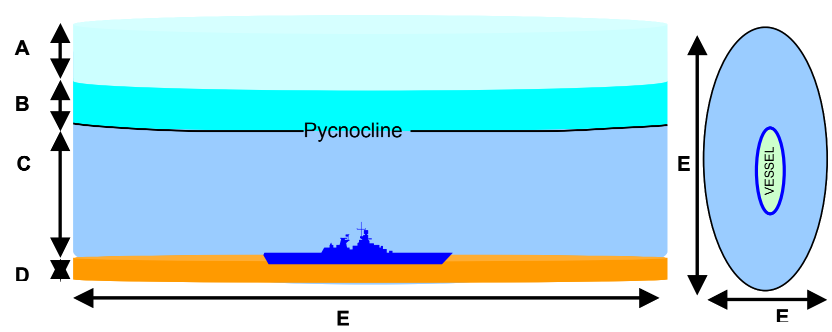
| ***RISK INPUTS - Adult*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 70 | 70 |
| Ingestion Rate (IRc) (kg/day) | 0.0261 | 0.0072 |
| Exposure Duration (EDc) (years) | 24 | 3 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 0.00002 | 0.000045 |
| Averaging Time for noncancer (ATnc-child) | 8.76E+03 | 1.10E+03 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |

| ***RISK INPUTS - Child*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 15 | 15 |
| Ingestion Rate (IRc) (kg/day) | 0.0092916 | 0.0025632 |
| Exposure Duration (EDc) (years) | 6 | 6 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 0.00002 | 0.000045 |
| Averaging Time for noncancer (ATnc-child) | 2.19E+03 | 2.19E+03 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |
| Child - Adult IR scaling factor | 0.356 | |

| | |
|---|---|
| Zone of Influence Multiplier | 4 |
| Scenario run on | 6/1/05 12:02 |

| ***PCB-LADEN MATERIAL INPUTS*** | Fraction PCB | Release Rate (ng/g-d) | kg Material Onboard | PCB Release (ng/day) |
|---|---|---|---|---|
| Ventilation Gaskets | 3.14E-05 | 1.58E+03 | 1.46E+03 | 7.23E+04 |
| Lubricants | 1.03E-04 | 2.20E+03 | 0.00E+00 | 0.00E+00 |
| Foam Rubber Material | 0.76% | 2.62E+00 | 0.00E+00 | 0.00E+00 |
| Black Rubber Material | 5.29E-05 | 1.58E+03 | 5.40E+03 | 4.50E+05 |
| Electrical Cable | 1.85E-03 | 2.79E+02 | 2.96E+05 | 1.53E+08 |
| Bulkhead Insulation Material | 5.37E-04 | 6.76E+04 | 1.44E+04 | 5.22E+08 |
| Aluminum Paint | 2.00E-05 | 1.11E+04 | 3.87E+05 | 8.62E+07 |
| Total | | | | 7.62E+08 |

| **Ex-Oriskany CV34** | |
|---|---|
| Ex-Oriskany CV34 | 27100 |
| Length (ft) | 888 |
| Beam (ft) | 120 |




| ZOI = | 4 | |
|---|---|---|
| Spatial Footprint on Ocean Floor | | |
| | 3.11E+04 | m2 |
| | 1.20E-02 | mile2 |
| Modeled Dimensions Outside the Vessel | | |
| A | 1.00E+01 | m |
| B | 1.50E+01 | m |
| C | 5.00E+01 | m |
| D | 1.00E-01 | m |
| E | 3.48E+02 | m |
| F | 1.14E+02 | m |
| Volumes | | |
| Air Column | | |
| Air | 3.11E+05 | m3 |
| Upper Water Column | | |
| Water | 4.67E+05 | m3 |
| TSS | 3.11E+00 | m3 |
| Lower Water Column | | |
| Water | 1.50E+06 | m3 |
| TSS | 1.00E+01 | m3 |
| Inside Vessel | | |
| Water | 5.38E+04 | m3 |
| TSS | 3.59E-01 | m3 |
| Sediment Bed | | |
| Sediment | 2.33E+03 | m3 |

| **Abiotic Inputs** | |
|---|---|
| Air Column | |
| Active air space height above water column (m) | 10 |
| Air current (m/h) | 13677 |
| Upper Water Column | |
| Temperature (oC) | 24.5 |
| Water depth (m) | 15 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 6.12 |
| Lower Water Column | |
| Temperature (oC) | 19.5 |
| Water depth (m) | 50 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Inside Vessel | |
| Temperature (oC) | 19.5 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Sediment Bed | |
| Sediment density (g/cm3) | 1.5 |
| Active sediment depth (m) | 0.1 |
| Sediment fraction organic carbon | 0.01 |
| All Regions | |
| Suspended solids density (g/cm3) | 1.5 |
| Suspended solids fraction organic carbon | 0.15 |
| Dissolved organic carbon density (g/cm3) | 1 |
| Water current - to out of the ZOI (m/h) | 926 |
| Water current - inside to outside the vessel (m/h) | 9.26 |

| **Total PCB concentrations** | | |
|---|---|---|
| Air Column | | |
| Air | 8.81E-17 | g/m3 |
| Upper Water Column | | |
| Freely dissolved in water | 9.48E-13 | mg/L |
| Suspended solids | 1.24E-08 | mg/kg |
| Dissolved organic carbon | 1.66E-07 | mg/kg |
| Lower Water Column | | |
| Freely dissolved in water | 2.89E-09 | mg/L |
| Suspended solids | 7.12E-05 | mg/kg |
| Dissolved organic carbon | 6.52E-04 | mg/kg |
| Inside Vessel | | |
| Freely dissolved in water | 1.80E-06 | mg/L |
| Suspended solids | 4.44E-02 | mg/kg |
| Dissolved organic carbon | 4.06E-01 | mg/kg |
| Sediment Bed | | |
| Freely dissolved in pore water | 2.89E-09 | mg/L |
| Bedded sediment | 4.75E-06 | mg/kg |
| Dissolved organic carbon in pore water | 6.52E-04 | mg/kg |

| **Total PCB concentrations in biota** | | | **Percent Exposures** | |
|---|---|---|---|---|
| Pelagic Community | | | Upper WC | Lower WC |
| Phytoplankton (TL-I) | 1.56E-09 | mg/kg | 100% | 0% |
| Zooplankton (TL-II) | 5.10E-05 | mg/kg | 50% | 50% |
| Planktivore (TL-III) | 2.47E-04 | mg/kg | 80% | 20% |
| Piscivore (TL-IV) | 3.83E-04 | mg/kg | 80% | 20% |
| Reef / Vessel Community | | | Lower WC | Vessel Int. |
| Attached Algae (TL-I) | 4.77E-06 | mg/kg | 100% | 0% |
| Sessile filter feeder (TL-II) | 1.05E-04 | mg/kg | 100% | 0% |
| Invertebrate Omnivore (TL-II) | 1.68E-02 | mg/kg | 80% | 20% |
| Invertebrate Forager (TL-III) | 3.60E-02 | mg/kg | 70% | 30% |
| Vertebrate Forager (TL-III) | 6.49E-02 | mg/kg | 70% | 30% |
| Predator (TL-IV) | 1.12E-01 | mg/kg | 80% | 20% |
| Benthic Community | | | Lower WC | Pore Water |
| Infaunal invert. (TL-II) | 3.62E-05 | mg/kg | 20% | 80% |
| Epifaunal invert. (TL-II) | 9.94E-05 | mg/kg | 50% | 50% |
| Forager (TL-III) | 2.28E-04 | mg/kg | 75% | 25% |
| Predator (TL-IV) | 7.82E-04 | mg/kg | 90% | 10% |

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION

## RISK ESTIMATES FOR Ex-Oriskany CV34

### Supplemental Information

**Scenario Run on** 6/1/05 12:02

**ZOI+4**

| PCB Homolog | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Molecular Weight (g/mol) | 1.89E+02 | 2.23E+02 | 2.58E+02 | 2.92E+02 | 3.26E+02 | 3.61E+02 | 3.95E+02 | 4.30E+02 | 4.64E+02 | 4.99E+02 |
| Solubility (mg/L) | 2.91E+00 | 6.78E-01 | 8.14E-02 | 6.67E-02 | 2.61E-02 | 9.50E-04 | 2.30E-04 | 2.11E-08 | 4.02E-09 | 1.69E-10 |
| Solubility (mol/m$^3$) | 1.54E-02 | 3.04E-03 | 3.16E-04 | 2.28E-04 | 8.00E-05 | 2.63E-06 | 5.82E-07 | 4.91E-11 | 8.65E-12 | 3.38E-13 |
| Vapor Pressure (Pa) | 6.32E-01 | 1.41E-01 | 5.11E-02 | 2.08E-02 | 2.96E-03 | 3.43E-03 | 2.56E-04 | 8.65E-05 | 2.77E-05 | 1.41E-05 |
| Henry's (Pa-m$^3$/mol) | 4.10E+01 | 4.65E+01 | 1.62E+02 | 9.10E+01 | 3.70E+01 | 1.30E+03 | 4.40E+02 | 1.76E+06 | 3.20E+06 | 4.18E+07 |
| $\log_{10}K_{ow}$ = | 4.47 | 5.24 | 5.52 | 5.92 | 6.50 | 6.98 | 7.19 | 7.70 | 8.35 | 9.60 |
| $\log_{10}K_{oc}$ = | 3.66 | 4.06 | 4.63 | 4.65 | 4.94 | 6.08 | 6.34 | 6.46 | 6.97 | 7.94 |
| $\log_{10}K_{doc}$ = | 3.34 | 4.11 | 4.39 | 4.79 | 5.51 | 5.85 | 6.06 | 6.57 | 7.22 | 8.47 |
| Chemical emission rate (g/day) | 1.37E-05 | 1.12E-01 | 9.95E-03 | 1.69E-01 | 3.20E-01 | 7.57E-02 | 7.37E-02 | 0.00E+00 | 8.28E-04 | 4.62E-04 |
| Chemical emission rate (mol/hr) | 3.03E-09 | 2.09E-05 | 1.61E-06 | 2.42E-05 | 4.08E-05 | 8.74E-06 | 7.77E-06 | 0.00E+00 | 7.43E-08 | 3.86E-08 |
| Biodegradation in sediment (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Biodegradation in water (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Fraction PCB in Material (wt/wt) | 0.0000314 | 0.000103 | 0.76% | 0.0000529 | 0.00185 | 0.000537 | 0.00002 |
| Material Mass Onboard (kg) | 1459 | 0 | 0 | 5397 | 296419 | 14379 | 386528 |
| Total PCBs (kg) | 0.0458126 | 0 | 0 | 0.2855013 | 548.37515 | 7.721523 | 7.73056 |
| Total PCB Release rate (ng/g-PCB per day) | 1.58E+03 | 2.20E+03 | 2.62E+00 | 1.58E+03 | 2.79E+02 | 6.76E+04 | 1.11E+04 |

| Release Rates in nanograms PCB per gram of PCB within the Material | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 4.14E+01 | 3.47E+01 | 0.00E+00 | 4.14E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Dichlorobiphenyl | 1.27E+03 | 1.72E+02 | 3.08E-02 | 1.27E+03 | 2.03E+02 | 5.36E+00 | 0.00E+00 |
| Trichlorobiphenyl | 5.66E+01 | 8.97E+01 | 7.63E-02 | 5.66E+01 | 1.14E+00 | 9.44E+02 | 2.61E+02 |
| Tetrachlorobiphenyl | 1.44E+02 | 1.08E+03 | 1.29E+00 | 1.44E+02 | 1.57E+01 | 2.07E+04 | 1.23E+02 |
| Pentachlorobiphenyl | 6.31E+01 | 6.60E+02 | 3.90E-02 | 6.31E+01 | 1.80E+01 | 3.79E+04 | 2.24E+03 |
| Hexachlorobiphenyl | 0.00E+00 | 9.42E+01 | 5.34E-01 | 0.00E+00 | 2.41E+01 | 6.76E+03 | 1.33E+03 |
| Heptachlorobiphenyl | 5.04E+00 | 7.17E+01 | 6.46E-01 | 5.04E+00 | 1.47E+01 | 1.30E+03 | 7.19E+03 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 1.72E-03 | 0.00E+00 | 1.51E+00 | 0.00E+00 | 0.00E+00 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.43E-01 | 0.00E+00 | 0.00E+00 |
| **Total** | **1.58E+03** | **2.20E+03** | **2.62E+00** | **1.58E+03** | **2.79E+02** | **6.76E+04** | **1.11E+04** |

| Release Rates in nanograms PCB per Day | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint | Total |
|---|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 1.90E+03 | 0.00E+00 | 0.00E+00 | 1.18E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.37E+04 |
| Dichlorobiphenyl | 5.80E+04 | 0.00E+00 | 0.00E+00 | 3.62E+05 | 1.11E+08 | 4.14E+04 | 0.00E+00 | 1.12E+08 |
| Trichlorobiphenyl | 2.59E+03 | 0.00E+00 | 0.00E+00 | 1.62E+04 | 6.25E+05 | 7.29E+06 | 2.02E+06 | 9.95E+06 |
| Tetrachlorobiphenyl | 6.60E+03 | 0.00E+00 | 0.00E+00 | 4.11E+04 | 8.61E+06 | 1.60E+08 | 9.51E+05 | 1.69E+08 |
| Pentachlorobiphenyl | 2.89E+03 | 0.00E+00 | 0.00E+00 | 1.80E+04 | 9.87E+06 | 2.93E+08 | 1.73E+07 | 3.20E+08 |
| Hexachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.32E+07 | 5.22E+07 | 1.03E+07 | 7.57E+07 |
| Heptachlorobiphenyl | 2.31E+02 | 0.00E+00 | 0.00E+00 | 1.44E+03 | 8.06E+06 | 1.01E+07 | 5.56E+07 | 7.37E+07 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.28E+05 | 0.00E+00 | 0.00E+00 | 8.28E+05 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.62E+05 | 0.00E+00 | 0.00E+00 | 4.62E+05 |
| **Total** | 7.23E+04 | 0.00E+00 | 0.00E+00 | 4.50E+05 | 1.53E+08 | 5.22E+08 | 8.62E+07 | 7.62E+08 |

| Air | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 4.24E-20 | 2.61E-16 | 1.72E-17 | 2.30E-16 | 2.51E-16 | 8.87E-18 | 3.16E-18 | 0.00E+00 | 1.12E-21 | 3.61E-24 |
| Air concentration (g/m3) | 3.26E-21 | 2.37E-17 | 1.80E-18 | 2.73E-17 | 3.34E-17 | 1.30E-18 | 5.09E-19 | 0.00E+00 | 2.12E-22 | 7.33E-25 |

| Upper Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 6.23E-18 | 4.71E-14 | 1.14E-14 | 9.19E-14 | 4.40E-14 | 5.60E-14 | 7.07E-15 | 0.00E+00 | 1.97E-14 | 8.59E-16 |
| Water concentration (mg/L) | 2.86E-17 | 2.26E-13 | 1.82E-14 | 2.95E-13 | 3.87E-13 | 1.55E-14 | 6.34E-15 | 0.00E+00 | 2.86E-18 | 1.02E-20 |
| Suspended solids concentration (mg/kg) | 1.98E-14 | 3.87E-10 | 1.15E-10 | 2.00E-09 | 5.00E-09 | 2.79E-09 | 2.08E-09 | 0.00E+00 | 3.96E-12 | 1.34E-13 |
| Dissolved organic carbon (mg/kg) | 6.31E-14 | 2.88E-09 | 4.47E-10 | 1.82E-08 | 1.26E-07 | 1.08E-08 | 7.27E-09 | 0.00E+00 | 4.75E-11 | 3.04E-12 |

| Lower Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 1.55E-14 | 1.19E-10 | 3.04E-11 | 2.51E-10 | 1.44E-10 | 4.45E-10 | 8.67E-11 | 0.00E+00 | 1.21E-09 | 6.57E-10 |
| Water concentration (mg/L) | 7.14E-14 | 5.72E-10 | 4.84E-11 | 8.05E-10 | 1.27E-09 | 1.23E-10 | 7.78E-11 | 0.00E+00 | 1.75E-13 | 7.83E-15 |
| Suspended solids concentration (mg/kg) | 4.93E-11 | 9.80E-07 | 3.06E-07 | 5.45E-06 | 1.64E-05 | 2.22E-05 | 2.55E-05 | 0.00E+00 | 2.43E-07 | 1.02E-07 |
| Dissolved organic carbon (mg/kg) | 1.57E-10 | 7.29E-06 | 1.19E-06 | 4.98E-05 | 4.13E-04 | 8.64E-05 | 8.92E-05 | 0.00E+00 | 2.91E-06 | 2.32E-06 |

| Inside the Vessel | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 9.67E-12 | 7.43E-08 | 1.89E-08 | 1.56E-07 | 8.96E-08 | 2.77E-07 | 5.40E-08 | 0.00E+00 | 7.51E-07 | 4.09E-07 |
| Water concentration (mg/L) | 4.45E-11 | 3.57E-07 | 3.02E-08 | 5.02E-07 | 7.90E-07 | 7.68E-08 | 4.85E-08 | 0.00E+00 | 1.09E-10 | 4.88E-12 |
| Suspended solids concentration (mg/kg) | 3.07E-08 | 6.11E-04 | 1.91E-04 | 3.39E-03 | 1.02E-02 | 1.39E-02 | 1.59E-02 | 0.00E+00 | 1.51E-04 | 6.38E-05 |
| Dissolved organic carbon (mg/kg) | 9.80E-08 | 4.54E-03 | 7.41E-04 | 3.10E-02 | 2.57E-01 | 5.38E-02 | 5.56E-02 | 0.00E+00 | 1.81E-03 | 1.45E-03 |

| Sediment Bed | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 1.55E-14 | 1.19E-10 | 3.04E-11 | 2.51E-10 | 1.44E-10 | 4.45E-10 | 8.67E-11 | 0.00E+00 | 1.21E-09 | 6.57E-10 |
| Pore Water concentration (mg/L) | 7.14E-14 | 5.72E-10 | 4.84E-11 | 8.05E-10 | 1.27E-09 | 1.23E-10 | 7.78E-11 | 0.00E+00 | 1.75E-13 | 7.83E-15 |
| Sediment concentration (mg/kg) | 3.29E-12 | 6.53E-08 | 2.04E-08 | 3.63E-07 | 1.09E-06 | 1.48E-06 | 1.70E-06 | 0.00E+00 | 1.62E-08 | 6.83E-09 |

| Bioenergetic Inputs | Species | Body Weight | Lipid | Moisture | Caloric Density | GE to ME | Met Energy | Caloric Density | Production | Respiration | Excretion | Caloric Density | Met Energy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (kg) | (%-dw) | (%) | (kcal/g-dry weight) | Fraction | (kcal/kg-lipid) | (kcal/kg-lipid) | (% of total) | (% of total) | (% of total) | (kcal/g-wt weight) | (kcal/g-wt weight) |
| **Pelagic Community** | | | | | | | | | | | | | |
| Phytoplankton (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Zooplankton (TL-II) | copepods | 0.000005 | 22% | 76% | 3.6 | 0.65 | 10636 | 16364 | 18% | 24% | 58% | 0.864 | 0.5616 |
| Planktivore (TL-III) | herring | 0.05 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Piscivore (TL-IV) | jack | 0.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| **Reef / Vessel Community** | | | | | | | | | | | | | |
| Attached Algae (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.05 | 5% | 82% | 4.6 | 0.65 | 59800 | 92000 | 28% | 31% | 41% | 0.828 | 0.5382 |
| Invertebrate Omnivore (TL-II) | urchin | 0.05 | 29% | 82% | 4.6 | 0.65 | 10310 | 15862 | 7% | 25% | 68% | 0.828 | 0.5382 |
| Invertebrate Forager (TL-III) | crab | 1 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Vertebrate Forager (TL-III) | triggerfish | 1 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Predator (TL-IV) | grouper | 1.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 0.2 | 0.14 |
| **Benthic Community** | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.01 | 6% | 84% | 4.6 | 0.65 | 50000 | 76923 | 71% | 26% | 3% | 0.736 | 0.4784 |
| Epifaunal invert. (TL-II) | nematode | 0.01 | 6% | 82% | 4.6 | 0.65 | 50000 | 76923 | 31% | 19% | 50% | 0.828 | 0.5382 |
| Forager (TL-III) | lobster | 2 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Predator (TL-IV) | flounder | 3 | 22% | 75% | 4.9 | 0.7 | 15591 | 22273 | 20% | 60% | 20% | 1.225 | 0.8575 |

| Bioenergetic Inputs | | Respiration Rate Allometric Regression Parameters | | | Resp. Rate | Resp. Rate | Consumption | Growth Rate | Consumption | Consumption | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | a | b1 | b2 | 1 / day | gO2 / kg-lipid-day | kcal / kg-lipid-day | 1 / day | g-wt weight / g-wt weight-d | kcal / -wet weight-da | As a % of body weight |
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | Algae | | | | | | | | | | |
| Zooplankton (TL-II) | copepods | 0.006375522 | 0 | 0.039935335 | 0.015425453 | 84.24400867 | 1286.168071 | 0.014147849 | 0.32636028 | 0.06790967 | 32.6% |
| Planktivore (TL-III) | herring | 0.0033 | -0.227 | 0.0548 | 0.004949927 | 21.1649 | 129.2512977 | 0.001482433 | 0.01616792 | 0.0090799 | 1.6% |
| Piscivore (TL-IV) | jack | 0.001118602 | -0.55 | 0.12 | 0.000630951 | 2.697821256 | 16.47524431 | 0.000188961 | 0.00139796 | 0.00115739 | 0.1% |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | Algae | | | | | | | | | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.012 | 0 | 0.036 | 0.024213411 | 581.8482643 | 6877.300342 | 0.020930914 | 0.24377539 | 0.0618957 | 24.4% |
| Invertibrate Omnivore (TL-II) | urchin | 0.000675466 | 0 | 0.079181846 | 0.003163548 | 13.1069075 | 192.1012396 | 0.000847751 | 0.03471132 | 0.01002768 | 3.5% |
| Invertibrate Forager (TL-III) | crab | 0.001158234 | 0 | 0.071193202 | 0.004642088 | 60.75673491 | 377.3221989 | 0.003592107 | 0.01678102 | 0.00900593 | 1.7% |
| Vertibrate Forager (TL-III) | triggerfish | 0.015181024 | -0.415 | 0.061 | 0.002837229 | 12.13142452 | 74.08503521 | 0.00084971 | 0.00907693 | 0.00520447 | 0.9% |
| Predator (TL-IV) | grouper | 0.00279 | -0.355 | 0.0811 | 0.001011362 | 4.324384181 | 26.40845301 | 0.000302889 | 0.00264734 | 0.00185519 | 0.3% |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 1903.064429 | 0.017565285 | 0.09800757 | 0.01820852 | 9.8% |
| Epifaunal invert. (TL-II) | nematode | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 2604.19343 | 0.0104949 | 0.09262416 | 0.02803154 | 9.3% |
| Forager (TL-III) | lobster | 0.0035 | -0.13 | 0.066 | 0.00471923 | 61.76639253 | 383.5925529 | 0.003651801 | 0.01899736 | 0.00915559 | 1.9% |
| Predator (TL-IV) | flounder | 0.0046 | -0.24 | 0.067 | 0.002486878 | 13.58174479 | 82.94195291 | 0.000744785 | 0.00974341 | 0.00456181 | 1.0% |

| Dietary Preferences | Suspended Solids (Epilimnion) | Suspended Solids (Hypolimnion) | Sediment | Phytoplankton | Zooplankton | Pelagic Plankitivore | Attached Algae | Reef Sessile Filter Feeder | Invertebrate Omnivore | Reef Invertebrate Forager | Reef Vertebrate Forager | Infaunal Benthos | Epifaunal Benthos | Benthic Forager |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | | | | |
| Phytoplankton (TL1) | | | | | | | | | | | | | | |
| Zooplankton (TL-II) | 15% | 15% | | 70% | | | | | | | | | | |
| Planktivore (TL-III) | | | | | 100% | | | | | | | | | |
| Piscivore (TL-IV) | | | | | 10% | 90% | | | | | | | | |
| **Reef / Vessel Community** | | | | | | | | | | | | | | |
| Attached Algae | | | | | | | | | | | | | | |
| Sessile filter feeder (TL-II) | | 10% | | 80% | 10% | | | | | | | | | |
| Invertebrate Omnivore (TL-II) | | | | | | | 80% | 20% | | | | | | |
| Invertebrate Forager (TL-III) | | 5% | | | 5% | 5% | | 35% | 50% | | | | | |
| Vertebrate Forager (TL-III) | | | | | | 19% | | 19% | 15% | 22% | | 12.5% | 12.5% | |
| Predator (TL-IV) | | | | | | | | | | 15% | 60% | 8% | 8% | 8% |
| **Benthic Community** | | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | | | 50% | 30% | 20% | | | | | | | | | |
| Epifaunal invert. (TL-II) | | | 25% | 30% | 20% | | | | | | | 25% | | |
| Forager (TL-III) | | | 5% | | | | | | | | | 50% | 45% | |
| Predator (TL-IV) | | | 2% | | | | | | | | | 20% | 20% | 58% |

| Water Exposures | | Upper Water Column | Lower Water Column | Vessel Interior | Sediment Pore Water |
|---|---|---|---|---|---|
| **Pelagic Community** | | | | | |
| Phytoplankton (TL1) | Algae | 100% | | | |
| Zooplankton (TL-II) | copepods | 50% | 50% | | |
| Planktivore (TL-III) | herring | 80% | 20% | | |
| Piscivore (TL-IV) | jack | 80% | 20% | | |
| **Reef / Vessel Community** | | | | | |
| Attached Algae | Algae | | 100% | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | | 100% | | |
| Invertebrate Omnivore (TL-II) | urchin | | 80% | 20% | |
| Invertebrate Forager (TL-III) | crab | | 70% | 30% | |
| Vertebrate Forager (TL-III) | triggerfish | | 70% | 30% | |
| Predator (TL-IV) | grouper | | 80% | 20% | |
| **Benthic Community** | | | | | |
| Infaunal invert. (TL-II) | polychaete | | 20% | | 80% |
| Epifaunal invert. (TL-II) | nematode | | 50% | | 50% |
| Forager (TL-III) | lobster | | 75% | | 25% |
| Predator (TL-IV) | flounder | | 90% | | 10% |

| Energy Estimates for Suspended Sediment and Bedded Sediment | GE | ME | ME | as kcal/g-ww |
|---|---|---|---|---|
| Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.01099776 |
| Suspended Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.1649664 |

| Respiratory Efficiencies | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Low body weight (<100g) | 4.335E-01 | 8.000E-01 | 8.000E-01 | 8.000E-01 | 4.492E-01 | 2.582E-01 | 2.018E-01 | 1.127E-01 | 5.303E-02 | 1.255E-02 |
| High body weight (>100g) | 5.000E-01 | 5.000E-01 | 5.000E-01 | 5.000E-01 | 3.769E-01 | 2.857E-01 | 2.526E-01 | 1.888E-01 | 1.295E-01 | 6.299E-02 |
| Dietary Assimilation Efficiencies | 27% | 46% | 53% | 62% | 69% | 69% | 68% | 59% | 44% | 16% |

| Tissue Conc. (mg/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 8.531E-13 | 2.260E-08 | 1.818E-09 | 2.948E-08 | 3.872E-08 | 1.549E-09 | 6.345E-10 | 0.000E+00 | 2.859E-13 | 1.024E-15 |
| Zooplankton (TL-II) | 4.810E-09 | 1.786E-04 | 1.802E-05 | 3.401E-04 | 3.373E-04 | 4.826E-05 | 4.293E-05 | 0.000E+00 | 2.153E-07 | 3.182E-08 |
| Planktivore (TL-III) | 1.087E-09 | 1.513E-04 | 2.758E-05 | 1.009E-03 | 1.798E-03 | 2.828E-04 | 2.454E-04 | 0.000E+00 | 8.118E-07 | 4.273E-08 |
| Piscivore (TL-IV) | 2.843E-10 | 2.667E-05 | 7.323E-06 | 5.893E-04 | 3.151E-03 | 8.484E-04 | 8.295E-04 | 0.000E+00 | 2.423E-06 | 5.285E-08 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.126E-09 | 5.724E-05 | 4.844E-06 | 8.050E-05 | 1.268E-04 | 1.233E-05 | 7.785E-06 | 0.000E+00 | 1.751E-08 | 7.830E-10 |
| Sessile filter feeder (TL-II) | 6.847E-08 | 2.309E-03 | 2.281E-04 | 4.289E-03 | 4.153E-03 | 3.678E-04 | 2.663E-04 | 0.000E+00 | 8.524E-07 | 9.249E-08 |
| Invertebrate Omnivore (TL-II) | 2.886E-07 | 2.238E-02 | 3.304E-03 | 1.062E-01 | 1.713E-01 | 1.206E-02 | 6.303E-03 | 0.000E+00 | 4.280E-06 | 5.404E-08 |
| Invertebrate Forager (TL-III) | 2.187E-06 | 8.913E-02 | 1.327E-02 | 4.471E-01 | 8.523E-01 | 6.720E-02 | 3.719E-02 | 0.000E+00 | 4.074E-05 | 2.693E-06 |
| Vertebrate Forager (TL-III) | 2.010E-07 | 1.408E-02 | 3.024E-03 | 1.770E-01 | 6.287E-01 | 6.345E-02 | 3.696E-02 | 0.000E+00 | 4.131E-05 | 1.372E-06 |
| Predator (TL-IV) | 1.113E-07 | 7.224E-03 | 1.705E-03 | 1.486E-01 | 1.146E+00 | 1.750E-01 | 1.120E-01 | 0.000E+00 | 1.203E-04 | 2.668E-06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 1.734E-08 | 6.813E-04 | 7.080E-05 | 1.401E-03 | 1.406E-03 | 1.287E-04 | 9.406E-05 | 0.000E+00 | 2.625E-07 | 1.871E-08 |
| Epifaunal invert. (TL-II) | 2.151E-08 | 1.267E-03 | 1.511E-04 | 3.420E-03 | 3.769E-03 | 3.612E-04 | 2.667E-04 | 0.000E+00 | 6.699E-07 | 3.673E-08 |
| Forager (TL-III) | 1.256E-08 | 6.936E-04 | 1.061E-04 | 3.205E-03 | 4.776E-03 | 4.466E-04 | 3.043E-04 | 0.000E+00 | 4.851E-07 | 1.113E-08 |
| Predator (TL-IV) | 1.112E-09 | 1.849E-04 | 4.875E-05 | 3.019E-03 | 9.098E-03 | 1.095E-03 | 7.729E-04 | 0.000E+00 | 9.936E-07 | 1.461E-08 |

| Tissue Conc. (mg/kg-WW) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.406E-14 | 3.724E-10 | 2.996E-11 | 4.859E-10 | 6.382E-10 | 2.552E-11 | 1.046E-11 | 0.000E+00 | 4.711E-15 | 1.687E-17 | 1.562E-09 |
| Zooplankton (TL-II) | 2.540E-10 | 9.431E-06 | 9.514E-07 | 1.796E-05 | 1.781E-05 | 2.548E-06 | 2.267E-06 | 0.000E+00 | 1.137E-08 | 1.680E-09 | 5.098E-05 |
| Planktivore (TL-III) | 7.638E-11 | 1.063E-05 | 1.938E-06 | 7.087E-05 | 1.263E-04 | 1.987E-05 | 1.724E-05 | 0.000E+00 | 5.703E-08 | 3.002E-09 | 2.469E-04 |
| Piscivore (TL-IV) | 1.997E-11 | 1.873E-06 | 5.144E-07 | 4.140E-05 | 2.214E-04 | 5.960E-05 | 5.827E-05 | 0.000E+00 | 1.702E-07 | 3.713E-09 | 3.832E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 3.504E-11 | 9.434E-07 | 7.983E-08 | 1.327E-06 | 2.089E-06 | 2.032E-07 | 1.283E-07 | 0.000E+00 | 2.886E-10 | 1.290E-11 | 4.771E-06 |
| Sessile filter feeder (TL-II) | 6.162E-10 | 2.078E-05 | 2.053E-06 | 3.860E-05 | 3.737E-05 | 3.310E-06 | 2.397E-06 | 0.000E+00 | 7.672E-09 | 8.324E-10 | 1.045E-04 |
| Invertebrate Omnivore (TL-II) | 1.507E-08 | 1.168E-03 | 1.725E-04 | 5.545E-03 | 8.940E-03 | 6.297E-04 | 3.290E-04 | 0.000E+00 | 2.234E-07 | 2.821E-09 | 1.678E-02 |
| Invertebrate Forager (TL-III) | 5.220E-08 | 2.127E-03 | 3.167E-04 | 1.067E-02 | 2.034E-02 | 1.604E-03 | 8.878E-04 | 0.000E+00 | 9.723E-07 | 6.427E-08 | 3.595E-02 |
| Vertebrate Forager (TL-III) | 1.412E-08 | 9.894E-04 | 2.125E-04 | 1.243E-02 | 4.416E-02 | 4.458E-03 | 2.597E-03 | 0.000E+00 | 2.902E-06 | 9.637E-08 | 6.486E-02 |
| Predator (TL-IV) | 7.815E-09 | 5.075E-04 | 1.198E-04 | 1.044E-02 | 8.048E-02 | 1.229E-02 | 7.868E-03 | 0.000E+00 | 8.451E-06 | 1.875E-07 | 1.117E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 1.659E-10 | 6.518E-06 | 6.774E-07 | 1.340E-05 | 1.345E-05 | 1.231E-06 | 8.999E-07 | 0.000E+00 | 2.512E-09 | 1.790E-10 | 3.619E-05 |
| Epifaunal invert. (TL-II) | 2.316E-10 | 1.364E-05 | 1.626E-06 | 3.681E-05 | 4.057E-05 | 3.888E-06 | 2.870E-06 | 0.000E+00 | 7.211E-09 | 3.954E-10 | 9.941E-05 |
| Forager (TL-III) | 2.998E-10 | 1.656E-05 | 2.531E-06 | 7.650E-05 | 1.140E-04 | 1.066E-05 | 7.263E-06 | 0.000E+00 | 1.158E-08 | 2.656E-10 | 2.275E-04 |
| Predator (TL-IV) | 6.115E-11 | 1.017E-05 | 2.681E-06 | 1.661E-04 | 5.004E-04 | 6.020E-05 | 4.251E-05 | 0.000E+00 | 5.465E-08 | 8.033E-10 | 7.821E-04 |

| BAFs (L/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Zooplankton (TL-II) | 1.347E+05 | 6.238E+05 | 7.437E+05 | 8.446E+05 | 5.320E+05 | 7.827E+05 | 1.103E+06 | 0.000E+00 | 2.458E+06 | 8.127E+06 |
| Planktivore (TL-III) | 7.602E+04 | 1.319E+06 | 2.843E+06 | 6.256E+06 | 7.082E+06 | 1.146E+07 | 1.575E+07 | 0.000E+00 | 2.317E+07 | 2.729E+07 |
| Piscivore (TL-IV) | 1.988E+04 | 2.325E+05 | 7.547E+05 | 3.655E+06 | 1.241E+07 | 3.439E+07 | 5.326E+07 | 0.000E+00 | 6.917E+07 | 3.375E+07 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Sessile filter feeder (TL-II) | 9.590E+05 | 4.034E+06 | 4.709E+06 | 5.328E+06 | 3.276E+06 | 2.983E+06 | 3.420E+06 | 0.000E+00 | 4.867E+06 | 1.181E+07 |
| Invertebrate Omnivore (TL-II) | 3.224E+04 | 3.118E+05 | 5.439E+05 | 1.052E+06 | 1.077E+06 | 7.802E+05 | 6.457E+05 | 0.000E+00 | 1.949E+05 | 5.504E+04 |
| Invertebrate Forager (TL-III) | 1.633E+05 | 8.300E+05 | 1.460E+06 | 2.961E+06 | 3.584E+06 | 2.905E+06 | 2.547E+06 | 0.000E+00 | 1.240E+06 | 1.833E+06 |
| Vertebrate Forager (TL-III) | 1.501E+04 | 1.311E+05 | 3.328E+05 | 1.172E+06 | 2.644E+06 | 2.744E+06 | 2.531E+06 | 0.000E+00 | 1.258E+06 | 9.340E+05 |
| Predator (TL-IV) | 1.243E+04 | 1.006E+05 | 2.807E+05 | 1.472E+06 | 7.207E+06 | 1.132E+07 | 1.147E+07 | 0.000E+00 | 5.478E+06 | 2.718E+06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.429E+05 | 1.190E+06 | 1.462E+06 | 1.740E+06 | 1.109E+06 | 1.044E+06 | 1.208E+06 | 0.000E+00 | 1.499E+06 | 2.389E+06 |
| Epifaunal invert. (TL-II) | 3.013E+05 | 2.213E+06 | 3.119E+06 | 4.248E+06 | 2.973E+06 | 2.930E+06 | 3.425E+06 | 0.000E+00 | 3.825E+06 | 4.691E+06 |
| Forager (TL-III) | 1.759E+05 | 1.212E+06 | 2.189E+06 | 3.981E+06 | 3.768E+06 | 3.622E+06 | 3.909E+06 | 0.000E+00 | 2.770E+06 | 1.421E+06 |
| Predator (TL-IV) | 1.557E+04 | 3.231E+05 | 1.006E+06 | 3.750E+06 | 7.177E+06 | 8.878E+06 | 9.928E+06 | 0.000E+00 | 5.673E+06 | 1.865E+06 |

Notes:
Kow = octanol to water partitioning coefficient, Koc = organic carbon partitioning coefficient, Kdoc = dissolved organic carbon partitioning coefficient
TL = trophic level, ww = wet weight

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION

***RISK ESTIMATES FOR Ex-Oriskany CV34***

| **ZOI = 5** | Cancer Risk Adult & Child | | Hazard Adult & Child | | Cancer Risk Child | | Hazard Child | |
|---|---|---|---|---|---|---|---|---|
| ***RISK ESTIMATES*** | RME | CTE | RME | CTE | RME | CTE | RME | CTE |
| Benthic fish (flounder) | 4.23E-08 | 3.28E-09 | 2.47E-03 | 5.66E-04 | 1.24E-08 | 2.52E-09 | 3.62E-03 | 6.53E-04 |
| Benthic shellfish (lobster) | 1.23E-08 | 9.53E-10 | 7.18E-04 | 1.65E-04 | 3.61E-09 | 7.33E-10 | 1.05E-03 | 1.90E-04 |
| Pelagic fish (jack) | 2.07E-08 | 1.61E-09 | 1.21E-03 | 2.78E-04 | 6.08E-09 | 1.23E-09 | 1.77E-03 | 3.20E-04 |
| Reef fish TL-IV (grouper) | 6.86E-06 | 5.31E-07 | 4.00E-01 | 9.18E-02 | 2.01E-06 | 4.08E-07 | 5.87E-01 | 1.06E-01 |
| Reef fish TL-III (triggerfish) | 3.98E-06 | 3.08E-07 | 2.32E-01 | 5.33E-02 | 1.17E-06 | 2.37E-07 | 3.41E-01 | 6.14E-02 |
| Reef shellfish (crab) | 2.21E-06 | 1.71E-07 | 1.29E-01 | 2.95E-02 | 6.48E-07 | 1.31E-07 | 1.89E-01 | 3.41E-02 |

| ***PREDICTED EXPOSURE CONCENTRATIONS (mg/kg in fresh weight)*** | |
|---|---|
| Benthic fish (flounder) | 6.88E-04 |
| Benthic shellfish (lobster) | 2.00E-04 |
| Pelagic fish (jack) | 3.37E-04 |
| Reef fish TL-IV (grouper) | 1.11E-01 |
| Reef fish TL-III (triggerfish) | 6.47E-02 |
| Reef shellfish (crab) | 3.59E-02 |

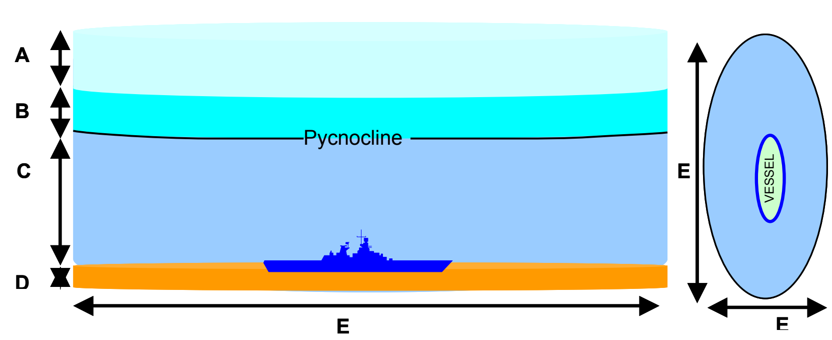
| ***RISK INPUTS - Adult*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 70 | 70 |
| Ingestion Rate (IRc) (kg/day) | 0.0261 | 0.0072 |
| Exposure Duration (EDc) (years) | 24 | 3 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 0.00002 | 0.000045 |
| Averaging Time for noncancer (ATnc-child) | 8.76E+03 | 1.10E+03 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |

| ***RISK INPUTS - Child*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 15 | 15 |
| Ingestion Rate (IRc) (kg/day) | 0.0092916 | 0.0025632 |
| Exposure Duration (EDc) (years) | 6 | 6 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 0.00002 | 0.000045 |
| Averaging Time for noncancer (ATnc-child) | 2.19E+03 | 2.19E+03 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |
| Child - Adult IR scaling factor | 0.356 | |

| | |
|---|---|
| Zone of Influence Multiplier | 5 |
| Scenario run on | 5/26/05 8:48 |

| ***PCB-LADEN MATERIAL INPUTS*** | Fraction PCB | Release Rate (ng/g-d) | kg Material Onboard | PCB Release (ng/day) |
|---|---|---|---|---|
| Ventilation Gaskets | 3.14E-05 | 1.58E+03 | 1.46E+03 | 7.23E+04 |
| Lubricants | 1.03E-04 | 2.20E+03 | 0.00E+00 | 0.00E+00 |
| Foam Rubber Material | 0.76% | 2.62E+00 | 0.00E+00 | 0.00E+00 |
| Black Rubber Material | 5.29E-05 | 1.58E+03 | 5.40E+03 | 4.50E+05 |
| Electrical Cable | 1.85E-03 | 2.79E+02 | 2.96E+05 | 1.53E+08 |
| Bulkhead Insulation Material | 5.37E-04 | 6.76E+04 | 1.44E+04 | 5.22E+08 |
| Aluminum Paint | 2.00E-05 | 1.11E+04 | 3.87E+05 | 8.62E+07 |
| Total | | | | 7.62E+08 |

| **Ex-Oriskany CV34** | |
|---|---|
| Ex-Oriskany CV34 | 27100 |
| Length (ft) | 888 |
| Beam (ft) | 120 |




| ZOI = | 5 | |
|---|---|---|
| Spatial Footprint on Ocean Floor | | |
| | 3.89E+04 | m2 |
| | 1.50E-02 | mile2 |
| Modeled Dimensions Outside the Vessel | | |
| A | 1.00E+01 | m |
| B | 1.50E+01 | m |
| C | 5.00E+01 | m |
| D | 1.00E-01 | m |
| E | 3.68E+02 | m |
| F | 1.34E+02 | m |
| Volumes | | |
| Air Column | | |
| Air | 3.89E+05 | m3 |
| Upper Water Column | | |
| Water | 5.83E+05 | m3 |
| TSS | 3.89E+00 | m3 |
| Lower Water Column | | |
| Water | 1.89E+06 | m3 |
| TSS | 1.26E+01 | m3 |
| Inside Vessel | | |
| Water | 5.38E+04 | m3 |
| TSS | 3.59E-01 | m3 |
| Sediment Bed | | |
| Sediment | 3.11E+03 | m3 |

| **Abiotic Inputs** | |
|---|---|
| Air Column | |
| Active air space height above water column (m) | 10 |
| Air current (m/h) | 13677 |
| Upper Water Column | |
| Temperature (oC) | 24.5 |
| Water depth (m) | 15 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 6.12 |
| Lower Water Column | |
| Temperature (oC) | 19.5 |
| Water depth (m) | 50 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Inside Vessel | |
| Temperature (oC) | 19.5 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Sediment Bed | |
| Sediment density (g/cm3) | 1.5 |
| Active sediment depth (m) | 0.1 |
| Sediment fraction organic carbon | 0.01 |
| All Regions | |
| Suspended solids density (g/cm3) | 1.5 |
| Suspended solids fraction organic carbon | 0.15 |
| Dissolved organic carbon density (g/cm3) | 1 |
| Water current - to out of the ZOI (m/h) | 926 |
| Water current - inside to outside the vessel (m/h) | 9.26 |

| **Total PCB concentrations** | | |
|---|---|---|
| Air Column | | |
| Air | 9.68E-17 | g/m3 |
| Upper Water Column | | |
| Freely dissolved in water | 9.32E-13 | mg/L |
| Suspended solids | 1.22E-08 | mg/kg |
| Dissolved organic carbon | 1.63E-07 | mg/kg |
| Lower Water Column | | |
| Freely dissolved in water | 2.55E-09 | mg/L |
| Suspended solids | 6.27E-05 | mg/kg |
| Dissolved organic carbon | 5.74E-04 | mg/kg |
| Inside Vessel | | |
| Freely dissolved in water | 1.80E-06 | mg/L |
| Suspended solids | 4.44E-02 | mg/kg |
| Dissolved organic carbon | 4.06E-01 | mg/kg |
| Sediment Bed | | |
| Freely dissolved in pore water | 2.55E-09 | mg/L |
| Bedded sediment | 4.18E-06 | mg/kg |
| Dissolved organic carbon in pore water | 5.74E-04 | mg/kg |

| **Total PCB concentrations in biota** | | | **Percent Exposures** | |
|---|---|---|---|---|
| Pelagic Community | | | Upper WC | Lower WC |
| Phytoplankton (TL-I) | 1.54E-09 | mg/kg | 100% | 0% |
| Zooplankton (TL-II) | 4.48E-05 | mg/kg | 50% | 50% |
| Planktivore (TL-III) | 2.17E-04 | mg/kg | 80% | 20% |
| Piscivore (TL-IV) | 3.37E-04 | mg/kg | 80% | 20% |
| Reef / Vessel Community | | | Lower WC | Vessel Int. |
| Attached Algae (TL-I) | 4.20E-06 | mg/kg | 100% | 0% |
| Sessile filter feeder (TL-II) | 9.19E-05 | mg/kg | 100% | 0% |
| Invertebrate Omnivore (TL-II) | 1.67E-02 | mg/kg | 80% | 20% |
| Invertebrate Forager (TL-III) | 3.59E-02 | mg/kg | 70% | 30% |
| Vertebrate Forager (TL-III) | 6.47E-02 | mg/kg | 70% | 30% |
| Predator (TL-IV) | 1.11E-01 | mg/kg | 80% | 20% |
| Benthic Community | | | Lower WC | Pore Water |
| Infaunal invert. (TL-II) | 3.18E-05 | mg/kg | 20% | 80% |
| Epifaunal invert. (TL-II) | 8.74E-05 | mg/kg | 50% | 50% |
| Forager (TL-III) | 2.00E-04 | mg/kg | 75% | 25% |
| Predator (TL-IV) | 6.88E-04 | mg/kg | 90% | 10% |

Scenario Run on 5/26/05 8:48 ZOI = 5

| PCB Homolog | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Molecular Weight (g/mol) | 1.89E+02 | 2.23E+02 | 2.58E+02 | 2.92E+02 | 3.26E+02 | 3.61E+02 | 3.95E+02 | 4.30E+02 | 4.64E+02 | 4.99E+02 |
| Solubility (mg/L) | 2.91E+00 | 6.78E-01 | 8.14E-02 | 6.67E-02 | 2.61E-02 | 9.50E-04 | 2.30E-04 | 2.11E-08 | 4.02E-09 | 1.69E-10 |
| Solubility (mol/m$^3$) | 1.54E-02 | 3.04E-03 | 3.16E-04 | 2.28E-04 | 8.00E-05 | 2.63E-06 | 5.82E-07 | 4.91E-11 | 8.65E-12 | 3.38E-13 |
| Vapor Pressure (Pa) | 6.32E-01 | 1.41E-01 | 5.11E-02 | 2.08E-02 | 2.96E-03 | 3.43E-03 | 2.56E-04 | 8.65E-05 | 2.77E-05 | 1.41E-05 |
| Henry's (Pa-m$^3$/mol) | 4.10E+01 | 4.65E+01 | 1.62E+02 | 9.10E+01 | 3.70E+01 | 1.30E+03 | 4.40E+02 | 1.76E+06 | 3.20E+06 | 4.18E+07 |
| $\log_{10}K_{ow}$ = | 4.47 | 5.24 | 5.52 | 5.92 | 6.50 | 6.98 | 7.19 | 7.70 | 8.35 | 9.60 |
| $\log_{10}K_{oc}$ = | 3.66 | 4.06 | 4.63 | 4.65 | 4.94 | 6.08 | 6.34 | 6.46 | 6.97 | 7.94 |
| $\log_{10}K_{doc}$ = | 3.34 | 4.11 | 4.39 | 4.79 | 5.51 | 5.85 | 6.06 | 6.57 | 7.22 | 8.47 |
| Chemical emission rate (g/day) | 1.37E-05 | 1.12E-01 | 9.95E-03 | 1.69E-01 | 3.20E-01 | 7.57E-02 | 7.37E-02 | 0.00E+00 | 8.28E-04 | 4.62E-04 |
| Chemical emission rate (mol/hr) | 3.03E-09 | 2.09E-05 | 1.61E-06 | 2.42E-05 | 4.08E-05 | 8.74E-06 | 7.77E-06 | 0.00E+00 | 7.43E-08 | 3.86E-08 |
| Biodegradation in sediment (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Biodegradation in water (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Fraction PCB in Material (wt/wt) | 0.0000314 | 0.000103 | 0.76% | 0.0000529 | 0.00185 | 0.000537 | 0.00002 |
| Material Mass Onboard (kg) | 1459 | 0 | 0 | 5397 | 296419 | 14379 | 386528 |
| Total PCBs (kg) | 0.0458126 | 0 | 0 | 0.2855013 | 548.37515 | 7.721523 | 7.73056 |
| Total PCB Release rate (ng/g-PCB per day) | 1.58E+03 | 2.20E+03 | 2.62E+00 | 1.58E+03 | 2.79E+02 | 6.76E+04 | 1.11E+04 |

| Release Rates in nanograms PCB per gram of PCB within the Material | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 4.14E+01 | 3.47E+01 | 0.00E+00 | 4.14E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Dichlorobiphenyl | 1.27E+03 | 1.72E+02 | 3.08E-02 | 1.27E+03 | 2.03E+02 | 5.36E+00 | 0.00E+00 |
| Trichlorobiphenyl | 5.66E+01 | 8.97E+01 | 7.63E-02 | 5.66E+01 | 1.14E+00 | 9.44E+02 | 2.61E+02 |
| Tetrachlorobiphenyl | 1.44E+02 | 1.08E+03 | 1.29E+00 | 1.44E+02 | 1.57E+01 | 2.07E+04 | 1.23E+02 |
| Pentachlorobiphenyl | 6.31E+01 | 6.60E+02 | 3.90E-02 | 6.31E+01 | 1.80E+01 | 3.79E+04 | 2.24E+03 |
| Hexachlorobiphenyl | 0.00E+00 | 9.42E+01 | 5.34E-01 | 0.00E+00 | 2.41E+01 | 6.76E+03 | 1.33E+03 |
| Heptachlorobiphenyl | 5.04E+00 | 7.17E+01 | 6.46E-01 | 5.04E+00 | 1.47E+01 | 1.30E+03 | 7.19E+03 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 1.72E-03 | 0.00E+00 | 1.51E+00 | 0.00E+00 | 0.00E+00 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.43E-01 | 0.00E+00 | 0.00E+00 |
| **Total** | **1.58E+03** | **2.20E+03** | **2.62E+00** | **1.58E+03** | **2.79E+02** | **6.76E+04** | **1.11E+04** |

| Release Rates in nanograms PCB per Day | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint | Total |
|---|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 1.90E+03 | 0.00E+00 | 0.00E+00 | 1.18E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.37E+04 |
| Dichlorobiphenyl | 5.80E+04 | 0.00E+00 | 0.00E+00 | 3.62E+05 | 1.11E+08 | 4.14E+04 | 0.00E+00 | 1.12E+08 |
| Trichlorobiphenyl | 2.59E+03 | 0.00E+00 | 0.00E+00 | 1.62E+04 | 6.25E+05 | 7.29E+06 | 2.02E+06 | 9.95E+06 |
| Tetrachlorobiphenyl | 6.60E+03 | 0.00E+00 | 0.00E+00 | 4.11E+04 | 8.61E+06 | 1.60E+08 | 9.51E+05 | 1.69E+08 |
| Pentachlorobiphenyl | 2.89E+03 | 0.00E+00 | 0.00E+00 | 1.80E+04 | 9.87E+06 | 2.93E+08 | 1.73E+07 | 3.20E+08 |
| Hexachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.32E+07 | 5.22E+07 | 1.03E+07 | 7.57E+07 |
| Heptachlorobiphenyl | 2.31E+02 | 0.00E+00 | 0.00E+00 | 1.44E+03 | 8.06E+06 | 1.01E+07 | 5.56E+07 | 7.37E+07 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.28E+05 | 0.00E+00 | 0.00E+00 | 8.28E+05 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.62E+05 | 0.00E+00 | 0.00E+00 | 4.62E+05 |
| **Total** | 7.23E+04 | 0.00E+00 | 0.00E+00 | 4.50E+05 | 1.53E+08 | 5.22E+08 | 8.62E+07 | 7.62E+08 |

| Air | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 4.65E-20 | 2.86E-16 | 1.89E-17 | 2.52E-16 | 2.76E-16 | 9.75E-18 | 3.48E-18 | 0.00E+00 | 1.23E-21 | 3.97E-24 |
| Air concentration (g/m3) | 3.58E-21 | 2.60E-17 | 1.98E-18 | 3.00E-17 | 3.67E-17 | 1.43E-18 | 5.60E-19 | 0.00E+00 | 2.33E-22 | 8.06E-25 |

| Upper Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 6.12E-18 | 4.63E-14 | 1.12E-14 | 9.04E-14 | 4.32E-14 | 5.50E-14 | 6.95E-15 | 0.00E+00 | 1.94E-14 | 8.44E-16 |
| Water concentration (mg/L) | 2.82E-17 | 2.22E-13 | 1.79E-14 | 2.90E-13 | 3.81E-13 | 1.52E-14 | 6.24E-15 | 0.00E+00 | 2.81E-18 | 1.01E-20 |
| Suspended solids concentration (mg/kg) | 1.95E-14 | 3.80E-10 | 1.13E-10 | 1.96E-09 | 4.92E-09 | 2.75E-09 | 2.05E-09 | 0.00E+00 | 3.89E-12 | 1.32E-13 |
| Dissolved organic carbon (mg/kg) | 6.21E-14 | 2.83E-09 | 4.39E-10 | 1.79E-08 | 1.24E-07 | 1.07E-08 | 7.15E-09 | 0.00E+00 | 4.67E-11 | 2.99E-12 |

| Lower Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 1.37E-14 | 1.05E-10 | 2.67E-11 | 2.21E-10 | 1.27E-10 | 3.92E-10 | 7.63E-11 | 0.00E+00 | 1.06E-09 | 5.78E-10 |
| Water concentration (mg/L) | 6.28E-14 | 5.03E-10 | 4.26E-11 | 7.08E-10 | 1.11E-09 | 1.08E-10 | 6.85E-11 | 0.00E+00 | 1.54E-13 | 6.89E-15 |
| Suspended solids concentration (mg/kg) | 4.34E-11 | 8.62E-07 | 2.69E-07 | 4.79E-06 | 1.44E-05 | 1.96E-05 | 2.25E-05 | 0.00E+00 | 2.13E-07 | 9.01E-08 |
| Dissolved organic carbon (mg/kg) | 1.38E-10 | 6.41E-06 | 1.05E-06 | 4.38E-05 | 3.63E-04 | 7.60E-05 | 7.85E-05 | 0.00E+00 | 2.56E-06 | 2.04E-06 |

| Inside the Vessel | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 9.67E-12 | 7.43E-08 | 1.89E-08 | 1.56E-07 | 8.96E-08 | 2.77E-07 | 5.40E-08 | 0.00E+00 | 7.51E-07 | 4.09E-07 |
| Water concentration (mg/L) | 4.45E-11 | 3.57E-07 | 3.02E-08 | 5.02E-07 | 7.90E-07 | 7.68E-08 | 4.85E-08 | 0.00E+00 | 1.09E-10 | 4.88E-12 |
| Suspended solids concentration (mg/kg) | 3.07E-08 | 6.11E-04 | 1.91E-04 | 3.39E-03 | 1.02E-02 | 1.39E-02 | 1.59E-02 | 0.00E+00 | 1.51E-04 | 6.38E-05 |
| Dissolved organic carbon (mg/kg) | 9.80E-08 | 4.54E-03 | 7.41E-04 | 3.10E-02 | 2.57E-01 | 5.38E-02 | 5.56E-02 | 0.00E+00 | 1.81E-03 | 1.45E-03 |

| Sediment Bed | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 1.37E-14 | 1.05E-10 | 2.67E-11 | 2.21E-10 | 1.27E-10 | 3.92E-10 | 7.63E-11 | 0.00E+00 | 1.06E-09 | 5.78E-10 |
| Pore Water concentration (mg/L) | 6.28E-14 | 5.03E-10 | 4.26E-11 | 7.08E-10 | 1.11E-09 | 1.08E-10 | 6.85E-11 | 0.00E+00 | 1.54E-13 | 6.89E-15 |
| Sediment concentration (mg/kg) | 2.89E-12 | 5.75E-08 | 1.80E-08 | 3.19E-07 | 9.60E-07 | 1.30E-06 | 1.50E-06 | 0.00E+00 | 1.42E-08 | 6.01E-09 |

| Bioenergetic Inputs | Species | Body Weight | Lipid | Moisture | Caloric Density | GE to ME | Met Energy | Caloric Density | Production | Respiration | Excretion | Caloric Density | Met Energy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (kg) | (%-dw) | (%) | (kcal/g-dry weight) | Fraction | (kcal/kg-lipid) | (kcal/kg-lipid) | (% of total) | (% of total) | (% of total) | (kcal/g-wt weight) | (kcal/g-wt weight) |
| **Pelagic Community** | | | | | | | | | | | | | |
| Phytoplankton (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Zooplankton (TL-II) | copepods | 0.000005 | 22% | 76% | 3.6 | 0.65 | 10636 | 16364 | 18% | 24% | 58% | 0.864 | 0.5616 |
| Planktivore (TL-III) | herring | 0.05 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Piscivore (TL-IV) | jack | 0.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| **Reef / Vessel Community** | | | | | | | | | | | | | |
| Attached Algae (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.05 | 5% | 82% | 4.6 | 0.65 | 59800 | 92000 | 28% | 31% | 41% | 0.828 | 0.5382 |
| Invertebrate Omnivore (TL-II) | urchin | 0.05 | 29% | 82% | 4.6 | 0.65 | 10310 | 15862 | 7% | 25% | 68% | 0.828 | 0.5382 |
| Invertebrate Forager (TL-III) | crab | 1 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Vertebrate Forager (TL-III) | triggerfish | 1 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Predator (TL-IV) | grouper | 1.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 0.2 | 0.14 |
| **Benthic Community** | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.01 | 6% | 84% | 4.6 | 0.65 | 50000 | 76923 | 71% | 26% | 3% | 0.736 | 0.4784 |
| Epifaunal invert. (TL-II) | nematode | 0.01 | 6% | 82% | 4.6 | 0.65 | 50000 | 76923 | 31% | 19% | 50% | 0.828 | 0.5382 |
| Forager (TL-III) | lobster | 2 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Predator (TL-IV) | flounder | 3 | 22% | 75% | 4.9 | 0.7 | 15591 | 22273 | 20% | 60% | 20% | 1.225 | 0.8575 |

| Bioenergetic Inputs | | Respiration Rate Allometric Regression Parameters | | | Resp. Rate | Resp. Rate | Consumption | Growth Rate | Consumption | Consumption | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | a | b1 | b2 | 1 / day | gO2 / kg-lipid-day | kcal / kg-lipid-day | 1 / day | g-wt weight / g-wt weight-d | kcal / -wet weight-da | As a % of body weight |
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | Algae | | | | | | | | | | |
| Zooplankton (TL-II) | copepods | 0.006375522 | 0 | 0.039935335 | 0.015425453 | 84.24400867 | 1286.168071 | 0.014147849 | 0.32636028 | 0.06790967 | 32.6% |
| Planktivore (TL-III) | herring | 0.0033 | -0.227 | 0.0548 | 0.004949927 | 21.1649 | 129.2512977 | 0.001482433 | 0.01616792 | 0.0090799 | 1.6% |
| Piscivore (TL-IV) | jack | 0.001118602 | -0.55 | 0.12 | 0.000630951 | 2.697821256 | 16.47524431 | 0.000188961 | 0.00139796 | 0.00115739 | 0.1% |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | Algae | | | | | | | | | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.012 | 0 | 0.036 | 0.024213411 | 581.8482643 | 6877.300342 | 0.020930914 | 0.24377539 | 0.0618957 | 24.4% |
| Invertibrate Omnivore (TL-II) | urchin | 0.000675466 | 0 | 0.079181846 | 0.003163548 | 13.1069075 | 192.1012396 | 0.000847751 | 0.03471132 | 0.01002768 | 3.5% |
| Invertibrate Forager (TL-III) | crab | 0.001158234 | 0 | 0.071193202 | 0.004642088 | 60.75673491 | 377.3221989 | 0.003592107 | 0.01678102 | 0.00900593 | 1.7% |
| Vertibrate Forager (TL-III) | triggerfish | 0.015181024 | -0.415 | 0.061 | 0.002837229 | 12.13142452 | 74.08503521 | 0.00084971 | 0.00907693 | 0.00520447 | 0.9% |
| Predator (TL-IV) | grouper | 0.00279 | -0.355 | 0.0811 | 0.001011362 | 4.324384181 | 26.40845301 | 0.000302889 | 0.00264734 | 0.00185519 | 0.3% |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 1903.064429 | 0.017565285 | 0.09800757 | 0.01820852 | 9.8% |
| Epifaunal invert. (TL-II) | nematode | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 2604.19343 | 0.0104949 | 0.09262416 | 0.02803154 | 9.3% |
| Forager (TL-III) | lobster | 0.0035 | -0.13 | 0.066 | 0.00471923 | 61.76639253 | 383.5925529 | 0.003651801 | 0.01899736 | 0.00915559 | 1.9% |
| Predator (TL-IV) | flounder | 0.0046 | -0.24 | 0.067 | 0.002486878 | 13.58174479 | 82.94195291 | 0.000744785 | 0.00974341 | 0.00456181 | 1.0% |

| Dietary Preferences | Suspended Solids (Epilimnion) | Suspended Solids (Hypolimnion) | Sediment | Phytoplankton | Zooplankton | Pelagic Plankitivore | Attached Algae | Reef Sessile Filter Feeder | Invertebrate Omnivore | Reef Invertebrate Forager | Reef Vertebrate Forager | Infaunal Benthos | Epifaunal Benthos | Benthic Forager |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | | | | |
| Phytoplankton (TL1) | | | | | | | | | | | | | | |
| Zooplankton (TL-II) | 15% | 15% | | 70% | | | | | | | | | | |
| Planktivore (TL-III) | | | | | 100% | | | | | | | | | |
| Piscivore (TL-IV) | | | | | 10% | 90% | | | | | | | | |
| **Reef / Vessel Community** | | | | | | | | | | | | | | |
| Attached Algae | | | | | | | | | | | | | | |
| Sessile filter feeder (TL-II) | | 10% | | 80% | 10% | | | | | | | | | |
| Invertebrate Omnivore (TL-II) | | | | | | | 80% | 20% | | | | | | |
| Invertebrate Forager (TL-III) | | 5% | | | 5% | 5% | | 35% | 50% | | | | | |
| Vertebrate Forager (TL-III) | | | | | | 19% | | 19% | 15% | 22% | | 12.5% | 12.5% | |
| Predator (TL-IV) | | | | | | | | | | 15% | 60% | 8% | 8% | 8% |
| **Benthic Community** | | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | | | 50% | 30% | 20% | | | | | | | | | |
| Epifaunal invert. (TL-II) | | | 25% | 30% | 20% | | | | | | | 25% | | |
| Forager (TL-III) | | | 5% | | | | | | | | | 50% | 45% | |
| Predator (TL-IV) | | | 2% | | | | | | | | | 20% | 20% | 58% |

| Water Exposures | | Upper Water Column | Lower Water Column | Vessel Interior | Sediment Pore Water |
|---|---|---|---|---|---|
| **Pelagic Community** | | | | | |
| Phytoplankton (TL1) | Algae | 100% | | | |
| Zooplankton (TL-II) | copepods | 50% | 50% | | |
| Planktivore (TL-III) | herring | 80% | 20% | | |
| Piscivore (TL-IV) | jack | 80% | 20% | | |
| **Reef / Vessel Community** | | | | | |
| Attached Algae | Algae | | 100% | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | | 100% | | |
| Invertebrate Omnivore (TL-II) | urchin | | 80% | 20% | |
| Invertebrate Forager (TL-III) | crab | | 70% | 30% | |
| Vertebrate Forager (TL-III) | triggerfish | | 70% | 30% | |
| Predator (TL-IV) | grouper | | 80% | 20% | |
| **Benthic Community** | | | | | |
| Infaunal invert. (TL-II) | polychaete | | 20% | | 80% |
| Epifaunal invert. (TL-II) | nematode | | 50% | | 50% |
| Forager (TL-III) | lobster | | 75% | | 25% |
| Predator (TL-IV) | flounder | | 90% | | 10% |

| Energy Estimates for Suspended Sediment and Bedded Sediment | GE | ME | ME | as kcal/g-ww |
|---|---|---|---|---|
| Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.01099776 |
| Suspended Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.1649664 |

| Respiratory Efficiencies | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Low body weight (<100g) | 4.335E-01 | 8.000E-01 | 8.000E-01 | 8.000E-01 | 4.492E-01 | 2.582E-01 | 2.018E-01 | 1.127E-01 | 5.303E-02 | 1.255E-02 |
| High body weight (>100g) | 5.000E-01 | 5.000E-01 | 5.000E-01 | 5.000E-01 | 3.769E-01 | 2.857E-01 | 2.526E-01 | 1.888E-01 | 1.295E-01 | 6.299E-02 |
| Dietary Assimilation Efficiencies | 27% | 46% | 53% | 62% | 69% | 69% | 68% | 59% | 44% | 16% |

| Tissue Conc. (mg/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 8.387E-13 | 2.222E-08 | 1.787E-09 | 2.899E-08 | 3.807E-08 | 1.523E-09 | 6.239E-10 | 0.000E+00 | 2.811E-13 | 1.007E-15 |
| Zooplankton (TL-II) | 4.231E-09 | 1.571E-04 | 1.585E-05 | 2.991E-04 | 2.967E-04 | 4.244E-05 | 3.776E-05 | 0.000E+00 | 1.893E-07 | 2.799E-08 |
| Planktivore (TL-III) | 9.564E-10 | 1.331E-04 | 2.426E-05 | 8.873E-04 | 1.581E-03 | 2.488E-04 | 2.158E-04 | 0.000E+00 | 7.140E-07 | 3.758E-08 |
| Piscivore (TL-IV) | 2.501E-10 | 2.346E-05 | 6.441E-06 | 5.183E-04 | 2.772E-03 | 7.462E-04 | 7.296E-04 | 0.000E+00 | 2.131E-06 | 4.648E-08 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 1.870E-09 | 5.035E-05 | 4.260E-06 | 7.080E-05 | 1.115E-04 | 1.084E-05 | 6.847E-06 | 0.000E+00 | 1.540E-08 | 6.887E-10 |
| Sessile filter feeder (TL-II) | 6.022E-08 | 2.031E-03 | 2.006E-04 | 3.773E-03 | 3.652E-03 | 3.235E-04 | 2.342E-04 | 0.000E+00 | 7.497E-07 | 8.135E-08 |
| Invertebrate Omnivore (TL-II) | 2.883E-07 | 2.235E-02 | 3.298E-03 | 1.060E-01 | 1.708E-01 | 1.202E-02 | 6.275E-03 | 0.000E+00 | 4.231E-06 | 5.249E-08 |
| Invertebrate Forager (TL-III) | 2.186E-06 | 8.904E-02 | 1.325E-02 | 4.464E-01 | 8.506E-01 | 6.702E-02 | 3.707E-02 | 0.000E+00 | 4.056E-05 | 2.689E-06 |
| Vertebrate Forager (TL-III) | 2.009E-07 | 1.406E-02 | 3.019E-03 | 1.767E-01 | 6.272E-01 | 6.326E-02 | 3.683E-02 | 0.000E+00 | 4.112E-05 | 1.369E-06 |
| Predator (TL-IV) | 1.112E-07 | 7.216E-03 | 1.703E-03 | 1.483E-01 | 1.143E+00 | 1.745E-01 | 1.116E-01 | 0.000E+00 | 1.199E-04 | 2.665E-06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 1.525E-08 | 5.992E-04 | 6.227E-05 | 1.232E-03 | 1.237E-03 | 1.132E-04 | 8.273E-05 | 0.000E+00 | 2.309E-07 | 1.645E-08 |
| Epifaunal invert. (TL-II) | 1.892E-08 | 1.114E-03 | 1.329E-04 | 3.008E-03 | 3.315E-03 | 3.177E-04 | 2.345E-04 | 0.000E+00 | 5.892E-07 | 3.231E-08 |
| Forager (TL-III) | 1.105E-08 | 6.101E-04 | 9.328E-05 | 2.819E-03 | 4.201E-03 | 3.928E-04 | 2.676E-04 | 0.000E+00 | 4.266E-07 | 9.788E-09 |
| Predator (TL-IV) | 9.779E-10 | 1.627E-04 | 4.287E-05 | 2.656E-03 | 8.002E-03 | 9.627E-04 | 6.798E-04 | 0.000E+00 | 8.739E-07 | 1.285E-08 |

| Tissue Conc. (mg/kg-WW) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.382E-14 | 3.661E-10 | 2.946E-11 | 4.777E-10 | 6.275E-10 | 2.510E-11 | 1.028E-11 | 0.000E+00 | 4.633E-15 | 1.659E-17 | 1.536E-09 |
| Zooplankton (TL-II) | 2.234E-10 | 8.295E-06 | 8.368E-07 | 1.579E-05 | 1.567E-05 | 2.241E-06 | 1.994E-06 | 0.000E+00 | 9.996E-09 | 1.478E-09 | 4.484E-05 |
| Planktivore (TL-III) | 6.719E-11 | 9.348E-06 | 1.704E-06 | 6.233E-05 | 1.111E-04 | 1.748E-05 | 1.516E-05 | 0.000E+00 | 5.016E-08 | 2.640E-09 | 2.172E-04 |
| Piscivore (TL-IV) | 1.757E-11 | 1.648E-06 | 4.525E-07 | 3.641E-05 | 1.947E-04 | 5.242E-05 | 5.125E-05 | 0.000E+00 | 1.497E-07 | 3.265E-09 | 3.371E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 3.082E-11 | 8.297E-07 | 7.021E-08 | 1.167E-06 | 1.837E-06 | 1.787E-07 | 1.128E-07 | 0.000E+00 | 2.538E-10 | 1.135E-11 | 4.196E-06 |
| Sessile filter feeder (TL-II) | 5.420E-10 | 1.828E-05 | 1.806E-06 | 3.395E-05 | 3.287E-05 | 2.911E-06 | 2.108E-06 | 0.000E+00 | 6.748E-09 | 7.322E-10 | 9.194E-05 |
| Invertebrate Omnivore (TL-II) | 1.505E-08 | 1.167E-03 | 1.722E-04 | 5.534E-03 | 8.918E-03 | 6.275E-04 | 3.276E-04 | 0.000E+00 | 2.209E-07 | 2.740E-09 | 1.675E-02 |
| Invertebrate Forager (TL-III) | 5.217E-08 | 2.125E-03 | 3.163E-04 | 1.065E-02 | 2.030E-02 | 1.600E-03 | 8.848E-04 | 0.000E+00 | 9.682E-07 | 6.418E-08 | 3.588E-02 |
| Vertebrate Forager (TL-III) | 1.411E-08 | 9.880E-04 | 2.121E-04 | 1.241E-02 | 4.406E-02 | 4.444E-03 | 2.587E-03 | 0.000E+00 | 2.889E-06 | 9.615E-08 | 6.471E-02 |
| Predator (TL-IV) | 7.809E-09 | 5.069E-04 | 1.196E-04 | 1.042E-02 | 8.031E-02 | 1.226E-02 | 7.840E-03 | 0.000E+00 | 8.420E-06 | 1.872E-07 | 1.115E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 1.460E-10 | 5.733E-06 | 5.958E-07 | 1.179E-05 | 1.183E-05 | 1.083E-06 | 7.915E-07 | 0.000E+00 | 2.209E-09 | 1.574E-10 | 3.183E-05 |
| Epifaunal invert. (TL-II) | 2.037E-10 | 1.199E-05 | 1.431E-06 | 3.238E-05 | 3.568E-05 | 3.420E-06 | 2.525E-06 | 0.000E+00 | 6.343E-09 | 3.478E-10 | 8.744E-05 |
| Forager (TL-III) | 2.636E-10 | 1.456E-05 | 2.226E-06 | 6.728E-05 | 1.003E-04 | 9.375E-06 | 6.388E-06 | 0.000E+00 | 1.018E-08 | 2.336E-10 | 2.001E-04 |
| Predator (TL-IV) | 5.379E-11 | 8.946E-06 | 2.358E-06 | 1.461E-04 | 4.401E-04 | 5.295E-05 | 3.739E-05 | 0.000E+00 | 4.806E-08 | 7.065E-10 | 6.879E-04 |

| BAFs (L/kg-lipid) | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Zooplankton (TL-II) | 1.347E+05 | 6.238E+05 | 7.437E+05 | 8.446E+05 | 5.321E+05 | 7.827E+05 | 1.103E+06 | 0.000E+00 | 2.458E+06 | 8.127E+06 |
| Planktivore (TL-III) | 7.602E+04 | 1.319E+06 | 2.842E+06 | 6.256E+06 | 7.082E+06 | 1.146E+07 | 1.575E+07 | 0.000E+00 | 2.317E+07 | 2.729E+07 |
| Piscivore (TL-IV) | 1.988E+04 | 2.325E+05 | 7.546E+05 | 3.654E+06 | 1.241E+07 | 3.439E+07 | 5.326E+07 | 0.000E+00 | 6.917E+07 | 3.375E+07 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Sessile filter feeder (TL-II) | 9.590E+05 | 4.034E+06 | 4.709E+06 | 5.328E+06 | 3.276E+06 | 2.983E+06 | 3.420E+06 | 0.000E+00 | 4.867E+06 | 1.181E+07 |
| Invertebrate Omnivore (TL-II) | 3.223E+04 | 3.116E+05 | 5.434E+05 | 1.051E+06 | 1.076E+06 | 7.781E+05 | 6.433E+05 | 0.000E+00 | 1.928E+05 | 5.351E+04 |
| Invertebrate Forager (TL-III) | 1.633E+05 | 8.295E+05 | 1.459E+06 | 2.957E+06 | 3.579E+06 | 2.899E+06 | 2.540E+06 | 0.000E+00 | 1.235E+06 | 1.831E+06 |
| Vertebrate Forager (TL-III) | 1.500E+04 | 1.310E+05 | 3.324E+05 | 1.170E+06 | 2.639E+06 | 2.736E+06 | 2.523E+06 | 0.000E+00 | 1.252E+06 | 9.322E+05 |
| Predator (TL-IV) | 1.243E+04 | 1.006E+05 | 2.806E+05 | 1.470E+06 | 7.197E+06 | 1.130E+07 | 1.144E+07 | 0.000E+00 | 5.462E+06 | 2.716E+06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.429E+05 | 1.190E+06 | 1.462E+06 | 1.740E+06 | 1.109E+06 | 1.044E+06 | 1.208E+06 | 0.000E+00 | 1.499E+06 | 2.389E+06 |
| Epifaunal invert. (TL-II) | 3.013E+05 | 2.213E+06 | 3.119E+06 | 4.248E+06 | 2.973E+06 | 2.930E+06 | 3.425E+06 | 0.000E+00 | 3.825E+06 | 4.691E+06 |
| Forager (TL-III) | 1.759E+05 | 1.212E+06 | 2.189E+06 | 3.981E+06 | 3.768E+06 | 3.622E+06 | 3.909E+06 | 0.000E+00 | 2.770E+06 | 1.421E+06 |
| Predator (TL-IV) | 1.557E+04 | 3.231E+05 | 1.006E+06 | 3.751E+06 | 7.177E+06 | 8.878E+06 | 9.928E+06 | 0.000E+00 | 5.673E+06 | 1.865E+06 |

Notes:
Kow = octanol to water partitioning coefficient, Koc = organic carbon partitioning coefficient, Kdoc = dissolved organic carbon partitioning coefficient
TL = trophic level, ww = wet weight

# PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION

*RISK ESTIMATES FOR Ex-Oriskany CV34*

| ZOI = 10 | Cancer Risk Adult & Child | | Hazard Adult & Child | | Cancer Risk Child | | Hazard Child | |
|---|---|---|---|---|---|---|---|---|
| ***RISK ESTIMATES*** | RME | CTE | RME | CTE | RME | CTE | RME | CTE |
| Benthic fish (flounder) | 2.87E-08 | 2.23E-09 | 1.68E-03 | 3.85E-04 | 8.43E-09 | 1.71E-09 | 2.46E-03 | 4.43E-04 |
| Benthic shellfish (lobster) | 8.36E-09 | 6.47E-10 | 4.88E-04 | 1.12E-04 | 2.45E-09 | 4.98E-10 | 7.15E-04 | 1.29E-04 |
| Pelagic fish (jack) | 1.41E-08 | 1.09E-09 | 8.21E-04 | 1.88E-04 | 4.13E-09 | 8.38E-10 | 1.21E-03 | 2.17E-04 |
| Reef fish TL-IV (grouper) | 6.82E-06 | 5.28E-07 | 3.98E-01 | 9.13E-02 | 2.00E-06 | 4.06E-07 | 5.84E-01 | 1.05E-01 |
| Reef fish TL-III (triggerfish) | 3.96E-06 | 3.07E-07 | 2.31E-01 | 5.30E-02 | 1.16E-06 | 2.36E-07 | 3.39E-01 | 6.11E-02 |
| Reef shellfish (crab) | 2.20E-06 | 1.70E-07 | 1.28E-01 | 2.94E-02 | 6.45E-07 | 1.31E-07 | 1.88E-01 | 3.39E-02 |

| ***PREDICTED EXPOSURE CONCENTRATIONS (mg/kg in fresh weight)*** | |
|---|---|
| Benthic fish (flounder) | 4.67E-04 |
| Benthic shellfish (lobster) | 1.36E-04 |
| Pelagic fish (jack) | 2.29E-04 |
| Reef fish TL-IV (grouper) | 1.11E-01 |
| Reef fish TL-III (triggerfish) | 6.44E-02 |
| Reef shellfish (crab) | 3.57E-02 |

| ***RISK INPUTS - Adult*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 70 | 70 |
| Ingestion Rate (IRc) (kg/day) | 0.0261 | 0.0072 |
| Exposure Duration (EDc) (years) | 24 | 3 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 0.00002 | 0.000045 |
| Averaging Time for noncancer (ATnc-child) | 8.76E+03 | 1.10E+03 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |

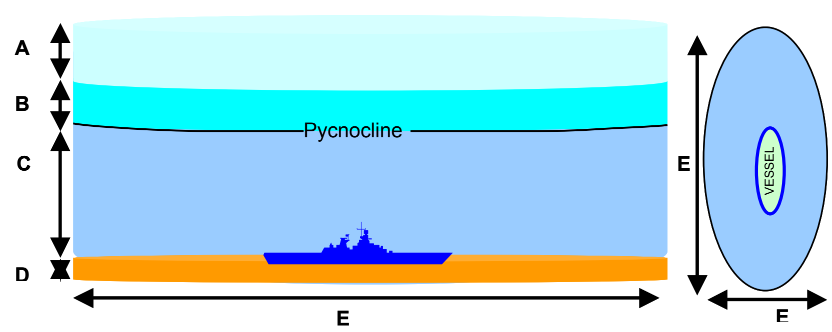
| ***RISK INPUTS - Child*** | RME | CTE |
|---|---|---|
| Body Weight (BWc) (kg) | 15 | 15 |
| Ingestion Rate (IRc) (kg/day) | 0.0092916 | 0.0025632 |
| Exposure Duration (EDc) (years) | 6 | 6 |
| Exposure Frequency (EFc) (days) | 365 | 365 |
| Averaging Time for cancer (ATc) | 25550 | 25550 |
| Slope Factor (mg/kg-day) | 2 | 1 |
| Reference dose for PCBs (RfD) (mg/kg-day) | 0.00002 | 0.000045 |
| Averaging Time for noncancer (ATnc-child) | 2.19E+03 | 2.19E+03 |
| Fractional Ingestion factor (FI) | 0.17 | 0.25 |
| Child - Adult IR scaling factor | 0.356 | |

| | |
|---|---|
| Zone of Influence Multiplier | 10 |
| Scenario run on | 6/1/05 12:03 |

| ***PCB-LADEN MATERIAL INPUTS*** | Fraction PCB | Release Rate (ng/g-d) | kg Material Onboard | PCB Release (ng/day) |
|---|---|---|---|---|
| Ventilation Gaskets | 3.14E-05 | 1.58E+03 | 1.46E+03 | 7.23E+04 |
| Lubricants | 1.03E-04 | 2.20E+03 | 0.00E+00 | 0.00E+00 |
| Foam Rubber Material | 0.76% | 2.62E+00 | 0.00E+00 | 0.00E+00 |
| Black Rubber Material | 5.29E-05 | 1.58E+03 | 5.40E+03 | 4.50E+05 |
| Electrical Cable | 1.85E-03 | 2.79E+02 | 2.96E+05 | 1.53E+08 |
| Bulkhead Insulation Material | 5.37E-04 | 6.76E+04 | 1.44E+04 | 5.22E+08 |
| Aluminum Paint | 2.00E-05 | 1.11E+04 | 3.87E+05 | 8.62E+07 |
| Total | | | | 7.62E+08 |

| Ex-Oriskany CV34 | |
|---|---|
| Ex-Oriskany CV34 | 27100 |
| Length (ft) | 888 |
| Beam (ft) | 120 |

| ZOI = | 10 |
|---|---|
| **Spatial Footprint on Ocean Floor** | |
| 7.78E+04 | m2 |
| 3.00E-02 | mile2 |
| **Modeled Dimensions Outside the Vessel** | |
| A | 1.00E+01 m |
| B | 1.50E+01 m |
| C | 5.00E+01 m |
| D | 1.00E-01 m |
| E | 4.53E+02 m |
| F | 2.19E+02 m |
| **Volumes** | |
| Air Column | |
| Air | 7.78E+05 m3 |
| Upper Water Column | |
| Water | 1.17E+06 m3 |
| TSS | 7.78E+00 m3 |
| Lower Water Column | |
| Water | 3.83E+06 m3 |
| TSS | 2.56E+01 m3 |
| Inside Vessel | |
| Water | 5.38E+04 m3 |
| TSS | 3.59E-01 m3 |
| Sediment Bed | |
| Sediment | 7.00E+03 m3 |




| **Abiotic Inputs** | |
|---|---|
| Air Column | |
| Active air space height above water column (m) | 10 |
| Air current (m/h) | 13677 |
| Upper Water Column | |
| Temperature (oC) | 24.5 |
| Water depth (m) | 15 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 6.12 |
| Lower Water Column | |
| Temperature (oC) | 19.5 |
| Water depth (m) | 50 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Inside Vessel | |
| Temperature (oC) | 19.5 |
| Total suspended solids (mg/L) | 10 |
| Dissolved organic carbon (mg/L) | 0.6 |
| Dissolved oxygen (mg/L) | 4.59 |
| Sediment Bed | |
| Sediment density (g/cm3) | 1.5 |
| Active sediment depth (m) | 0.1 |
| Sediment fraction organic carbon | 0.01 |
| All Regions | |
| Suspended solids density (g/cm3) | 1.5 |
| Suspended solids fraction organic carbon | 0.15 |
| Dissolved organic carbon density (g/cm3) | 1 |
| Water current - to out of the ZOI (m/h) | 926 |
| Water current - inside to outside the vessel (m/h) | 9.26 |

| **Total PCB concentrations** | | |
|---|---|---|
| Air Column | | |
| Air | 1.31E-16 | g/m3 |
| Upper Water Column | | |
| Freely dissolved in water | 8.95E-13 | mg/L |
| Suspended solids | 1.17E-08 | mg/kg |
| Dissolved organic carbon | 1.57E-07 | mg/kg |
| Lower Water Column | | |
| Freely dissolved in water | 1.73E-09 | mg/L |
| Suspended solids | 4.25E-05 | mg/kg |
| Dissolved organic carbon | 3.90E-04 | mg/kg |
| Inside Vessel | | |
| Freely dissolved in water | 1.80E-06 | mg/L |
| Suspended solids | 4.44E-02 | mg/kg |
| Dissolved organic carbon | 4.06E-01 | mg/kg |
| Sediment Bed | | |
| Freely dissolved in pore water | 1.73E-09 | mg/L |
| Bedded sediment | 2.84E-06 | mg/kg |
| Dissolved organic carbon in pore water | 3.90E-04 | mg/kg |

| **Total PCB concentrations in biota** | | | **Percent Exposures** | |
|---|---|---|---|---|
| Pelagic Community | | | Upper WC | Lower WC |
| Phytoplankton (TL-I) | 1.47E-09 | mg/kg | 100% | 0% |
| Zooplankton (TL-II) | 3.05E-05 | mg/kg | 50% | 50% |
| Planktivore (TL-III) | 1.47E-04 | mg/kg | 80% | 20% |
| Piscivore (TL-IV) | 2.29E-04 | mg/kg | 80% | 20% |
| Reef / Vessel Community | | | Lower WC | Vessel Int. |
| Attached Algae (TL-I) | 2.85E-06 | mg/kg | 100% | 0% |
| Sessile filter feeder (TL-II) | 6.24E-05 | mg/kg | 100% | 0% |
| Invertebrate Omnivore (TL-II) | 1.67E-02 | mg/kg | 80% | 20% |
| Invertebrate Forager (TL-III) | 3.57E-02 | mg/kg | 70% | 30% |
| Vertebrate Forager (TL-III) | 6.44E-02 | mg/kg | 70% | 30% |
| Predator (TL-IV) | 1.11E-01 | mg/kg | 80% | 20% |
| Benthic Community | | | Lower WC | Pore Water |
| Infaunal invert. (TL-II) | 2.16E-05 | mg/kg | 20% | 80% |
| Epifaunal invert. (TL-II) | 5.94E-05 | mg/kg | 50% | 50% |
| Forager (TL-III) | 1.36E-04 | mg/kg | 75% | 25% |
| Predator (TL-IV) | 4.67E-04 | mg/kg | 90% | 10% |

Scenario Run on 6/1/05 12:03 ZOI=10

| PCB Homolog | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Molecular Weight (g/mol) | 1.89E+02 | 2.23E+02 | 2.58E+02 | 2.92E+02 | 3.26E+02 | 3.61E+02 | 3.95E+02 | 4.30E+02 | 4.64E+02 | 4.99E+02 |
| Solubility (mg/L) | 2.91E+00 | 6.78E-01 | 8.14E-02 | 6.67E-02 | 2.61E-02 | 9.50E-04 | 2.30E-04 | 2.11E-08 | 4.02E-09 | 1.69E-10 |
| Solubility (mol/m$^3$) | 1.54E-02 | 3.04E-03 | 3.16E-04 | 2.28E-04 | 8.00E-05 | 2.63E-06 | 5.82E-07 | 4.91E-11 | 8.65E-12 | 3.38E-13 |
| Vapor Pressure (Pa) | 6.32E-01 | 1.41E-01 | 5.11E-02 | 2.08E-02 | 2.96E-03 | 3.43E-03 | 2.56E-04 | 8.65E-05 | 2.77E-05 | 1.41E-05 |
| Henry's (Pa-m$^3$/mol) | 4.10E+01 | 4.65E+01 | 1.62E+02 | 9.10E+01 | 3.70E+01 | 1.30E+03 | 4.40E+02 | 1.76E+06 | 3.20E+06 | 4.18E+07 |
| $\log_{10}K_{ow}$ = | 4.47 | 5.24 | 5.52 | 5.92 | 6.50 | 6.98 | 7.19 | 7.70 | 8.35 | 9.60 |
| $\log_{10}K_{oc}$ = | 3.66 | 4.06 | 4.63 | 4.65 | 4.94 | 6.08 | 6.34 | 6.46 | 6.97 | 7.94 |
| $\log_{10}K_{doc}$ = | 3.34 | 4.11 | 4.39 | 4.79 | 5.51 | 5.85 | 6.06 | 6.57 | 7.22 | 8.47 |
| Chemical emission rate (g/day) | 1.37E-05 | 1.12E-01 | 9.95E-03 | 1.69E-01 | 3.20E-01 | 7.57E-02 | 7.37E-02 | 0.00E+00 | 8.28E-04 | 4.62E-04 |
| Chemical emission rate (mol/hr) | 3.03E-09 | 2.09E-05 | 1.61E-06 | 2.42E-05 | 4.08E-05 | 8.74E-06 | 7.77E-06 | 0.00E+00 | 7.43E-08 | 3.86E-08 |
| Biodegradation in sediment (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Biodegradation in water (1/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Fraction PCB in Material (wt/wt) | 0.0000314 | 0.000103 | 0.76% | 0.0000529 | 0.00185 | 0.000537 | 0.00002 |
| Material Mass Onboard (kg) | 1459 | 0 | 0 | 5397 | 296419 | 14379 | 386528 |
| Total PCBs (kg) | 0.0458126 | 0 | 0 | 0.2855013 | 548.37515 | 7.721523 | 7.73056 |
| Total PCB Release rate (ng/g-PCB per day) | 1.58E+03 | 2.20E+03 | 2.62E+00 | 1.58E+03 | 2.79E+02 | 6.76E+04 | 1.11E+04 |

| Release Rates in nanograms PCB per gram of PCB within the Material | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint |
|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 4.14E+01 | 3.47E+01 | 0.00E+00 | 4.14E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Dichlorobiphenyl | 1.27E+03 | 1.72E+02 | 3.08E-02 | 1.27E+03 | 2.03E+02 | 5.36E+00 | 0.00E+00 |
| Trichlorobiphenyl | 5.66E+01 | 8.97E+01 | 7.63E-02 | 5.66E+01 | 1.14E+00 | 9.44E+02 | 2.61E+02 |
| Tetrachlorobiphenyl | 1.44E+02 | 1.08E+03 | 1.29E+00 | 1.44E+02 | 1.57E+01 | 2.07E+04 | 1.23E+02 |
| Pentachlorobiphenyl | 6.31E+01 | 6.60E+02 | 3.90E-02 | 6.31E+01 | 1.80E+01 | 3.79E+04 | 2.24E+03 |
| Hexachlorobiphenyl | 0.00E+00 | 9.42E+01 | 5.34E-01 | 0.00E+00 | 2.41E+01 | 6.76E+03 | 1.33E+03 |
| Heptachlorobiphenyl | 5.04E+00 | 7.17E+01 | 6.46E-01 | 5.04E+00 | 1.47E+01 | 1.30E+03 | 7.19E+03 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 1.72E-03 | 0.00E+00 | 1.51E+00 | 0.00E+00 | 0.00E+00 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.43E-01 | 0.00E+00 | 0.00E+00 |
| **Total** | **1.58E+03** | **2.20E+03** | **2.62E+00** | **1.58E+03** | **2.79E+02** | **6.76E+04** | **1.11E+04** |

| Release Rates in nanograms PCB per Day | Ventilation Gaskets | Lubricants | Foam Rubber Material | Black Rubber Material | Electrical Cable | Bulkhead Insulation Material | Aluminized Paint | Total |
|---|---|---|---|---|---|---|---|---|
| Monochlorobiphenyl | 1.90E+03 | 0.00E+00 | 0.00E+00 | 1.18E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.37E+04 |
| Dichlorobiphenyl | 5.80E+04 | 0.00E+00 | 0.00E+00 | 3.62E+05 | 1.11E+08 | 4.14E+04 | 0.00E+00 | 1.12E+08 |
| Trichlorobiphenyl | 2.59E+03 | 0.00E+00 | 0.00E+00 | 1.62E+04 | 6.25E+05 | 7.29E+06 | 2.02E+06 | 9.95E+06 |
| Tetrachlorobiphenyl | 6.60E+03 | 0.00E+00 | 0.00E+00 | 4.11E+04 | 8.61E+06 | 1.60E+08 | 9.51E+05 | 1.69E+08 |
| Pentachlorobiphenyl | 2.89E+03 | 0.00E+00 | 0.00E+00 | 1.80E+04 | 9.87E+06 | 2.93E+08 | 1.73E+07 | 3.20E+08 |
| Hexachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.32E+07 | 5.22E+07 | 1.03E+07 | 7.57E+07 |
| Heptachlorobiphenyl | 2.31E+02 | 0.00E+00 | 0.00E+00 | 1.44E+03 | 8.06E+06 | 1.01E+07 | 5.56E+07 | 7.37E+07 |
| Octachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nonachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.28E+05 | 0.00E+00 | 0.00E+00 | 8.28E+05 |
| Decachlorobiphenyl | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.62E+05 | 0.00E+00 | 0.00E+00 | 4.62E+05 |
| **Total** | 7.23E+04 | 0.00E+00 | 0.00E+00 | 4.50E+05 | 1.53E+08 | 5.22E+08 | 8.62E+07 | 7.62E+08 |

| Air | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 6.30E-20 | 3.88E-16 | 2.56E-17 | 3.42E-16 | 3.74E-16 | 1.32E-17 | 4.72E-18 | 0.00E+00 | 1.68E-21 | 5.39E-24 |
| Air concentration (g/m3) | 4.84E-21 | 3.52E-17 | 2.69E-18 | 4.07E-17 | 4.97E-17 | 1.95E-18 | 7.60E-19 | 0.00E+00 | 3.17E-22 | 1.10E-24 |

| Upper Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 5.87E-18 | 4.44E-14 | 1.08E-14 | 8.67E-14 | 4.15E-14 | 5.28E-14 | 6.67E-15 | 0.00E+00 | 1.86E-14 | 8.11E-16 |
| Water concentration (mg/L) | 2.70E-17 | 2.13E-13 | 1.72E-14 | 2.78E-13 | 3.65E-13 | 1.46E-14 | 5.99E-15 | 0.00E+00 | 2.70E-18 | 9.67E-21 |
| Suspended solids concentration (mg/kg) | 1.87E-14 | 3.65E-10 | 1.09E-10 | 1.88E-09 | 4.72E-09 | 2.64E-09 | 1.97E-09 | 0.00E+00 | 3.74E-12 | 1.27E-13 |
| Dissolved organic carbon (mg/kg) | 5.96E-14 | 2.72E-09 | 4.21E-10 | 1.72E-08 | 1.19E-07 | 1.02E-08 | 6.87E-09 | 0.00E+00 | 4.48E-11 | 2.87E-12 |

| Lower Water Column | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 9.27E-15 | 7.12E-11 | 1.82E-11 | 1.50E-10 | 8.59E-11 | 2.66E-10 | 5.18E-11 | 0.00E+00 | 7.20E-10 | 3.92E-10 |
| Water concentration (mg/L) | 4.26E-14 | 3.42E-10 | 2.89E-11 | 4.81E-10 | 7.57E-10 | 7.36E-11 | 4.65E-11 | 0.00E+00 | 1.05E-13 | 4.68E-15 |
| Suspended solids concentration (mg/kg) | 2.95E-11 | 5.85E-07 | 1.83E-07 | 3.25E-06 | 9.78E-06 | 1.33E-05 | 1.53E-05 | 0.00E+00 | 1.45E-07 | 6.12E-08 |
| Dissolved organic carbon (mg/kg) | 9.40E-11 | 4.36E-06 | 7.10E-07 | 2.97E-05 | 2.47E-04 | 5.16E-05 | 5.33E-05 | 0.00E+00 | 1.74E-06 | 1.39E-06 |

| Inside the Vessel | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 9.67E-12 | 7.43E-08 | 1.89E-08 | 1.56E-07 | 8.96E-08 | 2.77E-07 | 5.40E-08 | 0.00E+00 | 7.51E-07 | 4.09E-07 |
| Water concentration (mg/L) | 4.45E-11 | 3.57E-07 | 3.02E-08 | 5.02E-07 | 7.90E-07 | 7.68E-08 | 4.85E-08 | 0.00E+00 | 1.09E-10 | 4.88E-12 |
| Suspended solids concentration (mg/kg) | 3.07E-08 | 6.11E-04 | 1.91E-04 | 3.39E-03 | 1.02E-02 | 1.39E-02 | 1.59E-02 | 0.00E+00 | 1.51E-04 | 6.38E-05 |
| Dissolved organic carbon (mg/kg) | 9.80E-08 | 4.54E-03 | 7.41E-04 | 3.10E-02 | 2.57E-01 | 5.38E-02 | 5.56E-02 | 0.00E+00 | 1.81E-03 | 1.45E-03 |

| Sediment Bed | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Fugacity (Pa) | 9.27E-15 | 7.12E-11 | 1.82E-11 | 1.50E-10 | 8.59E-11 | 2.66E-10 | 5.18E-11 | 0.00E+00 | 7.20E-10 | 3.92E-10 |
| Pore Water concentration (mg/L) | 4.26E-14 | 3.42E-10 | 2.89E-11 | 4.81E-10 | 7.57E-10 | 7.36E-11 | 4.65E-11 | 0.00E+00 | 1.05E-13 | 4.68E-15 |
| Sediment concentration (mg/kg) | 1.96E-12 | 3.90E-08 | 1.22E-08 | 2.17E-07 | 6.52E-07 | 8.85E-07 | 1.02E-06 | 0.00E+00 | 9.66E-09 | 4.08E-09 |

| Bioenergetic Inputs | Species | Body Weight | Lipid | Moisture | Caloric Density | GE to ME | Met Energy | Caloric Density | Production | Respiration | Excretion | Caloric Density | Met Energy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (kg) | (%-dw) | (%) | (kcal/g-dry weight) | Fraction | (kcal/kg-lipid) | (kcal/kg-lipid) | (% of total) | (% of total) | (% of total) | (kcal/g-wt weight) | (kcal/g-wt weight) |
| **Pelagic Community** | | | | | | | | | | | | | |
| Phytoplankton (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Zooplankton (TL-II) | copepods | 0.000005 | 22% | 76% | 3.6 | 0.65 | 10636 | 16364 | 18% | 24% | 58% | 0.864 | 0.5616 |
| Planktivore (TL-III) | herring | 0.05 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Piscivore (TL-IV) | jack | 0.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| **Reef / Vessel Community** | | | | | | | | | | | | | |
| Attached Algae (TL-I) | Algae | | 10% | 84% | 2.36 | 0.6 | 13748 | 22913 | | | | 0.3776 | 0.22656 |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.05 | 5% | 82% | 4.6 | 0.65 | 59800 | 92000 | 28% | 31% | 41% | 0.828 | 0.5382 |
| Invertebrate Omnivore (TL-II) | urchin | 0.05 | 29% | 82% | 4.6 | 0.65 | 10310 | 15862 | 7% | 25% | 68% | 0.828 | 0.5382 |
| Invertebrate Forager (TL-III) | crab | 1 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Vertebrate Forager (TL-III) | triggerfish | 1 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 1.225 | 0.8575 |
| Predator (TL-IV) | grouper | 1.5 | 28% | 75% | 4.9 | 0.7 | 12206 | 17438 | 20% | 60% | 20% | 0.2 | 0.14 |
| **Benthic Community** | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.01 | 6% | 84% | 4.6 | 0.65 | 50000 | 76923 | 71% | 26% | 3% | 0.736 | 0.4784 |
| Epifaunal invert. (TL-II) | nematode | 0.01 | 6% | 82% | 4.6 | 0.65 | 50000 | 76923 | 31% | 19% | 50% | 0.828 | 0.5382 |
| Forager (TL-III) | lobster | 2 | 9% | 74% | 2.7 | 0.65 | 19118 | 29412 | 28% | 59% | 13% | 0.702 | 0.4563 |
| Predator (TL-IV) | flounder | 3 | 22% | 75% | 4.9 | 0.7 | 15591 | 22273 | 20% | 60% | 20% | 1.225 | 0.8575 |

| Bioenergetic Inputs | | Respiration Rate Allometric Regression Parameters | | | Resp. Rate | Resp. Rate | Consumption | Growth Rate | Consumption | Consumption | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | a | b1 | b2 | 1 / day | gO2 / kg-lipid-day | kcal / kg-lipid-day | 1 / day | g-wt weight / g-wt weight-d | kcal / -wet weight-da | As a % of body weight |
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | Algae | | | | | | | | | | |
| Zooplankton (TL-II) | copepods | 0.006375522 | 0 | 0.039935335 | 0.015425453 | 84.24400867 | 1286.168071 | 0.014147849 | 0.32636028 | 0.06790967 | 32.6% |
| Planktivore (TL-III) | herring | 0.0033 | -0.227 | 0.0548 | 0.004949927 | 21.1649 | 129.2512977 | 0.001482433 | 0.01616792 | 0.0090799 | 1.6% |
| Piscivore (TL-IV) | jack | 0.001118602 | -0.55 | 0.12 | 0.000630951 | 2.697821256 | 16.47524431 | 0.000188961 | 0.00139796 | 0.00115739 | 0.1% |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | Algae | | | | | | | | | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | 0.012 | 0 | 0.036 | 0.024213411 | 581.8482643 | 6877.300342 | 0.020930914 | 0.24377539 | 0.0618957 | 24.4% |
| Invertibrate Omnivore (TL-II) | urchin | 0.000675466 | 0 | 0.079181846 | 0.003163548 | 13.1069075 | 192.1012396 | 0.000847751 | 0.03471132 | 0.01002768 | 3.5% |
| Invertibrate Forager (TL-III) | crab | 0.001158234 | 0 | 0.071193202 | 0.004642088 | 60.75673491 | 377.3221989 | 0.003592107 | 0.01678102 | 0.00900593 | 1.7% |
| Vertibrate Forager (TL-III) | triggerfish | 0.015181024 | -0.415 | 0.061 | 0.002837229 | 12.13142452 | 74.08503521 | 0.00084971 | 0.00907693 | 0.00520447 | 0.9% |
| Predator (TL-IV) | grouper | 0.00279 | -0.355 | 0.0811 | 0.001011362 | 4.324384181 | 26.40845301 | 0.000302889 | 0.00264734 | 0.00185519 | 0.3% |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | polychaete | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 1903.064429 | 0.017565285 | 0.09800757 | 0.01820852 | 9.8% |
| Epifaunal invert. (TL-II) | nematode | 0.001682129 | 0 | 0.071034762 | 0.006721006 | 135.0382801 | 2604.19343 | 0.0104949 | 0.09262416 | 0.02803154 | 9.3% |
| Forager (TL-III) | lobster | 0.0035 | -0.13 | 0.066 | 0.00471923 | 61.76639253 | 383.5925529 | 0.003651801 | 0.01899736 | 0.00915559 | 1.9% |
| Predator (TL-IV) | flounder | 0.0046 | -0.24 | 0.067 | 0.002486878 | 13.58174479 | 82.94195291 | 0.000744785 | 0.00974341 | 0.00456181 | 1.0% |

**Dietary Preferences**

| | Suspended Solids (Epilimnion) | Suspended Solids (Hypolimnion) | Sediment | Phytoplankton | Zooplankton | Pelagic Plankitivore | Attached Algae | Reef Sessile Filter Feeder | Invertebrate Omnivore | Reef Invertebrate Forager | Reef Vertebrate Forager | Infaunal Benthos | Epifaunal Benthos | Benthic Forager |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | | | | |
| Phytoplankton (TL1) | | | | | | | | | | | | | | |
| Zooplankton (TL-II) | 15% | 15% | | 70% | | | | | | | | | | |
| Planktivore (TL-III) | | | | | 100% | | | | | | | | | |
| Piscivore (TL-IV) | | | | | 10% | 90% | | | | | | | | |
| **Reef / Vessel Community** | | | | | | | | | | | | | | |
| Attached Algae | | | | | | | | | | | | | | |
| Sessile filter feeder (TL-II) | | 10% | | 80% | 10% | | | | | | | | | |
| Invertebrate Omnivore (TL-II) | | | | | | | 80% | 20% | | | | | | |
| Invertebrate Forager (TL-III) | | 5% | | | 5% | 5% | | 35% | 50% | | | | | |
| Vertebrate Forager (TL-III) | | | | | | 19% | | 19% | 15% | 22% | | 12.5% | 12.5% | |
| Predator (TL-IV) | | | | | | | | | | 15% | 60% | 8% | 8% | 8% |
| **Benthic Community** | | | | | | | | | | | | | | |
| Infaunal invert. (TL-II) | | | 50% | 30% | 20% | | | | | | | | | |
| Epifaunal invert. (TL-II) | | | 25% | 30% | 20% | | | | | | | 25% | | |
| Forager (TL-III) | | | 5% | | | | | | | | | 50% | 45% | |
| Predator (TL-IV) | | | 2% | | | | | | | | | 20% | 20% | 58% |

**Water Exposures**

| | | Upper Water Column | Lower Water Column | Vessel Interior | Sediment Pore Water |
|---|---|---|---|---|---|
| **Pelagic Community** | | | | | |
| Phytoplankton (TL1) | Algae | 100% | | | |
| Zooplankton (TL-II) | copepods | 50% | 50% | | |
| Planktivore (TL-III) | herring | 80% | 20% | | |
| Piscivore (TL-IV) | jack | 80% | 20% | | |
| **Reef / Vessel Community** | | | | | |
| Attached Algae | Algae | | 100% | | |
| Sessile filter feeder (TL-II) | bivalves (w/o shell) | | 100% | | |
| Invertebrate Omnivore (TL-II) | urchin | | 80% | 20% | |
| Invertebrate Forager (TL-III) | crab | | 70% | 30% | |
| Vertebrate Forager (TL-III) | triggerfish | | 70% | 30% | |
| Predator (TL-IV) | grouper | | 80% | 20% | |
| **Benthic Community** | | | | | |
| Infaunal invert. (TL-II) | polychaete | | 20% | | 80% |
| Epifaunal invert. (TL-II) | nematode | | 50% | | 50% |
| Forager (TL-III) | lobster | | 75% | | 25% |
| Predator (TL-IV) | flounder | | 90% | | 10% |

**Energy Estimates for Suspended Sediment and Bedded Sediment**

| | GE | ME | ME | as kcal/g-ww |
|---|---|---|---|---|
| Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.01099776 |
| Suspended Sediment (kcal/kg-oc) | 11456 | 6873.6 | 0.6 | 0.1649664 |

| **Respiratory Efficiencies** | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| Low body weight (<100g) | 4.335E-01 | 8.000E-01 | 8.000E-01 | 8.000E-01 | 4.492E-01 | 2.582E-01 | 2.018E-01 | 1.127E-01 | 5.303E-02 | 1.255E-02 |
| High body weight (>100g) | 5.000E-01 | 5.000E-01 | 5.000E-01 | 5.000E-01 | 3.769E-01 | 2.857E-01 | 2.526E-01 | 1.888E-01 | 1.295E-01 | 6.299E-02 |
| **Dietary Assimilation Efficiencies** | 27% | 46% | 53% | 62% | 69% | 69% | 68% | 59% | 44% | 16% |

| **Tissue Conc. (mg/kg-lipid)** | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 8.048E-13 | 2.132E-08 | 1.715E-09 | 2.782E-08 | 3.655E-08 | 1.462E-09 | 5.990E-10 | 0.000E+00 | 2.699E-13 | 9.667E-16 |
| Zooplankton (TL-II) | 2.873E-09 | 1.067E-04 | 1.076E-05 | 2.032E-04 | 2.015E-04 | 2.882E-05 | 2.564E-05 | 0.000E+00 | 1.286E-07 | 1.900E-08 |
| Planktivore (TL-III) | 6.497E-10 | 9.038E-05 | 1.648E-05 | 6.027E-04 | 1.074E-03 | 1.689E-04 | 1.466E-04 | 0.000E+00 | 4.848E-07 | 2.552E-08 |
| Piscivore (TL-IV) | 1.699E-10 | 1.593E-05 | 4.375E-06 | 3.521E-04 | 1.883E-03 | 5.067E-04 | 4.954E-04 | 0.000E+00 | 1.447E-06 | 3.156E-08 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 1.270E-09 | 3.418E-05 | 2.893E-06 | 4.807E-05 | 7.570E-05 | 7.363E-06 | 4.649E-06 | 0.000E+00 | 1.046E-08 | 4.676E-10 |
| Sessile filter feeder (TL-II) | 4.089E-08 | 1.379E-03 | 1.362E-04 | 2.562E-03 | 2.480E-03 | 2.197E-04 | 1.590E-04 | 0.000E+00 | 5.091E-07 | 5.524E-08 |
| Invertebrate Omnivore (TL-II) | 2.877E-07 | 2.227E-02 | 3.285E-03 | 1.055E-01 | 1.699E-01 | 1.192E-02 | 6.211E-03 | 0.000E+00 | 4.116E-06 | 4.887E-08 |
| Invertebrate Forager (TL-III) | 2.183E-06 | 8.883E-02 | 1.321E-02 | 4.447E-01 | 8.466E-01 | 6.659E-02 | 3.678E-02 | 0.000E+00 | 4.016E-05 | 2.679E-06 |
| Vertebrate Forager (TL-III) | 2.006E-07 | 1.402E-02 | 3.008E-03 | 1.758E-01 | 6.239E-01 | 6.281E-02 | 3.650E-02 | 0.000E+00 | 4.067E-05 | 1.361E-06 |
| Predator (TL-IV) | 1.110E-07 | 7.198E-03 | 1.697E-03 | 1.476E-01 | 1.137E+00 | 1.733E-01 | 1.107E-01 | 0.000E+00 | 1.188E-04 | 2.655E-06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 1.036E-08 | 4.069E-04 | 4.229E-05 | 8.365E-04 | 8.399E-04 | 7.687E-05 | 5.618E-05 | 0.000E+00 | 1.568E-07 | 1.117E-08 |
| Epifaunal invert. (TL-II) | 1.285E-08 | 7.566E-04 | 9.025E-05 | 2.043E-03 | 2.251E-03 | 2.158E-04 | 1.593E-04 | 0.000E+00 | 4.001E-07 | 2.194E-08 |
| Forager (TL-III) | 7.500E-09 | 4.142E-04 | 6.334E-05 | 1.914E-03 | 2.853E-03 | 2.667E-04 | 1.817E-04 | 0.000E+00 | 2.897E-07 | 6.646E-09 |
| Predator (TL-IV) | 6.640E-10 | 1.104E-04 | 2.911E-05 | 1.803E-03 | 5.434E-03 | 6.537E-04 | 4.616E-04 | 0.000E+00 | 5.934E-07 | 8.723E-09 |

| **Tissue Conc. (mg/kg-WW)** | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca | Total PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | | |
| Phytoplankton (TL1) | 1.326E-14 | 3.513E-10 | 2.827E-11 | 4.585E-10 | 6.023E-10 | 2.410E-11 | 9.872E-12 | 0.000E+00 | 4.449E-15 | 1.593E-17 | 1.474E-09 |
| Zooplankton (TL-II) | 1.517E-10 | 5.634E-06 | 5.684E-07 | 1.073E-05 | 1.064E-05 | 1.522E-06 | 1.354E-06 | 0.000E+00 | 6.788E-09 | 1.003E-09 | 3.045E-05 |
| Planktivore (TL-III) | 4.564E-11 | 6.349E-06 | 1.158E-06 | 4.234E-05 | 7.545E-05 | 1.187E-05 | 1.030E-05 | 0.000E+00 | 3.406E-08 | 1.793E-09 | 1.475E-04 |
| Piscivore (TL-IV) | 1.194E-11 | 1.119E-06 | 3.074E-07 | 2.473E-05 | 1.323E-04 | 3.560E-05 | 3.480E-05 | 0.000E+00 | 1.017E-07 | 2.217E-09 | 2.289E-04 |
| **Reef / Vessel Community** | | | | | | | | | | | |
| Attached Algae | 2.093E-11 | 5.634E-07 | 4.767E-08 | 7.923E-07 | 1.248E-06 | 1.213E-07 | 7.662E-08 | 0.000E+00 | 1.724E-10 | 7.707E-12 | 2.849E-06 |
| Sessile filter feeder (TL-II) | 3.680E-10 | 1.241E-05 | 1.226E-06 | 2.306E-05 | 2.232E-05 | 1.977E-06 | 1.431E-06 | 0.000E+00 | 4.582E-09 | 4.971E-10 | 6.243E-05 |
| Invertebrate Omnivore (TL-II) | 1.502E-08 | 1.163E-03 | 1.715E-04 | 5.509E-03 | 8.868E-03 | 6.224E-04 | 3.242E-04 | 0.000E+00 | 2.149E-07 | 2.551E-09 | 1.666E-02 |
| Invertebrate Forager (TL-III) | 5.211E-08 | 2.120E-03 | 3.153E-04 | 1.061E-02 | 2.021E-02 | 1.589E-03 | 8.779E-04 | 0.000E+00 | 9.585E-07 | 6.394E-08 | 3.572E-02 |
| Vertebrate Forager (TL-III) | 1.409E-08 | 9.850E-04 | 2.113E-04 | 1.235E-02 | 4.383E-02 | 4.412E-03 | 2.564E-03 | 0.000E+00 | 2.857E-06 | 9.563E-08 | 6.436E-02 |
| Predator (TL-IV) | 7.795E-09 | 5.056E-04 | 1.192E-04 | 1.037E-02 | 7.990E-02 | 1.218E-02 | 7.776E-03 | 0.000E+00 | 8.347E-06 | 1.865E-07 | 1.109E-01 |
| **Benthic Community** | | | | | | | | | | | |
| Infaunal invert. (TL-II) | 9.910E-11 | 3.893E-06 | 4.046E-07 | 8.004E-06 | 8.036E-06 | 7.355E-07 | 5.375E-07 | 0.000E+00 | 1.500E-09 | 1.069E-10 | 2.161E-05 |
| Epifaunal invert. (TL-II) | 1.383E-10 | 8.144E-06 | 9.714E-07 | 2.199E-05 | 2.423E-05 | 2.322E-06 | 1.714E-06 | 0.000E+00 | 4.307E-09 | 2.361E-10 | 5.938E-05 |
| Forager (TL-III) | 1.790E-10 | 9.887E-06 | 1.512E-06 | 4.569E-05 | 6.809E-05 | 6.366E-06 | 4.337E-06 | 0.000E+00 | 6.915E-09 | 1.586E-10 | 1.359E-04 |
| Predator (TL-IV) | 3.652E-11 | 6.074E-06 | 1.601E-06 | 9.918E-05 | 2.989E-04 | 3.595E-05 | 2.539E-05 | 0.000E+00 | 3.264E-08 | 4.798E-10 | 4.671E-04 |

| **BAFs (L/kg-lipid)** | Mono | Di | Tri | Tetra | Penta | Hexa | Hepta | Octa | Nona | Deca |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pelagic Community** | | | | | | | | | | |
| Phytoplankton (TL1) | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Zooplankton (TL-II) | 1.347E+05 | 6.239E+05 | 7.438E+05 | 8.447E+05 | 5.321E+05 | 7.827E+05 | 1.103E+06 | 0.000E+00 | 2.458E+06 | 8.127E+06 |
| Planktivore (TL-III) | 7.601E+04 | 1.319E+06 | 2.841E+06 | 6.254E+06 | 7.080E+06 | 1.146E+07 | 1.575E+07 | 0.000E+00 | 2.317E+07 | 2.729E+07 |
| Piscivore (TL-IV) | 1.988E+04 | 2.325E+05 | 7.544E+05 | 3.653E+06 | 1.241E+07 | 3.438E+07 | 5.325E+07 | 0.000E+00 | 6.917E+07 | 3.375E+07 |
| **Reef / Vessel Community** | | | | | | | | | | |
| Attached Algae | 2.979E+04 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 1.000E+05 | 0.000E+00 | 1.000E+05 | 1.000E+05 |
| Sessile filter feeder (TL-II) | 9.590E+05 | 4.035E+06 | 4.709E+06 | 5.329E+06 | 3.276E+06 | 2.983E+06 | 3.421E+06 | 0.000E+00 | 4.867E+06 | 1.181E+07 |
| Invertebrate Omnivore (TL-II) | 3.221E+04 | 3.111E+05 | 5.422E+05 | 1.048E+06 | 1.071E+06 | 7.733E+05 | 6.379E+05 | 0.000E+00 | 1.879E+05 | 4.991E+04 |
| Invertebrate Forager (TL-III) | 1.632E+05 | 8.284E+05 | 1.456E+06 | 2.949E+06 | 3.565E+06 | 2.883E+06 | 2.523E+06 | 0.000E+00 | 1.224E+06 | 1.827E+06 |
| Vertebrate Forager (TL-III) | 1.500E+04 | 1.308E+05 | 3.315E+05 | 1.166E+06 | 2.628E+06 | 2.720E+06 | 2.503E+06 | 0.000E+00 | 1.240E+06 | 9.282E+05 |
| Predator (TL-IV) | 1.243E+04 | 1.005E+05 | 2.801E+05 | 1.466E+06 | 7.174E+06 | 1.124E+07 | 1.137E+07 | 0.000E+00 | 5.425E+06 | 2.712E+06 |
| **Benthic Community** | | | | | | | | | | |
| Infaunal invert. (TL-II) | 2.429E+05 | 1.190E+06 | 1.462E+06 | 1.740E+06 | 1.109E+06 | 1.044E+06 | 1.208E+06 | 0.000E+00 | 1.499E+06 | 2.389E+06 |
| Epifaunal invert. (TL-II) | 3.013E+05 | 2.213E+06 | 3.120E+06 | 4.249E+06 | 2.974E+06 | 2.930E+06 | 3.426E+06 | 0.000E+00 | 3.825E+06 | 4.691E+06 |
| Forager (TL-III) | 1.759E+05 | 1.212E+06 | 2.190E+06 | 3.982E+06 | 3.768E+06 | 3.622E+06 | 3.909E+06 | 0.000E+00 | 2.770E+06 | 1.421E+06 |
| Predator (TL-IV) | 1.557E+04 | 3.231E+05 | 1.006E+06 | 3.751E+06 | 7.178E+06 | 8.878E+06 | 9.929E+06 | 0.000E+00 | 5.673E+06 | 1.865E+06 |

Notes:
Kow = octanol to water partitioning coefficient, Koc = organic carbon partitioning coefficient, Kdoc = dissolved organic carbon partitioning coefficient
TL = trophic level, ww = wet weight

| | | | | | | |
|---|---|---|---|---|---|---|
| B.3 Summary of Total PCBs concentrations modeled for biological and abiotic compartments as a function of ZOI. | | | | | | |
| ZOI | 1 | 2 | 3 | 4 | 5 | 10 |
| Tissue Conc. (mg/kg-WW) | Total PCB | Total PCB | Total PCB | Total PCB | Total PCB | Total PCB |
| **Pelagic Community** | | | | | | |
| Phytoplankton (TL1) | 1.86E-09 | 1.67E-09 | 1.60E-09 | 1.56E-09 | 1.54E-09 | 1.47E-09 |
| Zooplankton (TL-II) | 1.21E-04 | 7.72E-05 | 6.04E-05 | 5.10E-05 | 4.48E-05 | 3.05E-05 |
| Planktivore (TL-III) | 5.88E-04 | 3.74E-04 | 2.92E-04 | 2.47E-04 | 2.17E-04 | 1.47E-04 |
| Piscivore (TL-IV) | 9.13E-04 | 5.80E-04 | 4.54E-04 | 3.83E-04 | 3.37E-04 | 2.29E-04 |
| **Reef / Vessel Community** | | | | | | |
| Attached Algae | 1.14E-05 | 7.23E-06 | 5.65E-06 | 4.77E-06 | 4.20E-06 | 2.85E-06 |
| Sessile filter feeder (TL-II) | 2.49E-04 | 1.58E-04 | 1.24E-04 | 1.05E-04 | 9.19E-05 | 6.24E-05 |
| Invertebrate Omnivore (TL-II) | 1.72E-02 | 1.69E-02 | 1.68E-02 | 1.68E-02 | 1.67E-02 | 1.67E-02 |
| Invertebrate Forager (TL-III) | 3.67E-02 | 3.62E-02 | 3.61E-02 | 3.60E-02 | 3.59E-02 | 3.57E-02 |
| Vertebrate Forager (TL-III) | 6.66E-02 | 6.55E-02 | 6.51E-02 | 6.49E-02 | 6.47E-02 | 6.44E-02 |
| Predator (TL-IV) | 1.15E-01 | 1.13E-01 | 1.12E-01 | 1.12E-01 | 1.11E-01 | 1.11E-01 |
| **Benthic Community** | | | | | | |
| Infaunal invert. (TL-II) | 8.62E-05 | 5.48E-05 | 4.28E-05 | 3.62E-05 | 3.18E-05 | 2.16E-05 |
| Epifaunal invert. (TL-II) | 2.37E-04 | 1.51E-04 | 1.18E-04 | 9.94E-05 | 8.74E-05 | 5.94E-05 |
| Forager (TL-III) | 5.42E-04 | 3.45E-04 | 2.69E-04 | 2.28E-04 | 2.00E-04 | 1.36E-04 |
| Predator (TL-IV) | 1.86E-03 | 1.18E-03 | 9.26E-04 | 7.82E-04 | 6.88E-04 | 4.67E-04 |
| | | | | | | |
| **Air concentration (g/m3)** | 5.26E-17 | 6.68E-17 | 7.83E-17 | 8.81E-17 | 9.68E-17 | 1.31E-16 |
| **Upper Water Column** | | | | | | |
| Fugacity (Pa) | | | | | | |
| Water concentration (mg/L) | 1.13E-12 | 1.02E-12 | 9.72E-13 | 9.48E-13 | 9.32E-13 | 8.95E-13 |
| Suspended solids concentration (mg/kg) | 1.48E-08 | 1.33E-08 | 1.27E-08 | 1.24E-08 | 1.22E-08 | 1.17E-08 |
| Dissolved organic carbon (mg/kg) | 1.98E-07 | 1.78E-07 | 1.70E-07 | 1.66E-07 | 1.63E-07 | 1.57E-07 |
| Bulk Upper Water Col (mg/L) | 2.67E-10 | 2.40E-10 | 2.30E-10 | 2.24E-10 | 2.21E-10 | 2.12E-10 |
| | | | | | | |
| **Lower Water Column** | | | | | | |
| Fugacity (Pa) | | | | | | |
| Water concentration (mg/L) | 6.90E-09 | 4.39E-09 | 3.43E-09 | 2.89E-09 | 2.55E-09 | 1.73E-09 |
| Suspended solids concentration (mg/kg) | 1.70E-04 | 1.08E-04 | 8.43E-05 | 7.12E-05 | 6.27E-05 | 4.25E-05 |
| Dissolved organic carbon (mg/kg) | 1.55E-03 | 9.88E-04 | 7.72E-04 | 6.52E-04 | 5.74E-04 | 3.90E-04 |
| Bulk Lower Water Col (mg/L) | 2.64E-06 | 1.68E-06 | 1.31E-06 | 1.11E-06 | 9.73E-07 | 6.61E-07 |
| | | | | | | |
| **Inside the Vessel** | | | | | | |
| Fugacity (Pa) | | | | | | |
| Water concentration (mg/L) | 1.80E-06 | 1.80E-06 | 1.80E-06 | 1.80E-06 | 1.80E-06 | 1.80E-06 |
| Suspended solids concentration (mg/kg) | 4.44E-02 | 4.44E-02 | 4.44E-02 | 4.44E-02 | 4.44E-02 | 4.44E-02 |
| Dissolved organic carbon (mg/kg) | 4.06E-01 | 4.06E-01 | 4.06E-01 | 4.06E-01 | 4.06E-01 | 4.06E-01 |
| Bulk Water Inside Vessel (mg/L) | 6.89E-04 | 6.89E-04 | 6.89E-04 | 6.89E-04 | 6.89E-04 | 6.89E-04 |
| | | | | | | |
| **Sediment Bed** | | | | | | |
| Fugacity (Pa) | | | | | | |
| Pore Water concentration (mg/L) | 6.90E-09 | 4.39E-09 | 3.43E-09 | 2.89E-09 | 2.55E-09 | 1.73E-09 |
| Sediment concentration (mg/kg) | 1.13E-05 | 7.19E-06 | 5.62E-06 | 4.75E-06 | 4.18E-06 | 2.84E-06 |