Artificial Reefing

Ex-ORISKANY Artificial Reef Project

Ecological Risk Assessment

SPAWAR
Systems Center
San Diego

MARINE ENVIRONMENTAL SUPPORT OFFICE
MESO
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FINAL REPORT

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Ex-ORISKANY
Artificial Reef Project

ECOLOGICAL RISK ASSESSMENT

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Prepared for:
Program Executive Office Ships (PMS 333)

Prepared by:
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EX-ORISKANY ARTIFICIAL REEF PROJECT:

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Prepared For:
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Photo by Keith Mille (keith.mille@MyFWC.com)
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Glossary of Terms, Acronyms, and Abbreviations

Term	*Definition*
Accuracy	The degree of agreement between a measured value and a true, expected value.
Acute Toxicity	The ability of a substance to cause effects resulting in severe biological harm within a short time after exposure to the toxic compound, usually within 24 to 96 hours.
AF	Assessment Factor – AFs are used to account for gaps in knowledge associated with estimating chronic toxicity from acute toxicity, accounting for species-to-species differences, and extrapolating from laboratory tests to field toxicity levels, where an assessment factor of 10 (the benchmark is divided by the AF of 10 – 1000, as appropriate) is applied for each extrapolation required (U.S. EPA 1984, Nabholz 2003, Zeeman 1995, Zeeman et al.1999).
Algae	Microscopic plants which contain chlorophyll and live floating or suspended in water as **phytoplankton** in the **plankton**. Larger multicellular **algae,** sometimes referred to as macro-algae or encrusting algae, may attach to structures, rocks or other submerged surfaces. They are food for fish and small aquatic animals. **Algae** produce oxygen during sunlight hours and use oxygen during the night hours.
Ambient	Environmental or natural surrounding conditions.
ANOVA	Analysis of variance
Anthropogenic	Something made by humans, which effects nature.
Assessment Endpoint	"An explicit expression of the environmental value to be protected, operationally defined as an ecological entity and its attributes." (USEPA, 1998; USEPA, 2003)
Avian Consumers	Birds of prey and waterfowl (ducks, geese, gulls, cormorants, and ospreys), which feed on prey from marine and estuarine waters.
Attribute	"A quality or characteristic of an ecological entity. An attribute is one component of an **assessment endpoint**." (USEPA 1998b)
Background Level	Naturally occurring levels, **ambient** concentrations.
BAF	bioaccumulation factor, "the ratio (in L/kg) of a substance's concentration in tissue of an aquatic organism to its concentration in the ambient water" (U.S. EPA 1995). BAFs are used to account for the trophic transfer of a contaminant in the food chain
BAF_{Lipid}	Lipid-normalized BAF which is the ratio of a chemical in the lipid of an organism to its freely dissolved concentration in the water
B_{CV}	The bioaccumulation critical value is the tissue concentration in an organism that when exceeded suggests that ambient water quality criteria were exceeded.
BCF	"the **bioconcentration** factor is defined as the ratio of chemical concentration in the organism to that in surrounding water. Bioconcentration occurs through uptake and retention of a substance from water only, through gill membranes or other external body surfaces. In the context of setting exposure criteria it is generally understood that the terms "BCF" and "steady-state BCF"' are synonymous. A steady-state condition occurs when the organism is exposed for a sufficient length of time that the ratio does not change substantially." http://www.acdlabs.com/products/phys_chem_lab/logd/bcf.html
Benchmark	A specific chemical concentration (in sediment, water, or tissue) or biological response

	when exceeded has been associated with adverse effects.
Benthic Community	Community of organisms, which spends the majority of their life living within the bottom **sediments** (worm, clam, amphipod, etc.).
Bioaccumulation	The **uptake** and retention of substances by an organism from its food and its surrounding environment. Chemicals that bioaccumulate become more concentrated at each successively higher level of the food chain. Bioaccumulative chemicals can be toxic to organisms at the upper end of a food chain, such as predatory fish, loons, eagles, otters, or humans that eat fish.
Bioassay	Study to measure the effects of a chemical on a living organism.
Bioconcentration	The increase in concentration of a chemical in an organism resulting from tissue absorption levels exceeding the rate of metabolism and excretion. http://www.acdlabs.com/products/phys_chem_lab/logd/bcf.html
Biomagnification	A phenomenon in which certain chemicals accumulate at higher concentrations in higher levels of a food chain through dietary routes. At the top of the food chain an animal, through its regular diet, may accumulate a much greater concentration of chemical than was present in organisms lower in the food chain.
Biota	Animal and plant life.
Bulk Sediment	The total **sediment** concentration (of a chemical) analyzed on a dry weight basis.
Carnivorous	Animals that subsist by feeding on flesh of prey (other animals)
Calibration	A procedure that checks or adjusts an instrument's accuracy by comparison with a standard or reference.
CBR	Critical Body Residue – The concentration of a contaminant in the tissue of an organism that can cause adverse effects to the organism when exceeded.
CCC	Criteria Continuous Concentration (CCC – chronic), an estimate of the highest concentration of a material in the water column to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect
CCME	Candaian Council of Ministers of the Environment
Chlorophyll	One of a number of green pigments present in plant cells that are essential in the utilization of light energy in photosynthesis.
Chronic Toxicity	The ability of a substance to cause poisonous effects from long-term exposure, usually months or years.
CMC	Criterion maximum concentration (CMC – acute) an estimate of the highest concentration of a material in the water column to which an aquatic community can be exposed briefly without resulting in an unacceptable effect
COC	Contaminants of Concern – chemicals identified as having the potential to cause ecological impacts.
Community	"An assemblage of populations of different species within a specified location in space and time." (USEPA 1998b)
Colloids	Very small, finely divided solids (particles that do not dissolve) that remain dispersed in a liquid for a long time due to their small size and electrical charge. When most of the particles in water have a negative electrical charge, they tend to repel each other. This repulsion prevents the particles from clumping together, becoming heavier, and settling out.

Conceptual Model	Theoretical representation of a situation. "A conceptual model in problem formulation is a written description and visual representation of predicted relationships between ecological entities and the stressors to which they may be exposed." (USEPA 1998)
Congener	Something closely resembling or analogous to something else, see **PCB congener**
Disturbance	"Any event or series of events that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment." (USEPA 1998d)
Dose-Response	A quantitative relationship between the dose of a chemical and an effect caused by the chemical.
Dose-Response Curve	A graphical presentation of the relationship between degree of **exposure** to a chemical (dose) and observed biological effect or response.
FCM	Food Chain Multiplier, the ratio of a **BAF** to the appropriate **BCF**. The FCM "reflects a chemical's tendency to biomagnify in the aquatic food web" (U.S. EPA 2002b).
EC_{20}	Effect Concentration 20% **-** the concentration of a chemical in air or water which is expected to cause an effect (other than death, e.g. reproductive impairment, reduced growth, biochemical response etc.) in 20% of test animals living in that air or water.
Ecological Entity	"A general term that may refer to a species, a group of species, an ecosystem function or characteristic, or a specific habitat. An ecological entity is one component of an **assessment endpoint**." (USEPA 1998d)
Ecological Receptors	Representative species selected to evaluate the likelihood of adverse impact to the **Assessment Endpoint**.
Ecological Risk Assessment	"The process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of **exposur**e to one or more **stressors**." (USEPA 1998d)
Ecosystem	An ecological system, a natural unit of living and nonliving components, which interact to form a stable system in which a cyclic interchange of materials takes place between living, and nonliving units.
EELAARS	Escambia East Large Area Artificial Reef Site is an area permitted by the Army Corps of Engineers for the creation of artificial reefs, it is located about 22.5 mi from Pensacola, FL (see Figure 2).
Effects Assessment	The determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration and extent of effects from exposure to a chemical.
Effects Measure	See **Measures of Effects.**
Environmental Media	Components of the environment (water, **sediment**, and **biota**) that can accumulate contaminants.
Environmental Release	The introduction of a pollutant into the environment through wastewater discharge, air emission, or volatilization or leaching from soil, landfill, or other contaminated site.
Epibenthic Species	The community of organisms (e.g. lobster, mussel) which spend the majority of their life attached to or in close proximity to the bottom of .a body of water.
Equilibrium Partitioning	The partitioning or distribution of an **organic** contaminant between **bulk** and **pore water** phases of the **sediment**.
EMAP	Environmental Monitoring and Assessment Program
ERL	Effects Range - Low - the concentrations of contaminants below which adverse biological effects would rarely occur.

ERM	Effects Range - Median - concentrations of contaminants above which adverse biological effects would probably occur.
Euphotic Zone	The portion of the upper water column which receives enough light to support photosynthesis.
Exposure	"Exposure is the contact or co-occurrence of a **stressor** with a **receptor**". (USEPA 1998b)
Exposure Assessment	The determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration, route, and extent of **exposure** to a chemical.
Exposure Level	The amount (concentration) of a chemical that comes into contact with an organism through the air, water, sediment, or food.
Exposure Scenario	A set of conditions or assumptions about sources, exposure pathways, concentrations of toxic chemicals and populations (numbers, characteristics and habits), which aid in evaluating and quantifying exposure.
FDEP	Florida Department of Environmental Protection
FFWCC	Florida Fish and Wildlife Conservation Commission
Food Chain	A sequence of organisms, each of which uses the next lower member of the sequence as a food source.
FCM	Food Chain Multiplier is the increase of a chemical in the food chain that "reflects a chemical's tendency to biomagnify in the aquatic food web" (U.S. EPA 2000b).
GLWQI-Wildlife	Great Lakes Water Quality Initiative criteria for protection of wildlife
Inorganic	Composed of matter other than plant or animal.
IVW	The interior vessel water is the water contained within the spaces of the sunken hulk not in direct contact with the ocean currents.
LC_{50}	Lethal Concentration 50% - the concentration of a chemical in air or water which is expected to cause death in 50% of test animals living in that air or water.
LD	Lethal Dose - the amount of a toxic substance required to cause death of an organism under study in a given period of time
LD_{50}	Lethal Dose 50% - the dosage of a toxic substance required to kill one half of the organisms under study in a given period of time
LKA	Landing amphibious cargo ship
LOAEL	Lowest Observed Adverse Effect Level – "The lowest level of a stressor evaluated in a test that causes statistically significant [negative] differences from the controls." (USEPA 1998d).
LOED	Lowest Observed Effects Dose – the lowest dose in an experiment, which produced an statistically significant difference from controls. The dose can refer to the concentration of chemical in the diet or the concentration of the chemical in tissues of the organism.
LWC	The lower water column is the water below the **pycnocline**.
MARAD	U.S. Maritime Administration
Measures of Effects	Measurements that provide information about effect, impact, or stress on **Ecological Receptors**.
Measures of Exposure	Measurements that quantify the concentration of **COCs** in sediment, water, or biota.
mg	Milligram - one-thousandth of a gram (0.000035 oz.).)

mg/L	Milligrams Per Liter - a measure of concentration of a dissolved substance. A concentration of one mg/L means that one milligram of a substance is dissolved in each liter of water which is equal to **parts per million** (**ppm**) since one liter of water is equal in weight to one million milligrams. For example: a liter of water containing 10 milligrams of calcium has 10 parts of calcium per one million parts of water, or 10 parts per million (10 ppm).
Molecular Weight	The molecular weight of a compound in grams is the sum of the atomic weights of the elements in the compound.
Mortality	The proportion of deaths to population.
NEHC	Navy Environmental Health Center, Norfolk, VA
NOAEL	No Observed Adverse Effect Level – "The highest level of a **stressor** evaluated in a test that does not cause statistically significant [negative] differences from the controls." (USEPA 1998d)
NOED	No Observed Effects Dose – the highest dose in an experiment which did notnot cause statistically significant differences from the control. The dose can refer to the concentration of chemical in the diet or the concentration of the chemical in tissues of the organism.
NOEL	No Observed Effect Level - The highest level of a **stressor** evaluated in a test that does not cause statistically significant differences from the controls..
Organic	Composed of plant or animal matter.
Particulate	Very small solid particles suspended in water which can vary widely in size, shape, density, and electrical charge. **Colloidal** and dispersed particulates are artificially gathered together by the processes of coagulation and flocculation.
Partition Coefficient	A measure of the extent to which a chemical is divided between the soil/sediment and water phases.
PCB	Polychlorinated Biphenyl - any of several compounds that are produced by replacing hydrogen atoms in biphenyl with chlorine. Used in various industrial applications, they tend to accumulate in animal tissues. PCB (or PCBs) is a category, or family, of chemical compounds formed by the addition of Chlorine (Cl2) to Biphenyl (C12H10), which is a dual-ring structure comprising two 6-carbon Benzene rings linked by a single carbon-carbon bond. For more information see: http://www.epa.gov/toxteam/pcbid/defs.htm
PCB congener	A group of 209 individual PCB compounds having from 1 to 10 chlorine atoms attached to biphenyl rings. The name of a congener specifies the total number of chlorine substituents and the position of each chlorine. For example: 4,4'-Dichlorobiphenyl is a congener comprising the Biphenyl structure with two chlorine substituents, one on each of the two carbons at the "4" (also called "para") positions of the two rings. For more information see: http://www.epa.gov/toxteam/pcbid/defs.htm
PCB homologs	"Homologs" are subcategories of **PCB congeners** having equal numbers of chlorine substituents. For example, the "Tetrachlorobiphenyls" (or "Tetra-PCBs" or "Tetra-CBs" or just "Tetras") are all PCB congeners with exactly 4 chlorine substituents that may be in any arrangement. For more information see: http://www.epa.gov/toxteam/pcbid/defs.htm
Pelagic Species	The community of organisms (fish, **plankton**), which spend the majority of their life floating or swimming in the water.
Phytoplankton	Microscopic plants (such as **algae**), that forms the basis of the **food chain** in oceans, estuaries, rivers, lakes, and other bodies of water.

Plankton	Aquatic organisms of fresh, brackish, or sea water which float passively or exhibit limited locomotor activity (e.g. **algae**, **phytoplankton**, **zooplankton**).
Point Source	A stationery location or fixed facility from which pollutants are discharged or emitted. Also, any single identifiable source of pollution, (e.g., a pipe, ditch, ship, ore pit, factory smokestack).
Pollutant	Any substance introduced into the environment that adversely affects the usefulness of a resource.
Pore Water (PW)	The spaces between sediment particles that are saturated with water.
ppb	Parts Per Billion - a measurement of concentration on a weight or volume basis. One ppb equals one unit of measurement per billion units of the same measurement. One ppb equals one microgram per liter (**μg/L**) for volume or one nanogram per gram (**ng/g**) or alternatively one microgram per kilogram (**μg/Kg**) for weight.
ppm	Parts Per Million - a measurement of concentration on a weight or volume basis. One ppm equals one unit of measurement per million units of the same measurement. One ppm equals one milligram per liter (**mg/L**) for volume or one microgram per gram (**μg/g**) or alternatively one milligram per kilogram (**mg/Kg**) for weight.
Precision	The ability of an instrument to measure a process variable and to repeatedly obtain the same result.
Prospective Risk Assessment	"An evaluation of the future risks of a **stressor**(s) not yet released into the environment or of future conditions resulting from an existing **stressor**(s)." (USEPA 1998d)
PRAM	Prospective Risk Assessment Model
Pycnocline	The pycnocline are layers of water where the water density changes rapidly with depth. http://www.windows.ucar.edu/tour/link=/earth/Water/density.html .
QA/QC	Quality Assurance/Quality Control
Receiving Waters	All distinct bodies of water that receive runoff or wastewater discharges, such as streams, rivers, ponds, lakes, estuaries, and oceans.
Receptor	"The ecological entity exposed to the stressor." (USEPA 1998d)
Receptor Species	A representative species used to evaluate exposure to the stressor for a class of organisms.
REEFEX	The creation of artificial reefs by sinking ex-Navy vessels.
Risk	A measure of the probability that damage to the environment will occur as a result of a given hazard.
Risk Assessment	A qualitative or quantitative evaluation of the environmental and/or health risk resulting from exposure to a chemical or physical agent (**pollutant**); combines **exposure assessment** results with **toxicity assessment** results to estimate risk.
Risk Characterization	Final component of **risk assessment** that involves integration of the data and analysis involved in the **exposure assessment** and the ecological **effects assessment** to determine the likelihood that ecological impacts have or will occur.
Risk Management	The process for evaluating and selecting responses to risk.
SCDNR	South Carolina Department of Natural Resoucres
Sediment	Matter which settles to the bottom in oceans, estuaries, rivers, lakes or other waterbodies.

SINKEX	The sinking of ex-Navy vessels as part of weapons testing operations.
Source	"A source is an entity or action that releases to the environment or imposes on the environment a chemical, physical, or biological stressor or stressors. Sources may include a waste treatment plant, a pesticide application, a logging operation, introduction of exotic organisms, or a dredging project." (USEPA 1998d).
SSD	Species sensitivity distributions are cumulative distribution functions that describe the proportion of a class of organisms that are expected to be affected by a given level of exposure to a contaminant.
SSD-SD	Space and Naval Warfare Systems Center, San Diego, CA
Stressor	"Stressor. A stressor is any physical, chemical, or biological entity that can induce an adverse response. This term is used broadly to encompass entities that cause primary effects and those primary effects that can cause secondary (i.e., indirect) effects. Stressors may be chemical (e.g., toxics or nutrients), physical (e.g., dams, fishing nets, or suspended sediments), or biological (e.g., exotic or genetically engineered organisms)". (USEPA 1998d)
sumPCB	The sum of the measured **PCB congeners**.
Superfund	Federal law, which authorizes EPA to manage the clean up of abandoned or uncontrolled hazardous waste sites.
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin (most toxic from of dioxin)
TDM	Time Dynamic Model
TEF	Dioxin Toxicity Equivalent Factor, **TEF** expresses the potency of PCB congeners relative to **TCDD** (i.e., TCDD TEF = 1)
TEQ	Toxicity equivalent quotient (**TEQ**). The TEQ is calculated by summing the products of the concentrations of individual congener [PCBcongener] and their toxicity equivalency factor (**TEF**): **TEQ** = Σ [PCBcongener]×TEF]
Threshold	The lowest dose of a chemical at which a specified measurable effect is observed and below which it is not observed.
TL	Trophic Level, how high an organism is in the food chain
Toxic	A substance that is poisonous to an organism.
Toxic Pollutants	Materials contaminating the environment that cause death, disease. birth defects in organisms that ingest or absorb them. The quantities and length of exposure necessary to cause these effects can vary widely.
Toxic Substance	A chemical or mixture that may represent an unreasonable risk of injury to health or the environment.
Toxicant	A harmful substance or agent that may injure an exposed organism.
Toxicity	The quality or degree of being poisonous or harmful to plant, animal or human life.
Toxicity Assessment	Characterization of the toxicological properties and effects of a chemical, including all aspects of its absorption, metabolism, excretion and mechanism of action, with special emphasis on establishment of dose- response characteristics.
Toxicology	The science and study of poisons control.
Trophic Transfer	The process by which contaminants are accumulated in the **food chain**.
TSV	Tissue Screening Values are the level of chemical residues in tissues, below which it is

	unlikely that adverse effects will occur.
TRV	Toxicity Reference Values are point estimates of ecological effects for a given receptor (e.g. the dose or exposure level above which ecological effects can occur).
Turbidity	A measure of water cloudiness caused by suspended solids
µg	Microgram - one-millionth of a gram (0.000000035 oz.).)
µg/L	Micrograms Per Liter - one microgram of a substance dissolved in each liter of water. This unit is equal to **parts per billion** (**ppb**) since one liter of water is equal in weight to one billion micrograms.
UWC	The upper water column is the water above the **pycnocline**.
Uptake	The entrance of a chemical into an organism — such as by breathing, swallowing, or absorbing it through the skin — without regard to its subsequent storage, metabolism, and excretion by that organism.
Water Quality Criteria	The concentration of a constituent in water below which is not considered harmful to aquatic life
Zooplankton	Animal life of the **plankton**.

Photo by Keith Mille (keith.mille@MyFWC.com)
Florida Fish & Wildlife Conservation Commission

1. Executive Summary

1.1 Objective and Purpose

The purpose of this report is to assess the potential ecological risks from polychlorinated biphenyl (PCB) exposure associated with sinking the aircraft carrier ex-ORISKANY (CVA-34, Figure 1) to create an artificial reef off the coast of Pensacola, FL (Figure 2) within the Escambia East Large Area Artificial Reef Site (Figure 3). Sinking the vessel requires a risk-based disposal approval under 40 CFR 761.62(c) because the ship contains PCBs in solid materials such as electrical cabling, gaskets, rubber products, insulation, and paints that contain concentrations of polychlorinated biphenyls (PCBs) ≥ 50 ppm.

1.2 Technical Approach

Future risks from sinking the ex-ORISKANY were assessed using a prospective risk assessment model (PRAM, NEHC/SSC-SD 2006a) and a time dynamic model (TDM, NEHC/SSC-SD 2006b) developed to model the release, transport, fate, and bioaccumulation of PCBs leached from solid materials contained onboard the vessel. Using empirical leach rate data, developed from laboratory studies of PCB releases from shipboard solids under shallow-water artificial reef conditions (George et al. 2006), PRAM simulates the steady state concentrations of PCBs in the water and sediment around the reef and the bioaccumulation of PCBs within the food chain of the reef (NEHC/SSC-SD 2006a). The TDM simulates the abiotic accumulation from the release of PCBs from the ship for a two-year period from the time of sinking until the reef is fully developed and near steady-state conditions at the reef are achieved (NEHC/SSC-SD 2006b). This ecological risk assessment evaluates the results of the models to characterize potential toxicological risks from PCBs to ecological receptors that could reside, feed, and/or forage at the artificial reef.

This risk assessment only evaluates potential toxicological effects of exposure to PCBs and does not address the presence and physical structure of the artificial reef, which greatly influences the ecological processes present at site.

1.3 Vessel Preparation

In preparation for use as an underwater reef, the ex-ORISKANY underwent an extensive cleanup program in accordance with the draft Best Management Practices for Preparing Vessels Intended to Create Artificial Reefs (U.S. EPA and MARAD 2004). Prior to vessel preparation the amount of PCBs contained within solid materials onboard the vessel ranged from 377.5 Kg to 699.6 Kg (832.2 to 1542.3 lbs, average to 95% upper confidence level – UCL, Table 4, Pape 2004). Following the removal of 100% of the lubricants, 72.6% of the bulkhead insulation, 10% of the cabling, and 5% of the paints the total amount of PCBs remaining in solid materials onboard the vessel ranged from 327.79 to 608.85 Kg (722.7 to 1342.3 lbs, average to 95% UCL). More than 97% of the PCBs remaining on the vessel are associated with electrical cabling.

1.4 Exposure Assessment

The models simulate the fate and transport of PCBs along defined exposure pathways from the PCB containing materials onboard the ship to representative organisms that are likely to inhabit the artificial reef (Table 2, Figure 11). The model predictions provide 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 (Table 3). The model outputs (Table 2) were concentrations of PCB homologs in water, sediment, primary producers (phytoplankton and encrusting algae), primary consumers (copepod, bivalve, urchin, polychaete, and nematode), secondary consumers (herring, triggerfish, lobster, and crab), and tertiary consumers (jack, grouper, and flounder). Additional exposure points were the PCB concentrations in prey for sea birds (cormorant and herring gull), loggerhead turtles, bottlenose dolphins, and reef predators (sandbar shark/barracuda, Table 3, Figure 11).

The exposure assessment evaluated exposures from water-borne releases of PCBs in the interior of the ship to the lower and upper water column, into bedded sediment and pore water, and through the pelagic, benthic, and reef community food chains for both the first two years post sinking and the subsequent steady state exposure periods. The exposure assessment showed that PCBs accumulated at the highest levels under steady state conditions; the highest concentrations were predicted for the upper trophic levels of the reef community (grouper, triggerfish, crab, and urchin, Table 9). These species bioaccumulated the highest levels of PCBs through contact with water inside the vessel, which was the most important route of exposure to organisms on the reef. Compared to background PCBs levels estimated for the northeastern Gulf of Mexico, tissue concentrations predicted for the pelagic and benthic community were lower than background. Tissue concentrations for grouper, triggerfish, crab, and sea urchin from the reef community were within the range of background PCB values for the Gulf of Mexico.

Model performance was evaluated to assure that the model results were internally consistent, that the model predictions conformed to the physiochemical properties being modeled, and that results produced by the model were consistent with similar studies reported in the literature. While there was uncertainty about the results obtained from PRAM, the analysis showed that PRAM provides reasonable and plausible results that can be used to assess risks associated with the ex-ORISKANY.

1.5 Effects Assessment

The benchmarks selected to evaluate potential effects of PCBs to a broad range of reef-dwelling organisms included concentrations for water (W_B), sediment (S_B), and tissue residues of fish (T_{Fish}) and invertebrates (T_{Invert}). The tissue benchmarks were for the bioaccumulation critical value (B_{CV}), tissue-screening value (TSV), critical body residues (CBR) corresponding to the no observed effect dose (NOED) and the lowest observed effect dose (LOED) for a fish or invertebrate species. Dietary benchmarks (D_{PREY}) were also developed to assess dietary exposure from prey for herring gulls, cormorants, dolphins, loggerhead turtles, and sharks/barracuda (Table 10).

In the last decade, evidence has been mounting that some congeners are more toxic than others, especially the dioxin-like coplanar PCBs. The concentrations of these dioxin-like coplanar PCB congeners are expressed as the equivalent concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), the most potent dioxin congener (Van den Berg et al. 1998), determined from the toxicity equivalent quotient (TEQ). Benchmarks for dietary exposure of TEQs to gulls, cormorants, and dolphins were developed to address potential toxicity from these compounds. Benchmarks were also developed to evaluate potential effects of TEQ exposure to fish eggs and sac-fry larvae, the most sensitive life stages to TEQ exposure.

1.6 Risk Characterization

The risk characterization evaluated ecological risks for the first two years post sinking using the data obtained from the TDM coupled to PRAM, and for the subsequent years using the results of PRAM under steady state conditions. The characterization method used Hazard Quotients (HQ), the ratio of predicted concentrations to the appropriate benchmark. Two benchmarks were developed for each effect level to define the lower and upper bound of the threshold that may cause adverse effects (U.S. EPA 1998c), corresponding to the no effect levels and lowest effect levels, or acute and chronic water quality criteria for each applicable exposure pathway and assessment endpoint (Table 25).

1.7 Summary of Findings

The outputs of the models were used to evaluate PCB exposures to the pelagic, benthic, and reef communities as well as dolphins, sea birds, sea turtles, and shark/barracuda that may be attracted to feed and forage on the reef (Table 27). The risk characterization showed:

- Predicted sediment and water concentrations around the reef showed no indication of risk during the first two years post sinking or subsequent years.

- The Total PCB exposure levels predicted by the models showed no indication of risk to plants, invertebrates, fishes, sea turtles, and sharks/barracudas that could live, feed, and forage on the reef.

- The no effect threshold for Total PCB was exceeded for dietary exposure to dolphins, cormorants, and herring gulls indicating risk, but, because the assessment assumed that dolphins, cormorants, and herring gulls would be life-long residents of the reef and would obtain 100% of their food requirements from the reef, it is likely that actual exposures would be much lower.

- There was no indication of risk from TEQ exposure to dolphins, sea birds, or fish eggs and larvae.

- Contact with elevated PCB concentrations modeled for the internal vessel water was identified as the predominant route of exposure and trophic transfer of PCBs through the food web.

1.8 Uncertainty

The major sources of uncertainty were the assumptions and parameters used in the models, the applicability and sensitivity of the benchmarks used in the assessment, and uncertainty about the sources of PCBs on the vessel. Due to the conservative estimates used in this analysis, it is very unlikely that potential risks were under estimated.

1.9 Conclusions

The potential ecological risks of sinking the ex-ORISKANY were evaluated using model predictions of future PCB exposure levels in the environment surrounding the reef. The model predictions were judged to be plausible and reasonably good estimates of what would occur given that the other model assumptions and input procedures were also accurate. The ecological risk assessment showed that the risks of exposure from PCBs in tissues of organisms associated with the reef and in the diet of reef consumers are acceptable. Therefore, it is unlikely that PCBs released from sinking the ex-ORISKANY to create an underwater reef will harm the environment.

Photo by Keith Mille (keith.mille@MyFWC.com)Florida Fish & Wildlife Conservation Commission

2. Introduction

The purpose of this report is to assess the ecological risks associated with sinking the aircraft carrier ex-ORISKANY (CVA-34, Figure 1) to create an artificial reef off the coast of Pensacola, FL (Figure 2) within the Escambia East Large Area Artificial Reef Site (Figure 3). Sinking the ex-ORISKANY requires a risk-based disposal approval under 40 CFR 761.62(c) because the vessel contains PCBs in solid materials such as electrical cabling, gaskets, rubber products, and paints that contain concentrations of polychlorinated biphenyls (PCBs) ≥ 50 ppm.[1]. Under the Toxic Substance Control Act (TSCA), the U.S. EPA must make a finding of no unreasonable risk of injury to human health and the environment must be made before allowing disposal of PCB-contaminated material with concentrations ≥ 50 ppm. The human health (NEHC/SSC-SD 2006c) and ecological risk assessments (this document) use the results of a prospective risk assessment model (PRAM) developed to model the potential release of PCBs from solid materials contained on ex-Navy vessels (Goodrich et al. 2003, Goodrich 2004, NEHC/SSC-SD 2005a, b, 2006a, b) to assess the future risk of creating artificial reefs.

The technical approach and procedures used in this ecological risk assessment are based on the findings and recommendations for assessing ecological risks of sunken ships developed by a multi-agency REEFEX Technical Working Group. The REEFEX Technical Working Group consisted of representatives from the U.S. EPA, the U.S. Navy, the South Carolina Department of Natural Resources (SCDNR), Florida Fish and Wildlife Conservation Commission (FFWC), Florida Department of Environmental Protection (FDEP), Florida Department of Health (FDOH), and Escambia County, FL. Previously, the REEFEX Technical Working Group conducted retrospective human health (NEHC 2004) and ecological risk (Johnston et al. 2005a) assessments using data from the ex-VERMILLION artificial reef, a former Navy troop-transport ship (amphibious cargo ship LKA 107) sunk off the coast of South Carolina in 1987. The U.S. EPA Office of Pesticides and Toxic Substances (OPPTS), Office of Research and Development (ORD), Region IV, and the Science Advisory Board (SAB) Polychlorinated Biphenyl – Artificial Reef Risk Assessment (PCB-ARRA) Consultative Panel (U.S. EPA 2005b, c) reviewed an

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[1] "(c) Risk-based disposal approval. (1) Any person wishing to sample or dispose of PCB bulk product waste in a manner other than prescribed in paragraphs (a) or (b) of this section, or store PCB bulk product waste in a manner other than prescribed in Sec. 761.65, must apply in writing to: the EPA Regional Administrator in the Region where the sampling, disposal, or storage site is located, for sampling, disposal, or storage occurring in a single EPA Region; or the Director of the National Program Chemicals Division, for sampling, disposal, or storage occurring in more than one EPA Region. Each application must contain information indicating that, based on technical, environmental, or waste-specific characteristics or considerations, the proposed sampling, disposal, or storage methods or locations will not pose an unreasonable risk of injury to health or the environment. EPA may request other information that it believes necessary to evaluate the application. No person may conduct sampling, disposal, or storage activities under this paragraph prior to obtaining written approval by EPA. (2) EPA will issue a written decision on each application for a risk-based sampling, disposal, or storage method for PCB bulk product wastes. EPA will approve such an application if it finds that the method will not pose an unreasonable risk of injury to health or the environment". 40 CFR 761.62(c)

earlier draft of this report (Johnston et al. 2005b). This final report has been revised to address the comments and revisions recommended by the U.S. EPA and SAB reviewers (see Appendix A. Responses to Comments on the Draft Final Report).

2.1 Objectives

The objective of this ecological risk assessment is to assess the potential toxicological risk of PCBs that may be released from the ex-ORISKANY after sinking to create an artificial reef. The risk assessment does not address the ecological consequences of creating the reef itself, it is focused on characterizing potential toxicological risks of PCBs that may be released from the ship.

This assessment addresses the following risk management question:

- *Is it likely that sinking the ex-ORISKANY, which contains solid materials bearing PCBs, will pose an unacceptable risk to the environment?*

2.2 Approach

This ecological risk assessment uses the output from two models: a prospective risk assessment model (PRAM, NEHC/SSC-SD 2005a, 2006a) and a time dynamic model (TDM, NEHC/SSC-SD 2005b, 2006b) to simulate the release, fate, transport, and bioaccumulation of PCBs leached from solid materials contained onboard the vessel. The model outputs were used to characterize potential toxicological risks from PCBs to ecological receptors that could reside, feed, and/or forage at the artificial reef. The results and conclusions from the ecological risk assessment will be used to support risk management decisions about the potential beneficial reuse of ex-ORISKANY as an artificial reef.

The models use empirical estimates of PCB leach rates, developed from laboratory studies of PCB releases from shipboard solids under shallow water artificial reef conditions (George et al. 2005, 2006). The empirical leach rate data showed that there was a time varying release of PCBs for most of the shipboard solids tested between 0 - 2 yrs of leaching (George et al. 2006, Figure 4). The time varying release rates showed an initial “rinsing” or “wetting” behavior characterized by highly variable release rates (Region 1), followed by the maximum release rate (Region 2), and then, finally, a monotonically decreasing release rate that asymptotically approached steady state after about 2 yrs of leaching (Region 3, Figure 4).

Two time periods were modeled; dynamic conditions 0 – 2 yrs after sinking and steady state conditions two years after sinking. PRAM simulates steady state concentrations of PCBs in the water and sediment around the reef and the bioaccumulation of PCBs within the fully developed food chain of the reef that would occur 2 yrs following sinking with a constant release rate of PCBs (NEHC/SSC-SD 2006a). The TDM model simulates changing levels of PCB in abiotic media during the 0 – 2 yr dynamic release period. The abiotic concentrations predicted by TDM were also input into a version of PRAM modified to accept TDM inputs (TDM/PRAM) to simulate the accumulation of PCBs in a progressively developing food chain hypothesized to arise during initial colonization of the reef during the first two years after sinking (NEHC/SSC-SD 2006b). The output from TDM/PRAM and PRAM models provided the exposure point concentrations needed to evaluate ecological risks to the reef community and other ecological consumers that may feed and forage on the reef (Table 2).

The results of the models were evaluated to the extent possible to assure that they provided reasonable, albeit conservative, estimates of PCB concentrations in the environment following sinking of the ex-ORISKANY (see Appendix B: 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). No data are currently available to compare the model predictions to field data. Therefore the results and conclusions derived for this ecological risk assessment are based on the assumption that the modeled data are valid and representative of future conditions expected to occur at the artificial reef.

2.3 Technical Working Group Studies

Since 1996, joint Navy and EPA Technical Working Groups have been working together as a team to gather data and perform technical analyses to address concerns about the potential release of PCBs from ex-Navy ships sunk in deep ocean during weapons testing exercises (SINKEX) and from ex-Navy ships sunk in shallow coastal waters to create artificial reefs (REEFEX). A number of studies were initiated, performed, and reviewed by working group participants including:

- A study of the potential human heath risk to active duty crew and shipyard workers exposed to solid materials containing PCBs in the performance of repair and decommissioning activities (Larcom et al. 1996), which showed that the level of risk for occupational health was acceptable.

- A modeling study on the release and fate of PCBs released from a Navy ship sunk in the deep ocean environment (Richter et al. 1994);
- A database of PCBs in solid materials present on Navy Ships (JJMA 1998, JJMA 1999).
- A human health and ecological risk conducted with data collected from the deep water SINKEX study of the ex-AGERHOLM (Gauthier et al. 2002, 2006);
- A detailed literature review of PCB levels measured in the sediments and biota of the deep ocean environment (Gauthier et al. 2005)
- A study conducted by the South Carolina Department of Natural Resources (SCDNR) of sunken vessels used to construct artificial reefs along the coast of South Carolina (Martore et al. 1998);
- Leachrate studies conducted to determine the leaching rate of PCBs from shipboard materials containing PCBs under shallow water conditions (George et al. 2005, 2006) and deep ocean conditions (high pressure and low temperature, George 2001a)

More recently, the REEFEX Technical Working Group developed information about assessing risks from ex-Navy ships sunk to create artificial reefs by conducting retrospective human health (NEHC 2004a) and ecological risk (Johnston et al. 2005a) assessments of the ex-VERMILLION sunk off the coast of South Carolina in 1987.

The anticipated benefits of building reefs include enhancing ecological resources by increasing the amount of productive hard-bottom habitat, using artificial reefs as marine protected and conservation areas, or using artificial reefs to provide alternative reefs for recreational fishing and diving so that natural reefs can be protected and conserved (Bell 2001). Artificial reefs can also provide economic benefits to local communities by increasing tourism and commercial activities associated with fishing and diving on the reef (Jones and Welsford 1997, Enemark 1999). A study by the Rand Corporation (Hess et al. 2001) concluded that shallow water reefing would be the most ecologically responsible and economically feasible option for disposing of decommissioned warships. The report estimated that more than $1.5 Billion of taxpayer dollars would be saved if decommissioned ships could be "reefed" instead of "scrapped" (San Diego Oceans Foundation 2002a). In a follow up report, the authors predicted that the shallow reef disposal option would generate enough tax revenue to cover the costs of a 20-year reefing program within 12 years (Hynes et al. 2004).

Up to 12 ex-Navy warships are being considered for use in creating artificial reefs.[2] As of December 12, 2005, the Navy's inventory lists 8 ships under consideration for reefing http://peos.crane.navy.mil/reefing/inventory.htm. Various standards and guidelines exist for reefing activities (Stone 1985). Canada has developed cleanup guidelines and standards for vessel disposal (Environment Canada 2001a, b), and environmentally based best management practices for preparing vessels to be sunk as artificial reefs is under development in the United States (U.S. EPA and MARAD 2004). By determining the potential ecological and human health risks, better decisions can be made to effectively manage the risks associated with creating reefs with ex-warships.

2.4 About this Report

This report follows the structure recommended by the U.S. EPA Risk Assessment Forum (U.S. EPA 1998d). Following the Executive Summary (Section 1) and Introduction (Section 2) the Problem Formulation (Section 3) identifies the contaminants of concern (PCBs), integrates the available information on environmental conditions, background levels of PCBs, and ship preparation procedures, identifies the assessment endpoints and receptor species, and presents the conceptual model and exposure pathways to be evaluated in the risk assessment. Section 4 provides the assessment of exposure conditions expected at the reef, Section 5 presents an assessment of potential effects from PCBs and the development of ecological risk benchmarks, and Section 6 identifies the risk evaluation criteria and characterizes the potential ecological risks based on the exposure and effects data. Section 7 discusses the major sources of uncertainty and Section 8 provides a summary of the conclusions and recommendations. Section 9 provides the bibliography of references cited in the report and the Tables and Figures are provided at the end of the report. The appendices include the responses to comments received from EPA and SAB reviewers of the Draft Final Report (Appendix A), an evaluation of PRAM (Version 1.4c) to predict the bioaccumulation of PCBs in the food chain (Appendix B), the results of a search of the Environmental Residue Effects Database (ERED) for tissue residue effects from PCBs

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[2] Minutes of the SAB Polychlorinated Biphenyl - Artificial Reef Risk Assessment (PCB-ARRA) Consultative Panel Meeting, August 1-2, 2005. http://www.epa.gov/sab/05minutes/pcb_artificial_reef_08_01_05_minutes.pdf

(Appendix C), the results of tissue concentrations and hazard quotients (HQs) calculated for short-term and long-term ecological risks (Appendix D), and the results of a quantitative uncertainty analysis (Appendix E). A glossary of terms, acronyms, and abbreviations is also provided.

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Photo by Keith Mille (keith.mille@MyFWC.com)
Florida Fish & Wildlife Conservation Commission

3. Problem Formulation

3.1 Contaminant of Concern

Banned from manufacturing and distribution since 1978, polychlorinated biphenyls (PCBs) are highly bioaccumulative and the U.S. EPA has developed a strategy for protecting human health and the environment from exposure to PCBs and other persistent, bioaccumulative, and toxic (PBT) pollutants (U.S. EPA 1998a). Used extensively in the manufacturing of electrical capacitors, carbon-less copy paper, fire retardants, and other applications that required products with high heat resistance, elasticity, and durability, many PCBs have been improperly disposed resulting in an almost ubiquitous contamination of the environment. In the early 1990s it became clear that PCBs were also in a wide assortment of solid materials that were used onboard U.S. Navy ships. These materials included electrical cables, rubber gaskets and hanger mounts, seals, insulating materials, foam rubber, and paints. Oils and greases were also found with high concentrations of PCBs present. It is impossible to know whether these materials were all manufactured with PCBs or if they became contaminated with PCBs during their life cycle or both.

The very properties that made PCBs so desirable for industrial applications are the same properties that cause PCBs to be resistant to degradation and to accumulate in the environment. PCBs are a mixture of compounds that consist of ten homologue groups (mono- through deca-biphenyl) and 209 different PCB congeners (See EPA Region V web site for PCB Species Identification, Barney 2001). PCBs were originally sold as Aroclor mixtures, or blends of PCB congeners manufactured to meet specified percentage levels of chlorination. In PRAM and TMD each homolog represents the contribution of all the congeners within that group and the amount of Total PCB was obtained as the sum of the individual homolog compounds:

$$\text{Total PCB} = \Sigma\ \text{HOMOCL}_i \qquad [1]$$

where HOMOCL_i = Concentration of homolog (i)
i = Number of chlorines attached to the biphenyl molecule

The physicochemical properties of PCBs govern their behavior in the environment. Key properties include solubility in water, vapor pressure, octanol-water partition coefficient (K_{OW}, also referred to as Log P), bioconcentration factor (BCF), and degradation rate. Relative to other organic compounds such as aliphatic hydrocarbons, polycyclic aromatic hydrocarbons, and nonchlorinated pesticides, PCBs have much lower solubility in water, low vapor pressure (semivolatile), higher K_{OW}, very high BCF, and very low degradation rates (MacKay, Shiu, and Ma 1992). Because PCBs are very hydrophobic (readily come out of solution), persistent, and highly lipophilic (partition into lipids and organic carbon) they readily adsorb onto particles and build up in the food chain (bio- and geoaccumulation, Froescheis et al. 2000). The concept of fugacity, or the mass transfer of a chemical from one compartment (atmosphere, hydrosphere, geosphere, or biosphere) to another as a function of its chemical properties is usually used to model the behavior of PCBs in the environment (McKay, Shiu, and Ma 1992, Connolly et al. 2000).

PCBs have been implicated as toxic agents capable of affecting reproduction and endocrine function in birds, fish, and mammals (Johnson et al. 2000). Although not necessarily toxic at low concentrations, their capacity to accumulate in the environment means that organisms at higher trophic levels (higher in the food chain) are more at risk of toxic exposure to PCBs (Barnthouse, Glaser, Young, 2003). Recent evidence suggests that some PCBs have dioxin-like properties that can lead to carcinogenic effects in mammals including humans (U.S. EPA 1996b).

3.2 Integration of Available Information

3.2.1 Environmental Conditions

The proposed location of ex-ORISKANY Memorial Reef is within the Army Corps of Engineers permitted Escambia East Large Area Artificial Reef Site (EELAARS) about 22.5 mi (19.6 nm, 36.2 km) from Pensacola, FL (Figure 2). The Florida Fish Wildlife Conservation Commission (FFWCC) selected this site and based on:

(1) The exclusion of all active oil and gas lease blocks as requested by the U.S. Department of Interior's Minerals Management Service;

(2) A request by the U.S. Coast Guard to locate the sites at least two nautical miles away from any navigational fairway;

(3) A Coast Guard requirement to provide for a navigational clearance of at least 50 feet;

(4) Florida Department of Environmental Protection (FDEP) requirements to avoid known hard/live bottom areas and sea grass beds,

(5) The shrimping industry's requirements to avoid historic shrimp trawling areas, and

(6) The ability to provide reasonable accessibility to the recreational fishing public (FFWCC 2004).

The sink plan (NAVSEA 2005b) states that the ex-ORISKANY (CVA-34) will be sunk in approximately 64 m (204 ft) of water within the Army Corps of Engineers permitted Escambia East Large Area Artificial Reef Site. The ocean floor is light brown sandy sediment with no live or hard bottom elements and is within the area managed by the FFWCC Artificial Reef Program[3].

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[3] Permit files and database records of the Florida Fish and Wildlife Conservation Commission Artificial Reef Program, 2590 Executive Circle East, Suite 203H Tallahassee, FL 32301. Provided by Jon W. Dodrill, Environmental Administrator, FWC Division of Marine Fisheries. (email Jon.Dodrill@fwc.state.fl.us. Ph. 850.922.4340 x 209)

There are no commercial fishing/trawling grounds, military restricted/testing areas, marine parks, marine reserves, aquatic preserves, and marine sanctuaries within 10 nautical miles of the EELAARS. According to the U.S. Department of Interior's Minerals Management Service, there is no known oil or gas submerged transmission crossings within the EELAARS and the site is over 2 nautical miles from the charted commercial fairways into Pensacola Bay. There is no direct evidence from the literature or through historic knowledge of local charter fishermen of the presence of any extensive hard bottom areas within the EELAARS and the only submerged grasses in northeastern portion of the Gulf of Mexico are within Escambia Bay, more than 23 nautical miles shoreward of the proposed sinking location. While small areas of isolated low relief, ephemeral hard bottom may exist within the EELASS, this type of live bottom is not well developed, contains no hard corals and is subject to burial and re-emergence as part of natural storm driven cycles (FFWCC 2004). Reef building activity in the EELAARS has been conducted by County, state, and federally funded public reef building efforts. These include artificial reefs constructed of concrete materials and modules, several steel hulled vessels, a decommissioned energy platform, and numerous public, private, and refugia reefs within the area (FFWCC 2004). Before sinking the ex-ORISKANY, observations from drop down cameras and sediment samples from Ponar grabs will be used to verify the bottom conditions. Extensive mapping of bottom topography within the area has revealed no bottom relief indicative of any developed reef structure. Little subsidence of artificial reef materials has been noted on multiple dives in the area in recent years in the 24 – 33.5 m (80-110 ft) depth range (FFWCC 2004).

3.2.2 Physical, Geological, and Biological Environment

The following information was excerpted from the State of Florida's letter application to obtain the ex-ORISKANY (FFWCC 2003):

> The Gulf of Mexico seafloor off northwest Florida consists of a quartzite sand veneer over a limestone substrate and is generally flat with a less than 5% slope to the south (offshore) towards De Soto Canyon. The specific site was chosen for the proposed artificial reef due to water depth and lack of presence of natural limestone rock outcroppings. The seafloor within this region of the Gulf of Mexico (GoM) was described by McBride et al. (1999) as Perdido Shoal, a relict deltaic accumulation of sand, presumably formed during a historic (probably Holocene) period of lower sea level. The proposed site for the USS Oriskany Memorial Reef is southeast of South Perdido Shoal. The keel of the vessel will rest along a north-south line at a depth of 212 ft [64.6 m]. Due to the depth of the deployment location, no sediment depth probes have been obtained at the exact site but sediment probes taken in other areas of the Escambia East LAARS have indicated sand of varying depths over the limestone shelf. Typically, the sand is at least several feet thick. At isolated locations, the overlying sand veneer has been removed, forming rock outcroppings that provide natural reef habitat. Because the seafloor depth is greater than 200 ft [61 m], no substantial sand transport is expected to occur at the proposed artificial reef site. Although we expect the Oriskany to settle several feet into the seafloor, the extreme vertical profile of the ship would prevent substantial loss of reef habitat by subsidence or burial. Other large artificial reef structures in the area have not been negatively impacted by subsidence. As required by the reauthorization of the original Corps permit, the minimum navigational clearance will be 55 ft [16.8 m] at

Mean Lower Low Water (MLLW) and greater at Mean High Water. The maximum tidal range at the proposed site is less than two feet [0.6 m].

Average monthly and annual wind speed, wave height, and other meteorological and oceanographic data in the vicinity of the proposed artificial reef site are measured by permanently moored buoys (NOAA NBDC). At buoy #42040 (73.7 mi [64 nm, 118.7 km] south of Dauphin Island, AL), average wind speed is less than 10 knots [12 mph, 19 km/h] in summer, and less than 15 kn [17 mph, 28 km/h] [during] September – April. Annual average wind speed at Pensacola is 7.4 knots [8 mph, 13 km/h] (NOAA, 2003). Wave data from buoy #42040 indicate that wave heights average 2-3 ft [0.6-0.91 m] in summer, and 3-4 ft [0.91-1.22 m] in winter (NOAA NBDC).

Water currents at the proposed site are generally very mild. Fringes and eddies of the Loop Current (easterly in summer, westerly in winter), wind and tidal action are the predominant sources of horizontal water movement in the northern Gulf of Mexico. Wind driven currents at the site are usually slight (<1/2 kn [0.6 mph, 0.85 km/h]) and dissipate with depth. Tidal currents are likewise weakened due to the water depth (>200 ft [> 60.1 m]) and distance from estuary outlets (>20 nm [23 mi, 37 km]]). Occasionally, horizontal water movement may increase in the area for brief periods (up to several days), possibly caused by eddies from the Loop Current (Gore, 1992).

The Pensacola area experiences irregularly occurring large-scale weather events such as tropical storms and hurricanes, typically occurring from July through October. However, based on the depth of water in which the vessel is proposed to be placed, hydrodynamic forces acting on the sunken vessel are anticipated to be reduced compared to placement at shallower depths during hurricane events. Based on a site-specific stability analysis (Paul Lin Associates Stability Analysis Software; Factor of Safety = 1.25), the maximum wave heights modeled to occur during a 50-year storm event in the vicinity of the proposed sinking site are 25.9 feet [7.9 m] with a period of 10.2 seconds (Corps of Engineers Wave Hindcast data). The site-specific stability analyses for both a broadside and head-on scenario indicate that the ship will remain stable during a 50-year storm event. Therefore, orientation of the ship is not a critical issue for reef stability. This level of stability exceeds that specified by the FWC Administrative Rule 68E-9.004(4), F.A.C., which only requires demonstrated stability for a 20-year storm event. The model stability calculations are extremely conservative. The model applies a 1.25 safety factor to all calculations. In addition, the model does not account for the suction forces applied to the reef resulting from it settling into the substrate, which for a vessel of this size, will add significant additional resistance to rolling and sliding. Also, uplift wave forces acting on the flight deck are a major factor in vessel stability. Calculations utilize the maximum beam for the vessel, while the flight deck actually narrows as one moves towards the bow and stern from the angled deck.

Miami-Dade County Department of Environmental Resource Protection (DERM) conducted two independent additional stability analyses for the Oriskany for 190 [57.9] and 215 feet [65.5 m] depths off Southeast Florida. One stability analysis utilized the same FWC state model stability analysis software utilized for the proposed Oriskany Escambia LAARS sinking location. The second model, the Miami-Dade DERM model was a more refined version of the state model. Both models evaluated the stability of the Oriskany in 20, 50 and 100-year storm return intervals. The DERM model results, based on a 24.19 ft [7.4 m] wave height with 9 sec wave interval, determined the Oriskany would be stable at both 215 feet [65.5 m] and 190 feet [57.9 m] if oriented broadside during a 50-year storm event. As with the State model, the reef was shown to be stable during a 100-year storm event if oriented bow into the anticipated general direction of the storm generated waves. The model also indicated resistance to overturning in a 100-year storm event, and resistance to sliding in a 50-year storm event in Southeast Atlantic waters. Based on similar wave criteria, these results are expected to apply to the Escambia East LAARS.

A study was performed on artificial reefs in an Escambia County artificial reef site after hurricanes Erin and Opal (Turpin and Bortone, 2002). Water depths in the study area were much less than at the proposed USS Oriskany Memorial Reef site (85 ft vs. 212 ft [25.9 vs 64.6 m]).

Although small, low-density artificial reef materials (e.g., steel frame shipping boxes and automobile bodies) were displaced by wave hydrodynamic forces, none of the steel barges and tugboats were displaced by *Hurricane Opal* (Saffir/Simpson Category IV). (Note: *Hurricane Opal* diminished in strength to a Category III by landfall, however, seas generated by the storm's Category IV winds impacted the artificial reef site). – Excerpted from FFWCC (2003).

3.2.3 Federally Listed Species and Critical Habitat

The following are the federally listed species that may be present within the Gulf of Mexico:

Federally Listed Species[4]:

Listed Species	Scientific Name	Status	Date Listed
Blue whale	*Balaenoptera musculus*	Endangered	Dec. 2, 1970
Finback whale	*Balaenoptera physalus*	Endangered	Dec. 2, 1970
Humpback whale	*Megaptera novaengliae*	Endangered	Dec. 2, 1970
Sei whale	*Balaenoptera borealis*	Endangered	Dec. 2, 1970
Sperm whale	*Physeter macrocephalus*	Endangered	Dec. 2, 1970
Green sea turtle	*Chelonia mydas*	Threatened	July 28, 1978
Hawksbill sea turtle	*Eretmochelys imbricate*	Endangered	June 2, 1970
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered	Dec. 2, 1970
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	June 2, 1970
Loggerhead sea turtle	*Caretta caretta*	Threatened	July 28, 1978
Gulf sturgeon	*Acipenser oxyrinchus desotoi*	Threatened	Sept. 30, 1991
Smalltoothed sawfish	*Pristis pectinata*	Endangered	Apr. 1, 2003

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[4] Endangered and Threatened Species and Critical Habitats under the Jurisdiction of NOAA Fisheries. http://sero.nmfs.noaa.gov/pr/pdf/Gulf%20of%20Mexico.pdf. March 8, 2004.

The Offshore Environmental Assessment (OEA) prepared for sinking the ex-ORISKANY determined the following (NAVSEA 2005a):

> The biological resources in the vicinity of the site are characterized by habitats typical of many locations with sandy substrates in the northeastern Gulf of Mexico region. The area includes minimal coverage with live bottom habitats including soft corals and other reef species that may be present on limestone outcroppings that cover approximately three percent of the sea floor. However, FWCC has identified that the closest hard/live bottom outcropping is approximately 3,600 ft [1097.3 m] from the proposed site.
>
> Fish Species: Spanish mackerel, red drum, jack crevelle, bonito, tarpon, speckled trout, red snapper, cobia, shark, black drum, sheephead, and flounder occur offshore of Florida and are important for fishing in the vicinity of the site. The most commercially and recreationally important fish species in the vicinity is the red snapper according to the FWCC. Shrimp and menhaden are also commercially important in the vicinity. The LAARS area currently has 24 manmade artificial reef locations that provide hard substrate materials for reef dwelling fish species. However, the closest artificial reef location is more than 1.5 nm [1.7 mi, 2.7 km] from the proposed site. Protected habitats: Based on review of sources information available from NOAA and the OPIS Mapping Tool, no protected areas or critical habitat areas are listed as Marine Protected Areas in the eastern Gulf of Mexico region that includes the proposed site.
>
> FWCC and ECMRD indicated that live bottom benthic habitats in the vicinity of the proposed site could include the presence of soft corals, non-reef building stony corals, sea fans, sea whips, and sponges. Outcroppings do not include tropical hard coral areas and are ephemeral in nature based on shifting sediments during storm events. Live bottoms attract other species such as sea turtles and mammals. The closest limestone outcropping was identified 3,600 ft from the proposed site.
>
> In the offshore waters of the northern Gulf of Mexico, up to 29 marine mammal species may occur, including seven mysticetes, 21 odontocetes, and one exotic pinniped. This listing is based on an extensive review of sightings and stranding reports for the Gulf of Mexico (Jefferson and Schiro, 1997). The sperm whale is the only endangered cetacean likely to occur in the vicinity in the site. There is a resident population of sperm whales in the northern Gulf of Mexico.
>
> Five species of sea turtles may occur in the vicinity of the proposed site location. All are protected under the Endangered Species Act (ESA). The hawksbill sea turtle (*Eretmochelys imbricato*), Kemp’s Ridley sea turtle (*Lepidochelys kempii*), and leatherback sea turtle (*Dermochelys coriacea*) are endangered species. The loggerhead sea turtle (*Caretta caretta*) is a threatened species. The Atlantic green sea turtle (*Chelonia mydas*) is threatened, except for the Florida breeding population, which is endangered.
>
> – Excerpted from NAVSEA (2004, pp 3-2 to 3-3).

3.2.4 Background Levels of PCBs

Ubiquitous contamination of PCBs is present in virtually every environment (Tilbury et al. 2002, Froescheis et al. 2002, Looser et al. 2002, Johnson et al. 2000). Concentrations of PCBs in ecological systems that vary greatly across large regions have been reported from the Great Lakes (Jackson et. al 2001), Hudson River and New York Bight (Barnthouse et al 2003), to California (Froescheis et al. 2000) and the Pacific Northwest (West et al. 2001). An explicit definition of background and reference data developed before the assessment can help provide a context for interpreting the results of risk investigations (Judd et al. 2003). Background concentrations of PCBs are PCBs that are present in the environment due to processes, sources, and human activities that are not related to releases that will occur at the proposed artificial reef site (CNO 2004, BMI et al. 2003).

An important source of background data available for the assessment is data reported as part of the U.S. EPA's Environmental Monitoring and Assessment Program (EMAP) national monitoring program. One of the more advanced monitoring programs is the coastal and estuarine monitoring program. Data available from these studies can provide information that can be used to evaluate contaminant trends in biota and develop an overall assessment of the environmental conditions in the various regions of the US (Figure 5). Although EMAP is focused on coastal areas and estuaries, which can have relatively high levels of pollutants, the sample program also included many pristine and unimpacted locations as well (Hyland et al. 1998).

Regional background data were evaluated to assess the current levels of PCBs in marine biota within coastal areas of the Gulf of Mexico and SE US. EMAP data available for the Louisianan and Carolinian Provinces through the EMAP website (Figure 5) were used to evaluate trends in PCB contamination levels in coastal fishes (Atlantic croaker — *Micropogonias undulates*, spot — *Leiostomus xanthurus*). In addition, some data were also available from the Florida Fish and Wildlife Research Institute (FFWRI 2004) Inshore Marine Monitoring and Assessment Program (IMAP) for 3 fish samples (spot, sea trout, and sea robin) collected from coastal areas near Pensacola, FL.

In the EMAP and IMAP programs 18 PCB congeners were quantified in the tissue and sediment samples (Wade et al. 1993). Total PCB was calculated as (T.L Wade, Geochemical and Environmental Research Group, Texas A&M University, personal communication[5]):

$$\text{Total PCB} = 2.19 \times \text{sumPCB} + 2.19 \qquad [2]$$

where sumPCB = the sum of the measured congeners (ng/g dry weight)

The Total PCB concentrations measured in Atlantic croaker from the Louisianan Province averaged 0.01 mg/Kg wet weight (range 0.001 – 0.217) and the concentrations of PCBs measured in Atlantic croaker from Floridian waters averaged 0.009 mg/Kg wet weight range (0.001 – 0.071) (Table 1). In general, similar levels of PCBs were measured in fish sampled from

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[5] The equation for total PCB (tPCB = 2.19sumPCB + 2.19) was obtained by NOAA's Status and Trends Program from a regression of empirical data from samples that were analyzed for both individual congeners (sumPCB) and total aroclors (tPCB) (NOAA 1991).

the SE U.S. with the highest levels being reported from Texas, Louisiana, Florida, and the Carolinian Province (Figure 6).

3.2.5 Ship Preparation

Commissioned in 1950, the U.S.S. ORISKANY (CVA 34), an 888-ft (270.7 m) aircraft carrier, served during the Korean and Vietnam Wars. She was decommissioned in 1976 (DON 2001). In preparation for use as an underwater reef the ex-ORISKANY underwent an extensive cleanup and preparation program in accordance with the draft Best Management Practices for Preparing Vessels Intended to Create Artificial Reefs (U.S. EPA and MARAD 2004). Vessel preparation involved removal of fuels, oils, loose asbestos containing material, capacitors, transformers or other liquid polychlorinated biphenyl (PCB) components, batteries, HALON, mercury, antifreeze, coolants, fire extinguishing agents, black and gray water, and chromated ballast water (NAVSEA 2005a, Figure 7). Due to the presence of PCBs found in the wooden flight deck and underlayment, much of flight deck and underlayment was removed and disposed of (Figure 8). Before vessel preparation the amount of PCBs contained within solid materials onboard the vessel were estimated to range from 377.5 Kg to 699.6 Kg (832.2 to 1542.3 lbs, average to 95% upper confidence level – UCL, Table 4, Pape 2004). Following the removal of 100% of the lubricants, 72.6% of the bulkhead insulation, 10% of the cabling, and 5% of the paints the total amount of PCBs remaining in solid materials onboard the vessel ranged from 327.79 to 608.85 Kg (722.7 to 1342.3 lbs, average to 95% UCL, Figure 9). More than 97% of the PCBs remaining on the vessel are associated with electrical cabling.

The leach rates obtained from the leachrate study (George et al. 2005a,b, 2006) were used to model the release of PCBs from the solid materials. The time-varying release rates over the first two years following sinking were used in the TDM model (NEHC/SSC-SD 2006b). The steady state release rate was simulated in PRAM using the upper bound estimate of the release rate at two-years if the homolog data indicated a statistically significant regression between time and release rate, otherwise the maximum observed leach rate was used (NEHC/SSC-SD 2006a). The fraction of PCBs in the materials on the ex-ORISKANY were estimated using a detailed statistical analysis of the data reported in Pape (2004) to derive an estimate of the 95% UCL of the source material (see Section 3.2, Table 10, and Figure 11 of NEHC/SSC-SD 2005a). The loading rate was obtained by multiplying the grams of PCB contained within each solid by the solid-specific leach rate observed for each homolog, and by summing, the amount of total PCBs released in ng PCB per day (Table 5, NEHC/SSC-SD 2005a, b). Because the leach rates measured for homologs in bulkhead insulation were much higher than the other materials, the bulkhead insulation will leach proportionally more PCBs than the other materials. In fact, vessel cleanup significantly reduced the amount of PCBs that could be released by removing the majority of bulkhead insulation present on the ship (Figure 9). The electrical cabling which accounts for the vast majority of PCBs present have a very low leach rate, so electrical cabling only contributes about 10% of the PCBs expected to be released at steady state.

3.3 Assessment Endpoints and Receptor Species

An assessment endpoint is “an explicit expression of the environmental value to be protected, operationally defined as an ecological entity and its attributes” (U.S. EPA 1998d). The assessment endpoints are valued ecological entities that are the focus of risk-management actions (U.S. EPA 2004a). Assessment endpoints usually cannot be directly quantified (Suter 1993, U.S. EPA 1992). Instead, data on exposure levels and information that relates the exposure to known effect levels are needed to perform the risk assessment (U.S. EPA 1998d, 2004a). For the ecological system under consideration, primary exposure to PCBs and indirect exposure through bioaccumulation of PCBs in the food chain can occur to the pelagic, benthic, and reef communities and as well as other ecological consumers that could be attracted to the abundance of food at the reef.

The assessment endpoints defined for this risk assessment are the growth, survival and fecundity of marine organisms that make up the pelagic, benthic, and reef communities of the reef as well as growth, survival, and fecundity of reef consumers such as dolphins, birds, sea turtles, and sharks that may be attracted to feed and forage on the abundance of food at the reef (Table 3). The risk hypothesis to be evaluated is:

- *Will PCBs that are expected to leach from the ex-ORISKANY cause adverse toxicological effects to ecological receptors that could reside, feed, and/or forage at the artificial reef through water, sediment, and food chain exposure pathways?*

Receptor species, or representative species of a class of organisms, were selected to assess PCB exposure to the species that comprise the reef community (Table 3). The receptor species used in this risk assessment were selected to represent species found at the reef as well as other predators such as sharks, barracuda, sea turtles, sea birds, and dolphins that may be attracted to feed on the abundance of food present at the reef. Based on the exposure and effects data that were available or could be inferred, the receptor species were assumed to be sensitive to PCB exposure. Because this risk assessment was concerned with evaluating toxicological risks associated with exposure to PCBs (especially PCBs migrating through the food chain), the primary ecological effects to the assessment endpoints evaluated were survival, reproduction, and individual growth and development. Evaluating ecological effects to other valued ecological entities, such as species diversity, primary productivity, or aquatic populations was possible only to the extent that the benchmarks (see Section 5.1) were also protective of those attributes. This risk assessment only evaluates the potential effects of contaminant exposure and does not address the presence and physical structure of the artificial reef, which greatly influences the ecological processes present at site.

3.3.1 Ecological Communities

The ecological communities associated with the artificial reef are the pelagic community, the benthic community, and the reef community. The pelagic community is composed of open water and mid-water species that could be attracted to the reef but spend most of their life in the water around the reef. The benthic community includes demersal fish and invertebrates that are closely associated with the bottom sediments around the reef. The ecological community associated with the reef includes the organisms that live on and within the reef itself. Many reef organisms spend most of their life on the reef, others may migrate over vast distances between reefs, and others may be larval or juvenile life stages of bottom dwelling organisms that will eventually settle out of the water column onto the reef before reaching maturity. The communities that develop on the ex-ORISKANY will probably be similar to natural assemblages that are present on natural reef structures (Weaver et al. 2002, Perkol-Finkel et al. 2005) and other artificial reefs (Patterson and Dance 2005) and oil platforms (MMS 2002) found within the northern Gulf of Mexico. Exposure to the reef community occurs from water-borne contaminants and/or contaminated sediment, which may accumulate on the reef, and to contaminants that accumulate in the food chain (Figure 10). Based on the life history and feeding behavior of different classes of reef organisms, there will be different exposure scenarios for the pelagic, benthic, and reef communities associated with the reef.

The ship will be sunk in the western Florida estuarine-influenced area of the warm-temperate Gulf of Mexico (Yanex-Arancibia and Day 2005). This hydrogeographic area is influenced by surface and groundwater discharges from the rivers of western Florida and the panhandle extending to Alabama and Mississippi. The western Florida shelf is a broad shallow area primarily consisting of carbonate sediments that accumulated from the deposition of microscopic skeletons and tests over millions of years (Texas A&M 1983). The biological organisms present are influenced by the transport of tropical species north from the Caribbean Sea by an anticyclonic loop current that enters the Gulf of Mexico through the Yucatan Channel and exits through the Straights of Florida (Texas A&M 1983). While the western Florida shelf off Pensacola is too far north and therefore too cool to support the growth of corals, many tropical species are well represented within the region (Texas A&M 1983, Weaver et al. 2002, Patterson and Dance 2005, Wilson et al. 2002). Studies of the continental margin along the Mississippi and Alabama coast (Brooks and Giammona 1998) revealed diverse habitats including sandy soft bottom, wave field ridges, patchy hard bottom, boulder fields, hard bottom areas, and low (depressions), moderate (< 15 m relief), and high (> 15 m relief, including oil platforms) topographic features.

The community structure and trophic ecology of fishes on natural pinnacle reefs located in the northeastern Gulf of Mexico at 60 –110 m depth about 50 miles off the coast of Florida and Alabama, has been the subject of detailed study since 1998 (Weaver et al. 2002). The study has documented 159 species of fish associated with the pinnacles reef including 88 species of obligate reef fishes (fish that need the reef structure to survive) and 32 species of facultative reef-associated fishes, which inhabited the reef top, reef crest, reef face/slope, reef base, talus zone, and soft bottom habitats (biotopes) present at the reef (Weaver et al. 2002). Interestingly, Weaver et al. (2002) reported that various species of Anthias (small bass-like planktivorous fishes) were numerically dominate at the reef and may provide an important route of energy transfer from the pelagic to deep reef fish community by their foraging in the water column and being preyed on by reef-dwelling fishes. The numerical dominance of medium to small planktivorous reef fish may be due to the removal of larger piscivores by increased fishing pressure in northern Gulf of Mexico in recent years (Weaver et al. 2002). A quantitative food web constructed from the analysis of gut contents showed the relative importance of food energy obtained from reef and "subsidized" from prey obtained from surrounding benthic and pelagic habitats (Weaver et al. 2002).

3.3.1.1 Primary Producers

Assuming light can penetrate to the depth of the reef, phytoplankton, benthic diatoms, encrusting algae, and other marine plants will be present on the reef. The phytoplankton that will be present in the euphotic zone of the water column around and over the reef and encrusting algae growing on the reef form the basis of the reef food chain. The primary producers can be exposed to contaminants in the water column and to contaminants that may come into contact with roots and holdfasts of marine macro flora, if present. Exposure can also occur through direct contact if the plants come into direct contact with the materials containing PCBs. Water column benchmarks are based on water quality criteria, which have been developed to be protective of aquatic species including phytoplankton and encrusting algae. Receptor species used to evaluate exposure to primary producers were phytoplankton (diatoms) and encrusting algae (Rhodophyta – red algae). Contaminant concentrations estimated for water column exposures were used to assess ecological risk to primary producers of the reef (i.e. water column benchmarks are protective of both plants and animals).

3.3.1.2 Primary Consumers

Primary consumers on the reef include zooplankton, epifauna, infauna, and grazing fish. Zooplankton, the tiny crustaceans, mollusks, and other larval vertebrates and invertebrates that feed on phytoplankton and detritus are a key link in the reef food chain. Primary consumers also include other water column grazers such as pelagic and midwater bait fishes that feed primarily on phytoplankton. Zooplankton and other grazers can be exposed to contaminants in the water column, suspended sediments, and bedded sediments. The reef community includes a wide diversity of benthic and epibenthic invertebrates that live on, below, and above the reef. If sedimentary deposits are present, benthic invertebrates that live by burrowing and feeding in the sediment and foraging along the bottom will colonize the sediment. Benthic organisms are directly exposed to any contaminants that become attached to particles and are deposited in the sediment. Epibenthic invertebrates live on the surface of the bottom and on rocks, ledges, and artificial substrates sitting on the bottom. Many epibenthic invertebrates are sessile organisms, which are attached to hard surfaces for the majority of their life span. Epibenthic organisms are exposed to contaminants present in the water column, contaminants present on the surface of the substrates to which they are attached, and contaminants accumulating in the food chain. The primary consumers will also accumulate contaminants present in their food. Receptor species selected to evaluate exposure to primary consumers were copepods (*Calanus* spp.) for the pelagic community, polychaetes and nematodes (worms) for the benthic community, and bivalves (mussel) and sea urchins (*Arbacia punctulata*) for the reef community.

3.3.1.3 Secondary Consumers

Secondary consumers include the many carnivorous fish and invertebrates that will inhabit the reef. These include pelagic and midwater fishes, benthic and demersal fishes, as well as the reef-associated fishes such as grunt, snapper, sea bass, toadfish, lobster, and crabs that live on or near the bottom and are closely associated with the reef. Secondary consumers also include organisms such as pelagic fishes that may be attracted to the reef to forage on the primary consumers present on the reef. Secondary consumers are exposed to contaminants present in the water column, associated with the sediment, and concentrated in prey they consume from the reef. The receptor species selected to evaluate exposure to secondary consumers were planktivorous fish (herring[6]) for the pelagic community, lobster (spiny lobster, *Panulirus* spp.) for the benthic community, and triggerfish (gray trigger fish, *Balistes capriscus*) and crab (stone crab, *Menippe* spp.) for the reef community.

3.3.1.4 Tertiary Consumers

Tertiary consumers are the reef-resident carnivorous fish and invertebrates that primarily feed on the secondary consumers present on the reef. The tertiary consumers are high on the reef food chain; they are exposed to contaminants in the water and the sediment as well as contaminants that may be accumulating in the food chain. The longer-lived, tertiary consumers include jacks, groupers, eels, flounders and octopi. The receptor species selected to evaluate exposure to tertiary consumers were jack (amberjack, *Seriola* spp) for the pelagic community, grouper (Family Serranidae, sea basses and grouper, *Mycteroperca microlepis*) for the reef community, and flounder (gulf flounder, *Paralichthys albigutta*) for the benthic community.

3.3.2 Avian Consumers

Sea birds may also be attracted by the abundance of food to feed and forage on the reef. While most avian predators would consume primary consumers (pelagic and bait fishes) some avian predators may consume secondary consumers such as demersal fish, midwater fish, and some invertebrates. Avian predators are exposed to contaminants in the food chain, and they may be exposed to water-borne contaminants while foraging. The receptor species for avian piscivore was the double-crested cormorant (*Phalacrocorax auritus*) and the receptor species for avian omnivore was the herring gull (*Larus argentatus*). Herring gulls are opportunistic feeders and will consume virtually any available food (U.S. EPA 1995) while double-crested cormorants feed almost exclusively on fish (Environment Canada 2004c). Even though the artificial reef will be located about 22.5 mi (19.6 nm, 36.2 km) offshore, it is expected that sea birds are likely to visit the reef at least occasionally. The Ocean Biogeographic Information System - Spatial Ecological Analysis of Megavertebrate Populations web mapping system provided by Duke University reports a few sightings of double-crested cormorants and many sightings of herring gulls offshore in the Northwestern Gulf of Mexico (Read et al. 2003).

3.3.3 Sea Turtles

Other reef consumers such as loggerhead sea turtles (*Caretta caretta*) may frequent reef habitats to take advantage of the relative abundance of food. Listed as a threatened species in U.S waters and an endangered species worldwide, loggerheads feed on a wide variety of invertebrates by using their powerful jaws to crush the shells of molluscs, barnacles, and crabs (Bolten and Witherington 2003, Turtle Trax 2004). Mature loggerhead sea turtles (*Caretta caretta*) weigh

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[6] Although Atlantic Herring are not endemic to the Gulf of Mexico, they are very similar to other herring-like fish (Family Clupeidae) including sardines and menhaden that are abundant in the northern Gulf of Mexico. Data for herring were used to estimate the parameters for the Trophic Level III planktivore in the PRAM model.

about 113 kg (Bolten and Witherington 2003, Turtle Trax 2004) and can consume about 3% of their body weight per feeding (Seaworld, Ask Shamu, personal communication). Captive loggerhead turtles generally feed about three times a week, but some loggerheads (especially rescued animals) feed every day (Seaworld, Ask Shamu, personal communication). Assuming that loggerheads in the wild will feed about five times a week (especially if food is plentiful at a reef), the daily intake rate was estimated as 2421 g/day.

3.3.4 Dolphins

Some marine mammals that may frequent reef habitats include dolphins, porpoises, and possibly toothed whales (odontocetes). Since whales migrate over vast distances of the ocean and most porpoises are wide ranging pelagic species, it is not very likely that these species would be commonly found in the reef areas. The worst-case exposure to a marine mammal would be from dolphins that could be attracted to the reef area by the abundance of food. Marine mammals (dolphin) can consume demersal fish and free-living invertebrates and incur incidental exposure to water- and sediment-borne contaminants. Depending on the availability of food, bottlenose dolphins (*Tursiops truncatus*) will eat a wide variety of food including tarpon, sailfish, sharks, speckled trout, pike, rays, mullet, and catfish. They are also known to eat anchovies, menhaden, minnows, shrimp, eel and other free-swimming invertebrates. The average dolphin will consume 18-36 kg of fish each day (Davis and Schmidl 1997). The most common feeding behaviors is foraging; bottlenose dolphins are also known to chase prey into very shallow water where they can capture the trapped fish by lunging onto mud banks and shoals (Davis and Schmidl 1997). Adult bottlenose dolphins average 2.5-3 m (8-10 ft.) and weigh between 136-295 kg (300-650 lb.), with males being slightly larger than females (Seaworld 2000).

3.3.5 Shark/Barracuda

The top predators on the reef are sharks and barracudas that would be drawn to the abundance of food at the reef. Long-lived and carnivorous, sharks only consume about 1-10% percent of their total body weight per week (Seaworld 2004b, Pauley 1989). Sharks don't require as much energy as birds and mammals because they are cold-blooded and very efficient swimmers (Seaworld 2004b). A common large, up to 2.4 m (7.5 ft.), coastal shark in the waters of Southeastern US is the sandbar shark (*Carcharhinus plumbeus*). In the Florida east coast shark fishery between 1938 and 1950 sandbar sharks constituted about 50,000 of the 100,000 coastal sharks caught commercially (Jon Dodrill, Florida Fish and Wildlife, personal communication). A reef-associated predator, sandbar sharks feed primarily on boney fishes (>95%) but they will also consume other elasmobranches, cephalopods, and shrimps (Fishbase 2004a). Growing up to 45-90 kg (100 – 200 lbs) in weight (Knickle 2004), sandbar sharks occupy the upper trophic level of the reef food chain (Trophic Level 4.1 to 4.5, Fishbase 2004a).

Another reef-associated top-level predator frequently observed foraging on artificial reefs is the great barracuda (*Sphyraena barracuda*) (Robert Turpin, Escambia County, FL, Marine Resources Division, personal communication). Smaller, 2 m (6.6 ft) total length and maximum weight 50.0 kg (110 lbs, Fishbase 2004b) but faster swimmers than sharks, barracuda probably require more energy needs (per unit body weight) than sharks. With their large mouths and very sharp teeth, barracuda feed on jacks, grunts, groupers, snappers, small tunas, mullets, killifishes, herrings, and anchovies, sometimes by chopping large fishes in half (FMNH 2004). An opportunistic predator, great barracuda feed throughout the water column and are located at a Trophic Level of 4.5 (Fishbase 2004b).

3.4 Conceptual Model and Exposure Pathways

The potential exposure pathways and assessment endpoints evaluated are shown in Figure 10. Contaminants can enter the system from releases from the sunken vessel. Because the sunken vessel is not isolated from coastal contamination sources, contamination at the sunken ship reef could come from other sources besides the sunken vessel itself. While other sources of contamination may be important in future monitoring of the site, this pathway was not evaluated in the risk assessment for the ex-ORISKANY.

Releases of PCBs were modeled by applying the empirical leachrates (George et al. 2006) to the types of PCB-bearing materials present onboard the ship (Pape 2004) to obtain the emission rate of PCBs (NEHC/SSC-SD 2006a, b) that were then mixed into the interior vessel water (IVW). The interior of the vessel is the interior compartments of ship (Figure 8), the spaces separated from the lower water column by bulkheads, passageways, and hatches. The exterior of the ship is any area that is in direct contact with ocean currents. The exterior of the sunken ship is made up of numerous nooks and crannies on the sunken vessel (hanger deck, gangways, catwalks, etc.) that would be readily colonized by marine organisms. 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.

The sinking plan for the ex-ORISKANY (NAVSEA 2005b) stipulates that no holes will be cut in the sides of the vessel. Scuttling the ship will entail opening, with preset charges, 22 valves and pipes in the bottom of the keel in a way that will evenly and smoothly fill the vessel with water. Numerous holes cut through the interior decks will allow air to escape and water to fill from the bottom of ship, so that the ex-ORISKANY will sink upright on the bottom, with her bow facing parallel to the prevailing current and expected direction of hurricane induced swells. These procedures will limit the exchange of water between the interior and exterior of the vessel. While it is still possible for organisms to reach the interior spaces of the ship, it is not expected that these spaces would provide very beneficial habitat owing to their isolation and lack of available food (Robert Turpin, Escambia County Marine Resources Division, personal communication). However, the REEFEX working group identified potential exposure to IVW as an important pathway, because many reef species could come into contact with IVW while feeding, foraging, or escaping predators. Therefore, PRAM was modified to simulate interior water exposure to primary and secondary consumers (Figure 10, Figure 11, NEHC/SSC-SD 2005a, 2006a).

Another potential pathway is direct contact by marine organisms to the PCB-bearing materials onboard the ship. Encrusting organisms or other epibenthic organisms could come into direct contact with PCBs held within the solid matrices of the materials. Direct exposure was assumed to be a relatively minor exposure pathway compared to aqueous-phase releases of PCBs and no attempt was made to model bioaccumulation from direct exposure in PRAM. The risk assessment assumes direct exposure is a minor pathway because:

- Surfaces containing PCBs are limited
- Materials containing PCBs are mostly located in the interior of the vessel where they will not be easily colonized by epibenthic organisms
- Encrusting organisms will tend to isolate any exposed surface containing PCBs

On the ex-ORISKANY the vast majority of PCB-containing materials will be in electrical cable (97.6% of the PCBs by mass, see Table 4). The PCBs are contained within the insulation of the cable, which is found inside the outer braided-metal shielding. The electrical cable and other PCB-containing materials – bulkhead insulation (0.94%), black rubber (0.06%), and ventilation gaskets (0.01%) – would most likely be located within the interior of ship where they would not be easily colonized by epibenthic organisms that need a constant source of food from the outside of the vessel. Additionally, almost all exposed surfaces on the ship were painted many times during the life of vessel, further isolating the solid matrices containing PCBs from direct contact with encrusting organisms. Yet, there is a small portion of the PCBs that are associated with aluminized paint (1.4%) that could be on the exterior of the ship and there is uncertainty about whether the PCB-bearing materials were manufactured with PCBs or if their surfaces became contaminated with PCBs during the life of the ship or both.

A further consideration is that the formation of concretions by encrusting organisms (barnacles, tubeworms, tunicates, bryzoans, sponges, and other fouling organisms) would serve to further isolate the PCB-bearing materials and inhibit the release. The dramatic decrease in the release of toxic substances from antifouling paint on ship hulls within days of cleaning (Schiff et al. 2003) is an example of this process. Studies on the release of contaminants from artificial reefs made of scrap tires showed that the release rate of contaminants decreased over time probably because of the depletion of contaminants from the surface of the tires (Collins et al. 1995) and the build-up colonizing organisms (Collins 1999, Collins et al. 2002). While the build-up of encrusting organisms on surfaces may impede the release of PCBs, fish and other invertebrates can prey on encrusting organisms and extreme events, such as hurricanes, could also cause fouling organisms to be broken off exposing new surfaces to aqueous-phase leaching. It is unlikely that marine organisms would actually "eat" the materials containing PCBs. Most of the materials are covered with metal or plastic shielding (electrical cables), bolted between flanges (rubber gaskets), and enclosed by paneling or painted surfaces (bulkhead insulation) which means that the main route of release would be from the surfaces being wetted and dissolution of PCBs into the aqueous phase. Although some organisms could incidentally consume the solid material (e.g. a snail grazing on a contaminated surface, or a crab feeding on fouling organisms), it was assumed that this pathway was very minor in comparison to aqueous releases. For the purposes of this risk assessment it was assumed that the predominant route of exposure from any PCBs contained in solid materials on the ship was from aqueous-phase leaching that could occur after sinking.

The PCBs released were expected to be well mixed in the IVW where they would be advected, as function of the bottom current, and mixed into the lower water column surrounding the vessel and extending up to the pycnocline and out to the edge of the zone of influence (ZOI, see below) of the reef (Figure 12). Within the lower water column the PCBs would partition to sediment, sediment pore water, total suspended solids (TSS), and dissolved organic carbon

(DOC) in the water column, and exchange with water, TSS, and DOC in the upper column. Resuspension and transport of suspended sediments is not included in PRAM or TDM. This is assumed to be conservative because including suspended sediments would increase the net transport of PCBs out of the system and reduce the exposure point concentrations. Organisms attached to the ship, free-swimming in the lower and upper water column, and on and within the sediment bed would be exposed to the PCB concentrations present. Advection from bottom currents and exchange across the air-sea boundary on the surface would transport PCBs beyond the boundary of the reef.

Depending on the nature of the contamination, PCBs may be present in various media, i.e., water, sediment, and biota, through transport, uptake and bioaccumulation (ingestion of prey). These media may pose a risk to valued and relevant ecological resources and humans if the exposure pathway is complete. Exposure to contaminants present in the water column could occur to marine organisms through contact and uptake (e.g. gill tissues) and to higher-level predators by ingestion of contaminated prey and incidental contact. PCBs can also accumulate in the sediments from sorption and settling and cause exposure to benthic organisms.

Reef building increases the biomass per unit area because the pre-existing habitat (sandy bottom continental shelf) does not provide favorable substrates or habitat for high-density populations of reef-dwelling marine species (Bell 2001). The sunken vessel provides habitat for reef-dwelling organisms, as well as additional resources to the existing fauna. From an ecological perspective, the valued resources or ecological receptors to protect are the species that might be affected by the sunken vessel and their relationships with other valued species in the local or regional marine ecology. Species that could be impacted by exposure from contaminants include marine species that have migrated to the artificial reef or transient marine species that visit the reef.

4. Exposure Assessment

This section reviews the exposure scenarios modeled, presents the simulated exposure point concentrations for abiotic and biotic media, documents the procedures for estimating exposure concentrations, and discusses the major assumptions and sources of uncertainty in the exposure assessment. Specific aspects of exposure to the benthic, pelagic, and reef communities, and dietary exposure to reef consumers are presented and the results of the model evaluation are also discussed.

4.1 Exposure Scenarios Modeled by PRAM and TDM/PRAM

The PRAM simulates the exposure pathways defined for PCBs leaching from the PCB containing materials to organisms comprising the artificial reef community. By definition, tertiary consumers feed primarily on secondary consumers and secondary consumers eat mostly primary consumers, which in turn feed on primary producers. Representative species were used to model these trophic levels in PRAM. The tropic structure in PRAM is similar to the trophic structure identified at the Pinnacles Reef (Weaver et al. 2002). The TDM/PRAM and PRAM models were specifically developed to model PCB releases from the ship and accumulation of PCBs in the abiotic compartments and food chain of the pelagic, benthic, and reef communities (Table 2, Figure 11). Data from the PRAM and TDM were used to estimate exposure point concentrations to assess impacts to survival, growth, and reproduction of the assessment endpoints (Table 3). The data modeled by PRAM (Table 2) were concentrations of PCB homologs in water, sediment, primary producers (Trophic Level – TL=1: phytoplankton and encrusting algae), primary consumers (TL=2: copepod, bivalve, urchin, polychaete, and nematode), secondary consumers (TL=III: herring, triggerfish, lobster, and crab), and tertiary consumers (TL=IV: jack, grouper, and flounder). By grouping organisms according to their habitat and diet preferences, PRAM also provided output to evaluate exposure point concentrations for the pelagic, benthic and reef communities (Table 2). Additional exposure points were the PCB concentrations in prey for avian consumers (cormorants and herring gulls), loggerhead turtles, bottlenose dolphins, sandbar sharks, and barracudas, Table 3, Figure 11).

Exposure less than 2 yr was evaluated with the TDM/PRAM model (NEHC/SSC-SD 2006b) using the time course of PCB release rates observed in the shallow-water leachrate study (George et al. 2006, Figure 4) and steady state exposure was simulated by PRAM assuming the constant (> 2 yr) PCB release rates (George et al. 2006) reached steady state conditions (NEHC/SSC-SD 2006a). The TDM predicted concentrations of PCBs in water (freely dissolved – C_{W_FD}, partitioned into dissolved organic carbon [DOC] – C_{DOC}, and sorbed onto total suspended solids [TSS] – C_{TSS}) and sediment (C_S and C_{PW}).

The TDM estimates are based on exposure concentrations within defined volumes, just as the PRAM estimates are of exposure concentrations within defined volumes. The TDM volumes are defined in terms of 15-meter wide annuli. The height of these annuli are a fixed height, for the annulus that is 15 m wide, and which begins at the exterior of the ship and extends laterally away from the ship to a distance of 15 m. For the lower water column, the height of the annulus is from the sediment up to the pycnocline; for the upper water column, the height of the annulus is from the top of the pycnocline to the surface of the water. A distance-averaged concentration was used for the TDM/PRAM model. The TDM provided exposure concentrations for bins 0-15m, 15-30m, 30-45m, 45–60m, etc. away from the ship, while PRAM provided an estimate of the steady state concentration for the whole volume as a function of ZOI. A ZOI=2 (14.7m) is roughly equivalent to the TDM bin of 0-15m and ZOI=5 (48.8m) falls at the boundary of the 30-45 m and 45-60m TDM bins. For the TDM/PRAM model the abiotic exposure concentrations were obtained from the TDM model. The TDM output was input into PRAM, for each time interval, by calculating the PCB concentration provided for the 0-15m bin, 0-45m interval (average of 0-15m, 15-30m, and 30-45m bins), and 0-60m interval (average of 0-15m, 15-30m, 30-45m, and 45-60m bins). The concentration for each bin was averaged over the appropriate time interval (eg. 1d (average for day 1), 7d (average from day 2 to 7), 14d (average from day 8 – 14), 28d (average from day 15 – 28), etc). TDM/PRAM then calculated the resulting steady concentrations for the biological compartments.

The TDM model simulated PCB concentrations in the IVW assuming a constant advective flux of PCBs that was proportional to the bottom current (1% of the bottom current), from the interior of the vessel to the exterior water column. The TDM calculated external PCB concentrations in concentric bins (elliptical annuli) 15 m wide extending outwards 200 bins (3000 m) from the ship, expanding away from the ship and extending to the surface for 2 years at 1-min time steps. The 15 m matches the distance that a particle will travel at the assumed bottom current speed of 25 cm sec-1 (0.5 knot/hr) in the 1-minute model time step. A pycnocline was fixed at 15 m so the vertical division provided an upper 15 m tall bin and a lower 49 m tall bin. The model assumed that the entire volume of a bin (water, suspended solids and dissolved organics) moved to the next bin at each time step. Sediment was not transported between bins (NEHC/SSC-SD 2006b). Daily averages (every 1440 min) were calculated for each compartment and bin to obtain a time series of exposure concentrations over the two-year (day 1 though day 730) simulation period (NEHC/SSC-SD 2006b).

The abiotic concentrations predicted by TDM were then input into a version of PRAM modified to simulate the accumulation of PCBs in the progressively developing food chain hypothesized to occur during the first two years following sinking (see NEHC/SSC-SD 2006b for a complete description of the TDM). The progressive food chain was developed in recognition that it would take time for the new reef to be colonized by marine organisms and complete the potential exposure pathways (see Section 3 of NEHC/SSC-SD 2005b). For example, an upper-level predator could not take prey from the reef until it was developed enough to provide a source of food. Assuming that it would take 2-years for the reef to fully develop, the food chain that would be present on the reef was defined for the following time periods after sinking: 1 day, 7 days, 14 days, 28 days, 6 months, 1 year, and 2 years. The TDM output was averaged for each time interval and three distance intervals 0-15 m, 0- 45 m, and 0-60 m from the sunken vessel for input to PRAM. The TDM provided time-averaged PCB concentrations for each PCB homolog (mono- through decachlorobiphenyl)[7], and for total PCBs (as the sum of

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[7] There are no octachlorobiphenyl (Cl-8) outputs, since none of the PCB-containing materials on the ex-ORISKANY were found to contain any octachlorobiphenyl congeners.

PCB homolog concentrations) in each of the abiotic media compartments (water, suspended solids, and dissolved organic carbon in the upper and lower water columns, and in the internal vessel compartment; and in sediment). The distance outputs were the arithmetic mean concentrations for the relevant bins. For example, the 0 to 60 meter output data were the average obtained from the arithmetic means of the 0-15 meter, 15-30 meter, 30-45 meter, and 45-60 meter bins. Graphs of the total PCB concentrations in abiotic media simulated by the TDM are provided in Appendix G of NEHC/SSC-SD (2006b).

The steady state exposure conditions expected to occur once the reef was fully developed and the release rates of the PCB-containing materials have reached a constant long-term rate (> 2 years from sinking) was evaluated using PRAM. PRAM consists of a multimedia environmental chemical fate module and a biotic-food web model. 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 (zone of influence – ZOI). The food web module, consisting of 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, is then used to predict the steady-state concentration of PCBs in the biotic compartments of the model (Figure 11, see NEHC/SSC-SD 2006a for a complete description of the PRAM model).

The state variables (concentrations of PCBs in abiotic and biotic compartments of the model) provided the exposure point concentrations (Table 2) needed to assess ecological risks to the assessment endpoints (Table 3). The exposure routes modeled by PRAM for the pelagic, benthic, and reef food chains are shown in Figure 12. The water exposure consisted of exposure to upper water column (UWC), lower water column (LWC), pore water (PW), and interior vessel water (IVW). The pelagic community were exposed the UWC and LWC, the benthic community was exposed to the LWC and PW, and the reef community was exposed to LWC and IVW (Table 6).

The default diet composition used in the PRAM model is shown in Table 7. The TL for each biological compartment of the PRAM food chain was calculated based on the weighted average of each component of each organism's diet:

$$TL_{(j)} = 1 + \Sigma f_{diet(i)} \times TL_{Prey(i)} \qquad [3]$$

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)

For this calculation the TL for sediment and suspended sediment was set to 1.5 and 1.125, respectively to account for the detrital carbon and bacteria in these compartments. The trophic levels modeled ranged from TL 1 - 3.96 for the pelagic community, TL 1 – 3.95 for the reef community, and TL 2.46 – 4.11 for the benthic community (Table 7). The highest TLs in model were for the benthic predator (flounder, TL =4.11), pelagic piscivore (jack, TL = 3.96), reef predator[8] (grouper, TL = 3.95), and benthic forager (lobster, TL = 3.52).

4.1.1 Exposure to the Benthic Community

The benthic community is composed of organisms living in or on the bottom (US EPA 2004b). The benthic community represented in PRAM includes the benthic infauna, benthic epifauna, benthic foragers, and benthic predators. The infauna is composed of macrobenthic suspension feeders, deposit feeders, and benthic carnivores that spend a predominant portion of their life living within the sediments (Berry et al. 2003a, b). Examples of benthic infauna include nematode and polychaete worms, clams, amphipods, ghost shrimp, 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. The contribution of the microbial community is included in the organic matter or detritial material, which is a major component of the diet for the benthic infauna (Table 7).

The benthic infauna compartment is composed of the biologically active zone of the sediment, the intersititial water (pore water), and the overlying water just above (2-6 cm) the sediment-water interface. The pore water and the overlying water are modeled as pore water within PRAM because these waters are geochemically distinct from the LWC water below the pycnocline. The overlying water contains higher amounts of sedimentary flocs, organic matter, and suspended particles than is present in the water column, and any currents present in the water column would be strongly dampened by friction with the bottom at the sediment water interface, especially near the hull of the ship. Toxicological studies have shown that overlying waters are similar to intersititial water with respect to partitioning and toxicity (Berry et al. 2003a, b). For example, the LC50 (lethal concentration to 50% of test organisms) values obtained for amphipods (*Hyalella azteca*) from 10-d sediment exposure to endrin were similar to LC50 values obtained for static tests on the overlying waters performed for the same sediment (Nebeker et al. 1989, cited in Berry et al. 2003b). To reflect these processes, PRAM assumes that water exposure of PCBs to benthic infauna is 20% from LWC and 80% from PW (Table 6, Figure 12). The benthic infauna diet is composed of 50% sediment, 30% phytoplankton, and 20% zooplankton (Table 7). It should be noted that the benthic infauna are not really consuming sediment, rather they are consuming the organic matter present on the particles, the inorganic matter would pass through the gut. The dietary requirements take into account the amount of organic matter that must be consumed (NEHC/SSC-SD 2006a).

The benthic epifauna are 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, sea fans, sponges, etc. Because of their close association with the bottom sediments PRAM assumes that water exposure to PCBs is 50% PW and 50% LWC

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[8] Note that the default setting in PRAM (version 1.4C) only accounts for 99% of the diet of the reef predator, correcting this would result in a TL of 3.98 (see Table 7). This error has a very minimal impact on the overall model results.

(Table 6, Figure 12). The benthic epifauna diet consists of 25% sediment organic matter, 30% phytoplankton, and 20% zooplankton (Table 7).

The benthic foragers are the lobsters, sea stars, crabs, octopus, etc that feed on the infauna (50%) and epifauna (45%, Table 7). Reflecting the relatively greater mobility of benthic foragers and the less time that they are actually in contact with bedded sediments, water exposure to benthic foragers is modeled as 75% LWC and 25% PW (Table 6, Figure 12). 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 (5%). This assumption is consistent with other risk assessments that have evaluated exposure from incidental sediment exposure as part of the consumption pathway (URS 1996b, MESO 2000).

The top predators in the benthic community are the flat fish, skates, toadfish, eels, and other carnivorous fish that feed on the benthic foragers (58%), epifauna (20%), and infauna (20%, Figure 12). Many benthic predators spend most of their time in the water column rather than in the sediment, so water exposure is modeled as 90% LWC and 10% PW (Table 6, Figure 12). Because the benthic predators also feed on infauna, incidental sediment consumption was set to 10% of the infauna consumed (2%, Table 7).

4.1.2 Exposure to the Pelagic Community

The base of the pelagic food chain and much of the reef itself are the phytoplankton. Comprised of microscopic plants including diatoms, coccolithophorids, dinoflagellates, and cyanobacteria, the phytoplankton are exposed to PCBs in the UWC euphotic zone where they must remain to utilize sunlight for photosynthesis. The pelagic zooplankton is composed of copepods, salps, ctenophores, jellyfish, beroes, pteropods, as well as larval forms of larger fish and invertebrates. Zooplankton is known to diurnally migrate in the water column, UWC during the night and LWC during the day, resulting in 50% exposure between UWC and LWC (Table 6, Figure 12). The zooplankton feed primarily on phytoplankton (70%) but they will also consume detrital organic matter associated with the suspended solids in the UWC (15%) and LWC (15%, Table 7). Planktivorous fish are herring-like fish (Family Clupeidae), which include sardines and menhaden, and bass-like Anthias (Family Serranidae) that are very plentiful on the Pinnacles natural reefs (Weaver et al. 2002). In PRAM, the pelagic planktivores were set to feed exclusively on zooplankton (100%). It was assumed that pelagic plankitvores would be exposed to PCBs in the UWC (80%) and LWC (20%, Table 6, Figure 12).

The top-level predators in the pelagic community are the pelagic picscivores. These are some of the prized game fish that could be attracted to the reef like greater and lesser amberjacks, pompanos, snappers, mackerels, and tunas. Many pelagic game fishes are attracted to natural and artificial structures in both freshwater and marine environments, but it is expected that these species are really ‘coastal pelagics’ which can travel greater than 200 km (124 mi) in their search for food and may be absent from the reef for extensive periods (Shipp 2002, Ingram and Patterson 1999, Stanley and Wilson 2003). In PRAM the pelagic predator was set to feed primarily on pelagic planktivores (90%) with 10% of their diet coming from zooplankton (Table

7). Based on their expected behavior of following the pelagic planktivores, the pelagic predators would be exposed to PCBs in the UWC (80%) and LWC (20%, Table 6, Figure 12).

4.1.3 Exposure to the Reef Community

The reef community is composed of the reef obligate species that will colonize the reef (Weaver et al. 2002, Bohnsack et al. 1994, Patterson et al. 2005). Assuming that light will penetrate to the depths of the reef, species of encrusting algae and other macrophytes will colonize on the surface of the vessel. Encrusting algae would be exposed to PCBs through the LWC (100%). It was assumed that plants could only survive on the outside of ship so they would not be exposed to IVW. Likewise, sessile filter feeders (tubeworms, barnacles, cnidarians, bryzoans, tunicates, bivalve mussels and oysters, and other fouling organisms) would more be likely to colonize the exterior of vessel where food and nutrients would be plentiful. It was assumed that the sessile filter feeders obtained 80% of their diet from phytoplankton, 10% from zooplankton, and 10% from suspended solids in the LWC (Table 7). The default setting for PCB exposure in water to sessile filter feeders was 100% LWC, Table 6,Figure 12).

Invertebrate omnivores are opportunistic feeders like sea urchins, gastropods, and isopods, and the invertebrate foragers are the carnivorous motile crustaceans (crabs) and polychaetes, sea stars, and other invertebrate predators found on the reef. While these species move about the reef looking for food, they can be exposed to PCBs in the LWC and IVW which was set to 80% **:** 20% and 70% **:** 30% for invertebrate omnivores and foragers, respectively (Table 6, Figure 12). The diet of the invertebrate omnivores consisted of attached algae (80%), zooplankton 10%, and suspended solids in the LWC (10%). The primary prey for the invertebrate forager was the invertebrate omnivore (50%), followed by sessile filter feeders (35%), pelagic planktivores (5%), zooplankton (5%), and LWC suspended sediment (5%,Table 7).

The reef vertebrate forager (triggerfish, grunt, sheepshead, and porgy) and predator (grouper, sea bass, and rock fish) are the prized game fish that will be resident at the reef. The reef foragers are expected to feed on a relatively wide diversity of prey species, while the majority of the reef predator's diet would be the reef forager (60%, Table 7). Reflecting the assumption that these fishes would utilize interior spaces of the vessel, the reef forager and predator would be exposed to PCBs in the LWC and IVW (70% **:** 30% and 80% **:** 20%, respectively, Figure 12). It was assumed that the reef forager (triggerfish) would spend the most time in contact with IVW of all the species in the model. This was to account for behavior patterns suggested for white grunt (*Haemulon plumierii*) in the ex-VERMILLION study (Johnston et al. 2005a), including frequent forays into the interior of the hull in search of food, relatively longer residence time on the reef than other fish species, and the use of interior vessel compartments as refugia to avoid predation.

4.1.4 Dietary Exposure to Reef Consumers

Reef consumers like sea birds, sea turtles, sharks/barracuda, and dolphins were not modeled by PRAM, therefore concentration of PCBs in prey, which was modeled by PRAM, was assessed to evaluate potential exposure to these species (Table 2, Table 3, Figure 10). Water exposure was not evaluated for birds, mammals, and sea turtles. None of these species have gills, which is the main route of contamination from water exposure for marine fish and invertebrates. For birds, incidental contact with the water would occur when foraging at the reef (diving and swimming), but it was assumed that this exposure would not be significant. Although dolphins and sea turtles could also be attracted to forage at the reef for long periods, they are not considered to be reef residents and it was assumed that uptake of contaminants from the water would be negligible and could be ignored. Water exposure for the reef shark and barracuda was evaluated by assuming that potentially harmful tissue concentrations could arise by accumulating contaminants from water and food. The description of the receptor species used to evaluate risks to reef consumers is provided in Section 3.3 for Avian Consumers, Sea Turtles, Dolphins, and Shark/Barracuda and the exposure models used to derive toxicological benchmarks for these species are presented in Section 5.1.3.4.

4.1.5 Exposure to Progressive Food Chain During 0-2 yrs After Sinking

The progressive food chain was developed to capture the exposure pathways expected to be present during the 0-2 yrs it would take for the new reef to be fully colonized by marine organisms (see Section 3 of NEHC/SSC-SD 2005b, NEHC/SSC-SD 2006a). The approach assumed that the pelagic and benthic food webs would be fully developed when the ship is sunk but it would take the reef community 2 years to become fully developed on the vessel. The progressive food chain used for the reef community is shown in Table 8. Initially, the components of the reef community were "forced" to obtain all of their dietary requirements from the pelagic and benthic communities, but, as the reef developed, the reef predators would switch to feeding on their preferred prey (i.e. the default dietary preferences used by PRAM, see Table 7). For example, during the first month after sinking (Table 8), the reef predator – grouper would obtain all its dietary requirements feeding on pelagic herring (20%) and benthic epifauna (20%) and lobster (60%). After six months the grouper would add crab (10%) and triggerfish (10%) to its diet and decrease reliance on lobster (40%). After one year (Table 8) the grouper would feed more heavily on the increasing abundance of crabs (15%) and triggerfish (25%) from the reef, reducing predation on pelagic herring (10%) and benthic epifauna (10%) and lobster (40%). Finally, after two years (Table 8) the grouper would have the default diet (Table 7).

The TDM provides time-varying concentrations in the abiotic media and PRAM calculates the resulting steady-state tissue concentrations. Therefore, higher trophic level fish tissue concentrations will be overestimated during the early life history of the reef because the bioaccumulation within the food web will be calculated as though the PCBs have been present in the environment long enough to reach steady state. The analysis also assumes that the pelagic and benthic communities are capable of supporting the reef community during the early phase of reef development, while in reality recruitment of reef-associated species will probably occur after the reef-obligate species have been established (Bartone et al. 1998). Additionally, the diet progression (Table 8) an approximation of what may occur under normal conditions, other events, such as storms that may cause mass migration of fish to seek shelter, were not considered.

4.2 Modeled Exposure Concentrations

This subsection explains the zone of influence (ZOI), presents the results of simulated exposure levels, compares the results obtained from TDM/PRAM and PRAM, and discusses the results of the model evaluation analysis. The concentrations of Total PCB in tissues and abiotic compartments predicted by TDM/PRAM at 0-15 m from the hull for day 0 - 2 yr and steady state concentrations predicted by PRAM with a ZOI=2 and ZOI=1 are presented in Table 9.

4.2.1 Zone of Influence

An important parameter in PRAM is the zone of influence (ZOI). The ZOI represents a column of water directly around the ship (see NEHC/SSC-SD 2006a for the derivation of ZOI). At ZOI=1 the water column boundary is defined by the hull of the ship, there is no sediment compartment,[9] 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 (Figure 13).

The ZOI was developed to define the model boundaries and a ZOI of 2 and 5 are recommended for assessing human health risks (NEHC/SSC-SD 2005a, b). However, the ZOI has little meaning to sessile organisms and other epibenthic organisms that will spend their entire life span only a few millimeters away from the substrate provided by the ship. These organisms will probably encompass the vast majority of the biomass present at the reef and provide the food and cover that will attract and support the higher trophic level organisms prized by anglers. Because of this, it is appropriate to focus the ecological risk analysis on the smallest perimeter possible, which was the community most closely associated with the hull (ZOI=1, 0 m) and areas directly adjacent to the reef (ZOI=2, 0 - 15 m and ZOI=3, 0 - 27 m).

4.2.2 Simulated Exposure Conditions

As discussed above, TDM/PRAM and PRAM simulate the fate and transport of each homolog (mono- through decachlorobiphenyl) and Total PCB was obtained as the sum of the individual homologs (EQU [1]). The Total PCB bulk water concentration (C_{BW}) for the IVW, LWC, and UWC was calculated from the model output as:

$$C_{BW} = C_{W\_FD} + TSS \times C_{TSS} + DOC \times C_{DOC} \text{ [mg/L]} \qquad [4]$$

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]

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[9] 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.

TSS = The amount of suspended sediment = 10 [mg/L]
DOC = The amount of dissolved organic matter = 0.6 [mg/L]

And C_{W_FD}, C_{TSS}, and C_{DOC} were the sum of homologs modeled in each water column compartment.

The TDM/PRAM and PRAM models were run with the default parameters to obtain the 0-2 year and steady state exposure concentrations for the reef (Table 9). The steady-state condition with ZOI=1 resulted in the highest modeled concentrations for all the biological, sediment, and bulk water compartments in the simulation (Table 9). The steady state simulation (ZOI=1) resulted in 5-7 orders of magnitude increase in the Total PCB levels modeled between the base of the food chain (TL=1 plankton and encrusting algae) and the top-level predators (TL=4) grouper, jack, and flounder (Figure 14). Owing to the reef community's close proximity to the source of PCBs, the Total PCBs in grouper (0.115 mg/Kg WW), triggerfish (0.067 mg/Kg WW), crab (0.037 mg/Kg WW) and urchin (0.017 mg/Kg WW) from the reef community were about 10-200 times higher than flounder (0.002 mg/Kg WW) and lobster (0.0005 mg/Kg WW) from the benthic community and jack (0.0009 mg/Kg WW) from the pelagic community (Table 9, Figure 14). For the reef community, the Total PCB accumulated in grouper were about twice as high as the PCBs in triggerfish, three times higher than crabs, and six times higher than urchins (Table 9). These four species had Total PCB concentrations at least an order of magnitude higher than any of the other species modeled (Figure 14). This higher accumulation can be attributed to the fact that these were the only organisms that were exposed to PCBs in the IVW (Figure 12, Table 6).

There were only relatively minor decreases between the PCB concentrations predicted for ZOI=1 and ZOI=2. By doubling the ZOI the concentrations of PCBs in grouper, triggerfish, crab, and urchin decreased by about 2% while the PCB concentrations in other species decreased by 36%, except for phytoplankton, which decreased by 10%. Doubling the ZOI did not affect the exposure to PCBs in the IVW for grouper, triggerfish, crab, and urchin, but doubling the ZOI increased the volume of the lower and upper water columns and the sediment bed diluting the PCB concentrations in LWC and PW by 36% and UWC by 10% (Table 9).

For the TDM/PRAM results, the highest tissue concentrations occurred on day 28 (one month after sinking) for all the species except triggerfish and grouper, which did not peak until day 180 (six months after sinking). Most of the biota compartments peaked on day 28 (Table 9) because the maximum release rates of tetra- and pentachlorobiphenyl occurred during the interval between day 14 – day 28 (see Figure C 31 –Table of PCB Homolog Release Rates used in the TDM in NEHC/SSC-SD 2005b). The triggerfish and grouper didn't reach their maximum TDM concentration until day 180, because more time was required for the reef to develop before they could shift their prey from benthic organisms to reef organisms. For example, on day 28 only 10% of the triggerfish's diet and 0% of the grouper's diet came from the reef, while on day 180 the diet from the reef for triggerfish and grouper had progressed to 33% and 20%, respectively (Table 8).

In comparison to the tissue concentrations predicted for day 730 (2 years after sinking) and steady state, with ZOI=2 (both simulations evaluated exposure levels 0-15 m from the ship), the tissue concentrations predicted for steady state (ZOI=2) were about 2 times higher for grouper, triggerfish, crab, and urchin and about 4 times higher for the other species, except for phytoplankton, which were more than 100 times higher (Table 9). Day 730 is the point of the dynamic model that all the exposure pathways are complete (i.e. the food web in TDM/PRAM is the same as PRAM) and the PCB release rates are approaching steady state values. Relative to day 730, the steady state (ZOI=2) PCB concentrations in bulk water concentrations of IVW increased by about a factor of 3, the LWC increased by a factor of 5 and the UWC increased by a factor of 90. It is interesting to note that on day 180, when the maximum abiotic concentrations were obtained in the TDM, the concentrations of Total PCBs for day 180 in C_{W_FD} and C_{TSS} were actually higher than the steady state values but the day 180 PCB concentration in C_{DOC} was lower than the steady state concentration, resulting a in higher bulk water concentration for the steady state condition. Even though the PCB release rates used in TDM/PRAM were about 5 times higher (maximum of 3.9 g PCB/day, see Figure C 31 in NEHC/SSC-SD 2005b) than the steady state release rate (0.762 g PCB/day, see Table 5) the steady state, which drives all the compartments to equilibrium, resulted in the highest exposure concentrations to the reef community.

The exposure assessment evaluated exposures from water-borne releases of PCBs in the interior of the ship to the lower and upper water column, into bedded sediment and pore water, and through the pelagic, benthic, and reef community food chains for both 0-2 yr and steady state exposure periods. The exposure assessment showed that PCBs accumulated at the highest levels under steady state conditions; the highest concentrations were predicted for the upper trophic levels of the reef community (grouper, triggerfish, crab, and urchin). These reef community species bioaccumulated the highest levels of PCBs through contact with IVW, which was the most important route of exposure to organisms on the reef.

4.2.3 Model Evaluation

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 (see Appendix B). Because the models are simulating future conditions, no field data are readily available to validate the model output (Beck et al. 1997). Model performance was evaluated to assure that the model results were internally consistent (the same set of inputs gives the same set of results), that the predictions of the model conformed with the physiochemical properties being modeled, and that results produced by the model were consistent with similar studies reported in the literature (see Appendix B for details of the evaluation). The model evaluation provides an important quality assurance check that PRAM can be used to support the risk assessment (Beck et al. 1997, Chen and Beck 1999, Beck and Chen 2000).

The evaluation compared predictions on the pattern of PCB bioaccumulation 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 from PRAM to data reported in the scientific 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). The evaluation showed that PRAM did very well in predicting the bioaccumulation of homologs with a $K_{ow} \geq 6.5$ (penta-, hexa-, and heptachlorobiphenyl). These homologs accounted 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. While there was 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 FWMF predicted by PRAM was more conservative than the available literature values for the reef community and was within the range of the literature values for the pelagic and benthic communities. This adds to confidence that the results from PRAM were not underestimating potential exposure levels.

4.3 Uncertainty About Exposure Assessment

The estimates of tissue residues in the reef community are based on the biogeochemical behavior of PCBs in aquatic systems as applied within the development of PRAM (NEHC/SSC-SD 2006a) and the TDM (NEHC/SSC-SD 2006b) models. The model outputs were assumed to be valid representations of future conditions and, based on the criteria used to evaluate model performance (see Appendix B) it appears that the models produced plausible and realistic results. The models are abstractions of real processes so there are uncertainties associated with the assumptions and mathematical procedures used in the models. In addition to strengths and weaknesses of PRAM (see Section 2.4, p2-25 in NEHC/SSC-SD 2005a) and TDM (see Section 2.4, p2-14 in NEHC/SSC-SD 2005b) there are also additional uncertainties associated with using the model results to address ecological risks (see Section 7 Uncertainty).

The output from the TDM was used to predict the release and accumulation of PCBs from the ship for the period of 0-2 yrs in 15 m bins extending out to 3000 m (see Appendix B and C of NEHC/SSC-SD 2005b for the details of these simulations). While the progressive food chain used in the TDM/PRAM simulations was developed to take into account changes in the food web during colonization, the time series of abiotic concentrations were used to project steady state tissue concentrations at each of the intervals (NEHC/SSC-SD 2005b). Clearly, it would take time for the reef community to fully develop and to reach a “steady state” with the exposure levels present. Although it could take years to reach thermodynamic steady state, studies have shown relatively rapid uptake of PCBs by fish (Fisk et al. 1998) and mussels (Bergen et al. 1998) indicating that marine communities can achieve 70-80% of the “steady-state” concentration within a month of exposure to high concentrations of PCBs. While the steady state assumption in PRAM may overestimate tissue concentrations, there may be components of food web that can reach equilibrium quickly and the PRAM output can be viewed as representing the portion of the reef community that would be most directly affected.

Many other ecological processes, that may also affect PCB bioaccumulation and potential risks, were not addressed by TDM-PRAM and PRAM. These include increased productivity, changes in biomass and abundance within the trophic structure, refugia, disequlibrium population dynamics between predators and prey, and ecosystem dynamics just to mention a few.

5. Effects Assessment

This section presents the development of benchmarks used to assess potential ecological effects associated with water, sediment, tissue residue, and dietary exposure to PCBs. The available toxicological data on the ecological effects from exposure to Total PCBs and dioxin-like coplanar congeners are reviewed and evaluated within the context of the exposure pathways identified for the artificial reef.

5.1 Selection of Benchmarks

Benchmarks were selected to evaluate potential effects of PCBs to a broad range of reef-dwelling organisms. Benchmark concentrations for water (W_B), sediment (S_B), and tissue residues of fish (T_{Fish}) and invertebrates (T_{Invert}) were selected. The tissue benchmarks were for the bioaccumulation critical value (B_{CV}), tissue-screening value (TSV), critical body residues (CBR) corresponding to the no observed effect dose (NOED) and the lowest observed effect dose (LOED) for a fish or invertebrate species. Benchmarks of ecological effects to assess dietary exposure to representative reef consumers were also developed. Dietary benchmarks (D_{PREY}) for fish as prey were developed for herring gulls, cormorants, dolphins, and sharks/barracuda. Dietary benchmarks for invertebrates (D_{PREY}) as prey were also developed for herring gulls, sea turtles and dolphins (Table 10).

In the last decade, evidence has been mounting that specific congeners are more toxic than others, especially the dioxin-like coplanar PCBs – PCBs with zero or one chlorine atom in the ortho position (closest to the biphenyl double bond, see information on orientation Polychlorinated Biphenyls (PCB) Multimedia Training Tool) (Ahlborg et al. 1994, Van den Berg et al. 1998, Barney 2001). The concentrations of these dioxin-like coplanar PCB congeners are expressed as the equivalent concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), the most potent dioxin congener (Van den Berg et al. 1998), determined from the toxicity equivalent quotient (TEQ). To address potential toxicity from TEQ exposure to reef consumers such as sea birds, sea turtles, and dolphins, benchmarks for exposure dietary of TEQs to gulls, cormorants, and dolphins were developed. To evaluate potential effects of TEQ exposure to fish eggs and sac-fry larvae, the most sensitive life stage of fishes to TEQ toxicity, benchmarks for the maternal transfer of TEQs to fish eggs and sac-fry larvae were also developed.

5.1.1 Effects from Water Exposure

Water quality criteria, the basis of the water exposure benchmarks, were developed to be protective of both short-term (acute) and long-term (chronic) exposure. The criterion continuous concentration (CCC – chronic) "… is an estimate of the highest concentration of a material in the water column to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect" and the criterion maximum concentration (CMC – acute) "… is an estimate of the highest concentration of a chemical in the water column to which an aquatic community can be exposed briefly without resulting in an unacceptable effect" (U.S. EPA 1995).

Water quality standards have been developed to be protective of 95% of the species tested, or more precisely, of the genera tested (U.S. EPA 1991, 1994). The water quality criterion for PCBs is defined as total PCBs (Total PCB), which "… is the sum of all homolog, all isomer, all congener, or all Aroclor analyses" (U.S. EPA 2002). The aquatic life criteria recommended by national water quality criteria for salt water continuous (WQC-Chronic) concentrations is 0.03 ug/L and maximum (WQC-Acute) is 10 ug/L (U.S. EPA 1998b, 1999b, summarized in Buchman 1999). The Great Lakes Water Quality Initiative criteria for protection of wildlife (GLWQI-Wildlife), which takes into account bioaccumulation in fish for chronic wildlife exposure, has recommended the criteria for Total PCB of 0.074 ug/L (GLWLC-TierI[10]), U.S. EPA 1995).

Recently, the State of Florida has proposed enacting water quality standards for persistent, bioaccumulative, and toxic contaminants such as PCBs to be protective of an exposure equivalent to the "risk of one in a million or a Hazard Index of 1.0 for the 90th percentile of all Florida adults eating fish species found in Florida waters" (FLDEP 2004). The proposed standard for the annual average ($FLWQC_{aap}$) exposure to Total PCB is 0.000023 ug/L, which is factor of 2 lower than the current annual average standard of 0.000045 ug/L ($FLWQC_{aa}$, F.A.C. 62-302.530) and 3 orders of magnitude lower than the recommended aquatic life chronic criteria. The $FLWQC_{aap}$ was developed for human health and therefore is not applicable to the ecological risk assessment. TheWQC-Chronic criterion of 0.03 ug/L is equal to the Florida State Standard for maximum concentration of Total PCB ($FLWQC_{max}$, F.A.C. 62-302.530). Because the ex-ORISKANY is to be sunk outside of the territorial waters of the State of Florida, the State of Florida Water Quality Standards are not legally applicable.

The chronic value of 0.03 ug/L (WQC-Chronic) recommended by the national guidance as protective of aquatic organisms was used as the most conservative ecological risk benchmark and the Great Lakes Tier 1 wildlife criteria of 0.074 ug/L (GLWLC-TierI) was used as the less conservative ecological risk benchmark. The WQC-Chronic value was also used to calculate the bioaccumulation critical value (B_{CV}) to evaluate potential toxic effects from PCB exposure to aquatic life (see Section 5.1.3 and Table 12).

The water exposure benchmarks (Table 10), were used to evaluate potential ecological effects to primary producers (phytoplankton and encrusting algae), primary consumers (zooplankton and grazers), as well as other components of the reef community (fish and invertebrates, Table 3). It was assumed that the water benchmarks were applicable and appropriate for protection of the reef community.

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[10] The Great Lakes Wildlife Criteria are based on "different methodologies to evaluate available scientific data. For pollutants for which data are abundant (called Tier 1), criteria would be generated using current, scientifically established methods for calculation. For pollutants for which data are extremely limited, yet controls are deemed necessary because of the substances' presence in the lakes (called Tier 2), criteria will be developed using alternative methodologies with added safety factors that intentionally produce more conservative criteria." (see Copeland 1996, http://www.ncseonline.org/NLE/CRSreports/Natural/nrgen-10.cfm?&CFID=2153896&CFTOKEN=76439908)

5.1.2 Sediment Exposure

The benchmarks for sediment exposure to PCBs (S_B, Table 10) were set to the Threshold Effects Level (TEL) and Probable Effects Level (PEL) recommended by Florida Sediment Quality Assessment Guidelines (SQAGs, MacDonald 1994a, b). The TEL and PEL were developed from studies where chemical concentrations in the sediment and ecological effects were measured or modeled. The TEL represents the concentration of a chemical below which effects are not expected, the PEL represents the concentration that is likely to cause ecological effects, and the "possible effects range" is defined for chemical concentrations between the TEL and PEL (MacDonald 1994a, b, Long et al. 1995, U.S. EPA 1996a, Buchman 1999).

The sediment benchmarks were used to evaluate PCB exposure to primary producers (benthic diatoms, encrusting algae), primary consumers (benthic infauna and epifauna) and other components of the reef community that would come into contact with sediments associated with the reef (free swimming fish and invertebrates Table 3). The sediment benchmarks for PCBs were based on Total PCB exposure characterized by the sum of the measured congeners (sumPCB) converted to Total PCB using empirical relationships[11] (NOAA 1991, Long and Morgan 1990). It was assumed that the sediment benchmarks were applicable and appropriate for protection of the reef community.

5.1.3 Tissue Exposure

Tissue residue benchmarks were based on bioaccumulation critical values (B_{CV}), tissue screening values (TSV), critical body residues, and dietary uptake benchmarks. These benchmarks (Table 10) are chemical residue thresholds at or below which adverse toxicological effects would not be expected.

5.1.3.1 Tissue Screening Values (TSV)

Tissue screening values (TSV), originally developed for screening-level ecological risk assessments at Navy sites (URS 1996, 2002), are the concentrations of chemicals in the tissue of an organism at or below which adverse effects would not be expected to occur. The TSV is based on water quality criteria that were derived to be protective of aquatic organisms (U.S. EPA 1986, URS 1996, Shepard 1998, Dyer et al. 2000). Because the TSV is equal to the no effect tissue concentration, a single TSV applies to both freshwater and marine organisms (URS 1996), in other words the same tissue concentration would cause an effect regardless of whether the organism was a marine or freshwater species. This assumes that the difference between freshwater and saltwater criteria are due to differences in chemical uptake between freshwater and marine organisms rather than differences in tissue concentrations that would cause adverse effects. The TSV for PCB was calculated by URS (1996) as (Table 11):

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[11] The equation for total PCB (Total PCB = 2.19sumPCB + 2.19) was obtained by NOAA's Status and Trends Program from a regression of empirical data from samples that were analyzed for both individual congeners (sumPCB) and total Aroclors (Total PCB) (NOAA 1991).

$$TSV = WQC \frac{\mu g}{L} \times BCF_a \frac{L}{Kg(wet)} \times 0.001 \frac{mg}{\mu g} \quad [mg/Kg\ wet\ weight] \qquad [5]$$

Where

BCF_a = Bioconcentration factor for aquatic organisms (L/kg wet weight) normalized to the average (3%) lipid content[12] of aquatic organisms, BCF_a = 31200 (URS 1996)

$WQC_{FWChronic}$ = Was selected as the lowest value reported for marine or fresh water quality criteria (μg/L) that was in effect at the time the TSVs were calculated, $WQC_{FWChronic}$ = 0.014 μg/L (URS 1996)

Chemical residue levels below the TSV are assumed to pose little or no risk to aquatic biota (Shepard 1995, URS 1996, Dyer et al. 2000).

5.1.3.2 Bioaccumulation Critical Values (B_{CV})

Bioaccumulation critical values (B_{CV}) were based on empirical relationships between chemical exposure and organism uptake and accumulation (Table 12). Similar in concept to the TSV, the B_{CV} was calculated using the most recent saltwater quality criteria for chronic exposure to PCBs (U.S. EPA 1999a, Buchman 1999) and bioconcentration factors applicable to marine fish and invertebrates. The B_{CV} was defined as the tissue concentration that would occur if water exposure levels reached the chronic value of 0.03 ug/L Total PCB recommended by the national guidance as protective of aquatic organisms (W_B):

$$B_{CV} = W_B \frac{\mu g}{L} \times BCF_M \frac{L}{kg(wet)} \times 0.001 \frac{mg}{\mu g} \quad [mg/Kg\ wet\ weight] \qquad [6]$$

where W_B = Most recent salt water chronic criteria (EPA 1998, Buchman 1999, 0.03 ug/L)

BCF_M = Bioconcentration factor for marine organisms (L/kg wet weight), see Table 12

The BCFs used for invertebrate tissue were obtained from URS 1996 and the fish tissue BCF for Total PCB was estimated from Mackay (1982, cited in Petersen and Kristensen 1998):

$$\log(BCF_{ww}) = -1.32 + \log(Kow) \qquad [7]$$

BCF_{ww} = Bioconcentration factor in adult fish in wet weight basis

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[12] The BCF for PCBs (log BCF = (0.85 x logKow) – 0.70) was determined from experiments conducted with using fathead minnows (*Pimephales promelas*) with an average lipid content of 7.6 % (U.S. EPA 1980, URS 1996). Freshwater and marine organisms that are commonly consumed in the US have a weighted average of about 3% lipid content (U.S. EPA 1980, URS 1996). Therefore to make the BCF for PCB more applicable to water quality criteria the U.S. EPA adjusted the BCF value by 3%/7.6% = 0.395 (URS 1996).

The B_{CV} for Total PCB accumulation in fish and invertebrate tissue was calculated using a BCF weighted by the fraction of Total PCB (f_{PCB}) present in each homolog group measured in reef fish (vermillion snapper, black sea bass, and white grunt) sampled in the REEFEX study for the ex-VERMILLION (Johnston et al. 2005a, Figure 15, Table 13). The BCF was calculated as:

$$BCF_{PCB} = \Sigma f_{PCBi} \times BCF_i \times 0.64 \text{ [L/kg wet weight]} \qquad [8]$$

Where i is the index for each homolog group mono through deca (Table 13) and 0.64 is a lipid-normalizing factor used to normalize the average lipid content of REEFEX fish (3.51%) to 3%. The U.S. EPA uses 3% as the average lipid content of aquatic organisms to determine the water quality criteria value for PCBs (U.S. EPA 1980, URS 1996, Table 13).

5.1.3.3 Critical Body Residues

Critical body residues (CBR) are defined as the threshold concentration of a contaminant in the tissue of an organism above which adverse effects could occur (McCarty et al. 1992, Pabst 1999). Generally, the effect occurs as a result noncancerous effects and can result in death (mortality), or a reduction in fecundity, reproduction, or growth (chronic effects). Data from the US Army Corps of Engineers Environmental Residue-Effects Database (ERED 2002, see http://el.erdc.usace.army.mil/ered/) were used to develop benchmarks for critical body residues. The database was searched for effects from PCBs on reproduction, growth and development, and survival. Results that were based on adult, juvenile, or larval exposure, whole body concentration, and ingestion or absorption were used, if available (Figure 16, Appendix C. Search Results from ERED Database). Benchmarks were selected for the highest no observed effect dose (NOED) and lowest observed effect dose (LOED) for the receptor species of interest (i.e. fish and invertebrates).[13] If the highest NOED was greater than the lowest LOED, then a NOED was selected that was lower than the lowest LOED (Table 10, Table 14, Table 15).

An uncertainty factor (UF), if applicable, was used to derive the NOED and LOED benchmarks for fish (T_{FISH}) and invertebrates (T_{INVERT}) [mg/Kg wet weight] by:

$$NOED = NOED_{ERED} \times UF \qquad [9]$$

$$LOED = LOED_{ERED} \times UF \qquad [10]$$

The NOED for fish was based on sheepshead minnow and the fish tissue LOED was based on lake trout data. The NOED for invertebrates was based on mussels and the invertebrate tissue LOED was based on toxicity to grass shrimp. No adjustment to the effects levels were required (effects levels were for a chronic endpoint during a sensitive life stage) and the exposure levels were assumed to be directly applicable to reef organisms being evaluated in the ecological risk assessment, therefore an UF=1 was used in calculating the NOED and LOED benchmarks (Table 14, Table 15, Appendix C. Search Results from ERED Database).

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[13] NOED and LOED are used to be consistent with the ERED nomenclature, which defined "dose" as the body burden concentration. Values selected from the database were the no observed adverse effects (NOED) and lowest observed adverse effect (LOED), where adverse was defined as a negative impact to growth, development, reproduction, or survival.

Procedures for conducting ecological effects assessments under TSCA commonly use hazard “assessment factors” (AF) to account for gaps in knowledge associated with estimating chronic toxicity from acute toxicity, accounting for species-to-species differences, and extrapolating from laboratory tests to field toxicity levels (Zeeman 1995, the benchmark is divided by the AF of 10 – 1000, as appropriate). For example, an AF of 10 is used to extrapolate from chronic effects to no effects, an AF of 100 is used to extrapolate from acute toxicity to no effects, and an AF of 1000 is used to extrapolate from structure-activity relationships (SAR) and quantitative (Q)SAR estimates of toxicity to no effects levels (U.S. EPA 1984, Nabholz 2003, Zeeman 1995, Zeeman et al.1999). The AF provides an additional level of conservatism in the ecological risk assessment to provide a consistent basis needed for regulatory decision-making. The AF is applied by dividing the appropriate benchmark (B) by the AF before calculating a hazard quotient (HQ):

$$B^* = B/AF \qquad [11]$$

Where

B^* = The benchmark adjusted for AF uncertainties (U.S. EPA 1984, Zeeman 1995)

If environmental concentrations are below the benchmark/AF, it doesn’t necessarily mean that there is no risk, rather it suggests that the level of risk “… is probably too low to warrant taking any regulatory action” (Zeeman 1995). The CBR data obtained from ERED contained data for many fish and invertebrate species, however, there is uncertainty of whether the toxicological data from ERED are directly applicable and protective to sensitive species that could be present at the reef. Therefore, an AF=10 was applied to the NOED and LOED to account for species-to-species differences in toxicity (Table 10).

One-way of addressing the broader implications of potential ecotoxicolgical effects from PCBs is to compare the benchmarks to species sensitivity distributions (SSD). Derived from toxicity data, SSDs are cumulative distribution functions that describe the proportion of a class of organisms (in this case fish and invertebrates) that will be affected by a given level of exposure to a contaminant (Posthuma et al 2001, Maltby et al. 2005). Data from the ERED database on effects of PCBs to fish and invertebrates (both fresh and saltwater species) were used to calculate SSDs for PCB residues in fish. Assuming that the toxicity data conformed to a lognormal distribution, the ERED data for effects to growth, reproduction, or survival from PCB residues in juvenile/adult fish (Figure 17), and invertebrates (Figure 18) were used to calculate the cumulative probability distributions for no effect (NOED) and low effect (LOED). The available toxicity data included freshwater species (lake trout, golden ide, catfish, etc). Sheepshead minnow, pinfish, salmonids, and others represented saltwater species. The SSD calculated from the ERED data are not based on genus-mean concentrations, rather the raw toxicity data were used. While genus-mean concentrations are more preferable for evaluating potential toxicity effects across a wide range of organisms (Posthuma et al 2001, Maltby et al. 2005), developing genus-mean effects levels was beyond the scope of this report. The SSDs for PCB residues shows that the benchmarks selected for the risk analysis are protective of effects from PCBs that have been observed in fish (Figure 17) and invertebrates (Figure 18).

5.1.3.4 Food Chain Benchmarks

The potential for PCBs to affect higher trophic levels was evaluated by assessing contaminant concentrations in tissues of representative prey. The exposure to an upper trophic level predator (bird of prey, dolphin etc.) is related to the exposure from eating prey species (clam, fish, worm, etc.) that have bioaccumulated contaminants from exposure pathways present within the reef community (Figure 11). Benchmarks were calculated for herring gulls and double crested cormorants, bottlenose dolphins, loggerhead sea turtles, and sandbar sharks/greater barracudas. Point estimates of ecological effects for a test species or Toxicity Reference Values (TRVs) corresponding to the No Observed Adverse Effect Level (NOAEL) and Lowest Observed Adverse Effect Level (LOAEL) were used to determine potential adverse exposure to the predators. When a NOAEL is used to calculate the TRV, the TRV represents a chemical concentration at or below which significant effects to the receptor are not anticipated. When the LOEAL is used to calculate the TRV, the TRV represents a chemical concentration above which ecological effects to the receptor could occur. Because the TRVs were derived from test species that differed from the receptor species, an AF=10 was used to account for species-to-species differences in toxicity (Equation [11], Table 10).

5.1.3.4.1 Avian Consumers

The benchmarks for PCB exposure to omnivorous herring gulls (*Larus argentatus*) and piscivorous double-crested cormorant (*Phalacrocorax auritus*) were developed based on toxicological studies on ring-necked pheasants (*Phasianus colchicus*, Table 16, Table 17, Sample et al. 1996). Introduced into North America from Asia, ring-necked pheasants consume a wide variety of plants (seeds and grains) and animals including insects (grasshoppers, crickets, and ants are the primary food for young chicks) and occasionally small snakes and rodents (USFS 2004). Although ring-necked pheasants have a very different diet than seabirds, they are about the same size (1 kg) and have the about the same dietary needs (Sample et al. 1996) as herring gulls (body weight of 1.1 g and a dietary intake of 264 g/d, U.S. EPA 1995) and cormorants (body weight 1.9 g and a dietary intake of 475 g/d, Environment Canada 2004c).

Sample et al. (1996) reported that scaling factors, such as used for mammals, are not appropriate for avian species because an analysis of existing data showed that the scaling factor which ranged from 0.63 to 1.55 with a mean of 1.15, was not significantly different than 1. This suggests that toxicity effects to birds of prey receptor species would be similar to the species tested (ring-necked pheasant for PCB) after adjusting for differences in food consumption rate and body weight of the receptor species. Therefore, based on the similarity of toxicity values reported among avian species, the NOAELs and LOAELs reported for ring-neck pheasants were assumed to be equivalent for herring gulls and cormorants (Equation [12] and [13], Sample et al. 1996).

NOAEL:

$$TRV_{Gull} = TRV_{Cormorant} = NOAEL_{Pheasant} = 0.18 \text{ ug/g bw/day WW (Sample et al. 1996)} \quad [12]$$

LOAEL:

$$TRV_{Gull} = TRV_{Cormorant} = LOAEL_{Pheasant} = 1.80 \text{ ug/g bw/day WW (Sample et al. 1996)} \quad [13]$$

The dietary consumption benchmarks (D_{PREY}) of prey tissues for the NOAEL and LOAEL were calculated for herring gulls and double crested cormorants (Table 17) by:

D_{PREY} = $(TRV \times UF)/F$ µg/g (wet weight) [14]
UF = Uncertainty factor
F = Dietary uptake factor (g/g body weight/day)
F = $aRdL$ [15]
R = Food ingestion rate (g/g body weight/day)
R = f/bw g/g body weight/day (Sample et al. 1996) [16]

Where

a = Assimilation efficiency = 0.9
f = Food consumption rate:
Herring gull = 264 g/d (U.S. EPA 1995, CFR40 part132).
Cormorant = 475 g/d (Environment Canada 2004c).
bw = Herring gull body weight = 1,100 g (U.S. EPA 1995, CFR40 part132)
Cormorant body weight = 1,900 g (Environment Canada 2004c)
d = Fraction of diet = 1.0
L = Fraction of life span = 1.0

The avian benchmarks assumed that PCBs would have similar toxic effects and mode of action in herring gulls and cormorant as was observed in pheasants, after converting the dose for body weight and ingestion rate. Because of the similarity in toxicity to avian species, the UF in Equation [12] was set to 1. The Total PCB benchmark was based on a 17-week chronic exposure to technical grade Aroclor 1254 introduced by gel capsules mixed into the ring-necked pheasants' food. The test showed significantly reduced egg hatchability following exposure throughout a critical life stage (reproduction, Dahlgren et al. 1972 cited in Sample et al. 1996), and these effects were assumed to be applicable and appropriate for the protection of sea birds. The benchmarks for exposure to Total PCB were 0.8 mg/Kg wet weight for the no effects level and 8.0 mg/Kg wet weight for the low effects level, reflecting the factor of ten difference assumed between the observed LOAEL and calculated NOAEL reported in Sample et al. (1996). The benchmarks obtained for avian consumers (Table 16, Table 17) indicated that cormorants and gulls would have about the same sensitivity to PCB exposure. The main difference between the gull and cormorant benchmark was that invertebrate PCB concentrations could be evaluated using the benchmarks for herring gull, while the cormorant benchmarks were only applicable to concentrations of PCBs in fish. Because the TRVs for cormorants and gulls were derived from a test species (ring-necked pheasant) that differed from the receptor species, an AF=10 was used to account for species-to-species differences in toxicity (Equation [11], Table 10).

5.1.3.4.2 Dolphins

The mink (*Mustela vison*) was selected as the most similar mammalian test species to dolphins. Minks are voracious carnivores (1 kg body weight, consuming 137 g/day of food, Sample et al. 1996), a large component of a mink's diet consists of fish (Sample et al. 1996), and mink are more similar to dolphins than other mammalian species for which toxicology data are available, such as laboratory rats, white-footed mice, and oldfield mice (Sample et al. 1996). Additionally, mink are more sensitive to PCBs than laboratory rats or white-footed mice (Sample et al. 1996). Experimentally derived toxicity values for mink ($NOAEL_{mink}$, $LOAEL_{mink}$) were converted to effects levels for dolphins ($TRV_{Dolphin}$) by scaling the dose to the ratio of body weight of mink to the body weight of dolphins using an empirical relationship (Sample et al. 1996):

$$TRV_{Dolphin} = NOAEL_{mink}\left(\frac{bw_{mink}}{bw_{dolphin}}\right)^{1/4} \qquad [17]$$

The dietary consumption benchmarks (D_{PREY}) of prey tissues for dolphins (Table 18) were determined using Equations [14], [15], and [16] with the following relationships:

a = Assimilation efficiency = 0.9
f = Dolphin food consumption rate = 27,000 g/day (Davis and Schmidl 1997)
bw = Dolphin body weight = 215,000 g (Seaworld 2000)
d = Fraction of diet = 1.0
L = Fraction of life span = 1.0

The relative increased sensitivity of mammalian species to PCBs was evident in the fact that the dolphin NOAEL benchmark (0.32 mg/Kg wet weight) was about 3 times lower than the cormorant NOAEL benchmark (0.8 mg/Kg wet weight) and the dolphin LOAEL benchmark (1.58 mg/Kg wet weight) was 5 times lower than the cormorant LOAEL benchmark (8 mg/Kg wet weight). The Total PCB benchmarks for dolphins were based on a 4.5-month chronic study where mink were feed a diet mixed with varying concentrations of technical grade Aroclor 1254. The study found that prolonged exposure to PCBs in the mink's diet reduced the number of live kits born at the end of the reproductive cycle (Aulerich and Ringer 1977 cited in Sample et al. 1996). Enough treatment doses were tested to allow the NOAEL to be calculated rather than estimated as was done for the ring-necked pheasant study (Sample et al. 1996), which explains the reduced range between the NOAEL and LOAEL benchmarks for dolphins as compared to birds. The effects from PCBs observed in mink were assumed to be applicable and appropriate for the protection of dolphins and the UF in Equation [12] was set to 1. Because the TRVs for dolphins were derived from a test species (mink) that differed from the receptor species, an AF=10 was used to account for species-to-species differences in toxicity (Equation [11], Table 10).

In a study of PCB risk to bottlenose dolphins (*Tursiops truncates*), Schwacke et al. (2002) justified the use of mink as surrogates for dolphins because mink are the most sensitive mammalian species for which PCB toxicity data are available and that mink have similar pharmokinetic pathways as dolphins (cetaceans), specifically, both have relatively lower levels of phenobarbital-type (PB-type) and 3-methylcholanthrene-type (MC-type) enzymes necessary for metabolizing PCBs than other birds or mammals. Additionally, it is very difficult to obtain toxicological data for a protected species such as dolphins (Schwacke et al. 2002).

The NOAEL benchmark for bottlenose dolphin obtained for Total PCB in fish tissue (0.32 ug/g wet weight) is similar to the wildlife protection value (WV_{Fish}) derived to be protective of piscivorous birds and mammals (U.S. EPA 1997). The WV_{Fish} is based on monitoring data compiled in the National Sediment Quality Survey; it is based on the sum of measured congeners (sumPCB, i.e. NOAA 18) and set to the lowest toxicity threshold calculated for kingfisher, herring gull, otter, mink, or eagle (U.S. EPA 1997). The mammalian species are more sensitive to PCBs, so the U.S. EPA set the WV_{Fish} value to the mammalian threshold (U.S.

EPA 1997). When the WV_{Fish} value of 0.16 mg/Kg wet weight sumPCB is expressed as Total PCB using the empirical relationship[14] from the NOAA Status and Trends Program (NOAA 1991), the value of 0.352 mg/Kg wet weight is obtained, which is essentially the same as the dolphin benchmark.

5.1.3.4.3 Loggerhead Sea Turtles

No applicable TRVs are currently available for reptiles (Chris Salice, Headquarters, U.S. EPA, personal communication) so the mammalian TRV (which was lower on a per-body-weight basis that the avian TRV) for PCBs was assumed to be protective of sea turtles after converting to account for body weight and dietary intake rate of sea turtles. This approach assumes that benchmarks protective of avian and mammalian species would also be protective of reptiles (see Great Lakes Water Quality Initiative Methodology for the Development of Wildlife Criteria, U.S. EPA 1995, CFR 40 part 132).

Due to the lack of toxicity data on reptiles, the PCB TRVs obtained for dolphins were assumed to be protective of loggerheads. By using the same scaling factor used for mammals (Equation [17]) and substituting the body weight and ingestion rate of loggerhead turtles into Equations [14], [15], [16], and [17]) the benchmarks (D_{PREY}) of prey tissues for loggerhead turtles (Table 19) were obtained:

a = Assimilation efficiency = 0.9
f = Loggerhead food consumption rate = 2421 g/day (Seaworld, Ask Shamu, personal communication)
bw = Loggerhead body weight = 113,000 g (Bolten and Witherington 2003)
d = Fraction of diet = 1.0
L = Fraction of life span = 1.0

Because applicable TRVs are currently not available for reptiles (Chris Salice, U.S. EPA, personal communication), the mammalian TRV for PCB was assumed to be protective of loggerhead sea turtles after accounting for consumption rate and size of the sea turtles. The sea turtle benchmarks for Total PCB were based on mammalian (mink) TRVs (Table 19). The relatively low feeding rate of cold-blooded sea turtles compared to warm-blooded mammals accounts for the higher mammalian-based benchmarks for turtles. It is assumed that warm-blooded birds and mammals are more sensitive to PCBs than sea turtles (and other reptiles) and the UF in Equation [12] was set to 1, but, in fact, it is not known whether this is true or not. Because the TRVs for loggerhead sea turtles were derived from a test species (mink) that differed from the receptor species, an AF=10 was used to account for species-to-species differences in toxicity (Equation [11], Table 10).

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[14] The equation for total PCB (tPCB = 2.19sumPCB + 2.19) was obtained by NOAA's Status and Trends Program from a regression of empirical data from samples that were analyzed for both individual congeners (sumPCB) and total Aroclors (tPCB) (NOAA 1991).

5.1.3.4.4 Sharks and Barracuda

For shark and barracuda the food chain benchmarks were based on the dietary dose that corresponded to the concentration in the diet that would result in the NOED or LOED concentration for the most similar species available from the ERED database (Appendix C. Search Results from ERED Database). The NOED was based on the no effect level reported for striped bass (*Morone saxatilis*, Westin et al. 1983) and the LOED was based on reduced growth to winter flounder (*Pseudopleuronectes americanus*) larvae (Black et al. 1998).

Toxicological benchmarks for PCBs in shark and barracuda were developed using the ratio of Food Chain Multipliers (FCMs) between trophic level IV (TL-IV reef predator, e.g. shark) and Trophic Level III (TL-III reef forager, e.g. prey) obtained from USEPA (2000b). The FCMs apply to chemicals with $\log K_{ow}$ values between 4.0 and 9.0 and “reflects a chemical’s tendency to biomagnify in the aquatic food web” (U.S. EPA 2000b). The FCMs are used to account for relative increase of a contaminant in the food chain. The ratio between FCM for TL-IV and TL-III gives the relative increase in contaminant concentrations between a TL-IV predator and its prey, assuming all the predator’s dietary requirements came from TL-III. The ratio was calculated by:

$$FCM_{TotalPCB} = \Sigma(f_{PCBi} \times FCM4_i/FCM3_i) \qquad [18]$$

where

$FCM4_i$ = The TL-IV FCM for homolog i (i=1, 10) (U.S. EPA 2000).
$FCM3_i$ = The TL-III FCM for homolog i (i=1, 10) (U.S. EPA 2000).
f_{PCBi} = The fraction of PCB present as homolog i (i=1, 10) in fish tissue (see Table 13)

This formulation is weighted by the fraction of PCBs observed in fish tissue for each homolog group (Table 13, Figure 15) and assumes that the predator and its prey have the same relative distribution of PCBs in their tissues. Using the above ratio, the benchmark tissue concentrations for Total PCB in the diet of sharks/barracudas were calculated by setting the shark’s tissue concentration to the critical body residue NOED and LOED, and solving for the allowable tissue concentration in the diet of a shark or barracuda (D_{PREY}, Table 20):

$$Shark_{NOAEL} = NOED/wFCM_{TotalPCB} \qquad [19]$$

$$Shark_{LOAEL} = LOED/wFCM_{TotalPCB} \qquad [20]$$

The FCMs used to calculate the shark/barracuda benchmarks were based on assumptions about the conceptualized food chain for the reef represented by phytoplankton and encrusting algae (TL-I), sessile filter feeder (TL-II), planktivore (TL-II), forager (TL-III), and predator (TL-IV) and that a steady state existed among PCB sources (PCB-containing materials) and PCBs in all the abiotic (sediment, pore water, water, suspended solids, dissolved organic carbon) and biological compartments. Assuming that the shark/barracuda feed 100% on fish, grouper (TL=3.95), triggerfish (TL=2.97), jack (TL=3.96), or flounder (TL=4.11, see Table 7), the shark/barracuda’s effective TL would range within 3.97 to 5.11 (from Equation [3]). The shark/barracuda NOED (2.52 mg/Kg wet weight) and LOED (4.066 mg/Kg wet weight) were about 8 and 2.5 times higher than the dolphin prey NOAEL and LOAEL benchmarks, respectively. The shark/barracuda benchmarks assumed that these large voracious predators had the same sensitivity to PCBs as striped bass (Westin et al. 1983) and winter flounder (Black et al. 1988) tested in the laboratory (Table 20). Because the TRVs were derived from test species that differed from the receptor species, an AF=10 was used to account for species-to-species differences in toxicity (Equation [11], Table 10).

5.1.4 Analysis of Dioxin-like Toxicity

Early toxicity studies on PCBs were conducted on technical Aroclors and effects were reported as a function of Total PCB or total Aroclor concentrations. In the last decade, evidence has been mounting that specific congeners are more toxic than others, especially the dioxin-like coplanar PCBs (Ahlborg et al. 1994, Van den Berg et al. 1998, Barney 2001). The TEQ is calculated by summing the products of the concentrations of individual coplanar congeners [PCB_i] and their dioxin toxicity equivalency factors (TEF_i):

$$TEQ = \Sigma\ coPCB_i \times TEF_{ij} \qquad [21]$$

Where, TEF_i expresses the potency of coplanar congener "i" to species "j" (fish, mammals, or birds) relative to TCDD (i.e., TCDD TEF=1). The World Health Organization (Van den Berg et al. 1998, EPA 1998) has established TEFs for fish, birds, and mammals that can be used in ecological risk assessments for the coplanar dioxin-like PCBs (Table 21, see TEF Table on U.S. EPA PCB web site).

As explained above, the current version of PRAM only models the accumulation of PCB homologs not individual congeners. However, leach rate data was collected on individual congeners, including the coplanar congeners (except for PCB081) during the leachrate experiments (Table 22, George et al. 2005, 2006). Assuming that individual coplanar congeners behave in the same way as the homologs modeled in PRAM, the proportionality between the individual coplanar congener and corresponding homolog observed during the leachrate experiments (Table 23) was used to estimate the coplanar congener concentration present in the food chain modeled by PRAM:

$$coPCBi = ww\_HOMOCLj \times fh\_PCBi \times 10^6 \text{ [pg PCB/g WW]} \qquad [22]$$

$$coPCBLi = lipid\_HOMOCLj \times fh\_PCBi \times 10^6 \text{ [pg PCB/g Lipid]} \qquad [23]$$

Where fh_PCBi = The fraction of homolog "j" accounted for by coplanar congener "i" observed in the leachrate experiments on a wet weight basis (Table 23)

ww_HOMOCLj = The wet weight concentration of homolog "j" predicted by PRAM [mg/Kg WW]

lipid_HOMOCLj = The lipid weight concentration of homolog "j" predicted by PRAM [mg/Kg Lipid]

No data were available for PCB081, so the concentration of 3,4,4',5-tetrachlorobiphenyl (PCB081e) was estimated using the concentration of 3,3',4,4'-tetrachlorobiphenyl (PCB077) assuming that the ratio of PCB081 **:** PCB077 reported for lake trout (*Salvelinus namaycush*, Table 24, Cook et al. 2003) and pre- and postmigrating sockeye salmon (deBruyn et al. 2004) was applicable to the model results.

$$PCB081e = R_{81:77} \times PCB077 \qquad [24]$$

Where

$R_{81:77}$ = Average ratio of PCB081/PCB077 reported by Cook et al. (2003) and deBruyn et al. (2004)

The homolog concentrations for terta-, penta-, hexa-, and heptachlorobiphenyl predicted by PRAM were multiplied by the proportionality factor (fh_PCBi) to obtain the concentration of coplanar congeners, which were then multiplied by the respective TEFs to calculate TEQs for fish eggs and to assess dietary exposure to birds and mammals. Eggs and sac-fry larvae are the most susceptible life stage of fish to dioxin-like toxicity (deBruyn et al. 2004, Cook et al. 2003). Risk to fish from exposure to dioxin-like coplanar PCBs was evaluated by estimating the TEQ concentration that could be passed from female fish to eggs. Mortality to lake trout sac fry larvae (*Salvelinus namaycush*) has been reported at 30 pg TEQ/g egg (wet weight) and sublethal effects have been reported above 5 pg TEQ/g egg wet (Cook et al. 2003). Rainbow trout (*Oncorhynchus mykiss*) were found to be more sensitive with a no effect to egg mortality at 0.3 pg/g egg wet weight and low effect level of 3 pg/g egg lipid wet weight (deBruyn et al. 2004, see Table 14 and Table 15). Assuming that the coplanar concentrations obtained for fish species from PRAM represented tissue residues in female fish, the TEQ concentrations in eggs were estimated using the average egg to female transfer ratio for each coplanar congener (EF_{PCBi}) calculated from data for lake trout and pre- and postmigrating sockeye salmon eggs and females reported in Cook et al. (2003) and deBruyn et al. (2004, Table 24). The fish egg TEQ (C_{EGG}) was obtained by:

$$\text{TEQ\_eggL} = \Sigma\ \text{coPCBLi} \times EF_{PCBi} \times \text{TEFi(fish)}\ \ [\text{pg TEQ/g egg lipid}] \qquad [25]$$

$$\text{TEQ\_eggW} = \text{TEQ\_eggL} \times \text{f\_eggLIPIDw}\ \ [\text{pg TEQ/g egg wet weight}] \qquad [26]$$

Where

f_eggLIPIDw = = 0.1091 the average mass fraction of lipid:wet weight in eggs (roe) reported from literature (see Table 24C)

$$EF_{PCBi} = \frac{\text{[PCBi] pg/ g lipid egg tissue}}{\text{[PCBi] pg/ g lipid female muscle tissue}} \qquad [27]$$

$TEF_{PCBi(Fish)}$ = Fish dioxin TEF for coplanar congener “i”

The TEQs for dietary exposure were calculated to assess the risk of dioxin-like exposure to fish eating birds and mammals (see Table 16, Table 17, and Table 18).

$$\text{TEQB} = \Sigma\ [\text{coPCBi}] \times TEF_{PCBi(Bird)}\ [\text{pg TEQ/g ww}] \qquad [28]$$

$TEF_{PCBi(Bird)}$ = Avian dioxin TEF for coplanar congener i

and

$$\text{TEQM} = \Sigma\ [\text{coPCBi}] \times TEF_{PCBi(Mammal)}\ [\text{pg TEQ/g ww}] \qquad [29]$$

$TEF_{PCBi(Mammal)}$ = Mammalian dioxin TEF for coplanar congener i

The predicted concentrations of TEQs in fish eggs, and prey of birds and mammals were compared to fish egg (Table 14 and Table 15), avian (Table 16 and Table 17), and mammalian (Table 18) TEQ benchmarks. Because the TEQ benchmarks were derived from test species that differed from the receptor species expected to be present at the reef, an extra level of conservatism was achieved by applying an AF=10 to account for species-to-species differences in sensitivity to TEQ exposure (Table 10).

Photo by Keith Mille (keith.mille@MyFWC.com) Florida Fish & Wildlife Conservation

6. Risk Characterization

This section characterizes the ecological risk by comparing the exposure point concentrations estimated by the models to the benchmarks developed to be protective of the ecological assessment endpoints. Following a description of the procedures and evaluation criteria used in the risk analysis the risks from water, sediment, tissue residue, and dietary exposure to Total PCB and dioxin-like TEQs are characterized and discussed.

6.1 Ecological Risk Analysis

The ecological effects benchmarks (Table 10) define the boundaries of the threshold concentrations that and would raise "sufficient concern regarding adverse ecological effects" (U.S. EPA 1996a) if exceeded. For each effect level, two benchmarks were developed to define the lower and upper bound of the threshold that may cause adverse effects (U.S. EPA 1998c). These benchmarks were used to assess potential ecological risks to the assessment endpoints associated with the artificial reef (Table 3). Risks from sediment and water exposures modeled by TDM and PRAM were evaluated by comparing the predicted concentrations to the sediment and water benchmarks. Risks to primary producers, primary consumers, secondary consumers, and tertiary consumers of the reef were evaluated by comparing the exposure point concentrations to benchmarks protective of tissue residue exposures. Risks to reef consumers were evaluated by benchmarks protective of dietary exposure.

The risk analysis consisted of two components: a graphical analysis and a hazard quotient analysis. The data predicted by the TDM/PRAM models were plotted as time series from 0 – 730 days following sinking to represent the transient release period followed by the steady state condition predicted by PRAM for ZOI=2 (plotted as "Day 770") and ZOI=1 (plotted as "Day 800"). Simulated data for water, sediment, and tissue residues for the pelagic, benthic, and reef communities were plotted on the time series plots along with the lowest applicable benchmark(s) (if the benchmark(s) fell within the scale of the data plotted). The average and minimum to maximum range of PCB concentrations obtained from the EMAP and IMAP data were also plotted on the plots of tissue residues to compare modeled data to regional and background concentrations.

To quantify the potential for ecological risk, an ecological hazard quotient[15] (HQ) was calculated for each receptor in a given exposure pathway, where the HQ is the ratio between the potential exposure level (concentration or dose C) and the ecological effects benchmark (B):

$$\mathrm{HQ} = C / \mathrm{B} \qquad [30]$$

And

$$\mathrm{HQ}^* = C / \mathrm{B}^* \qquad [31]$$

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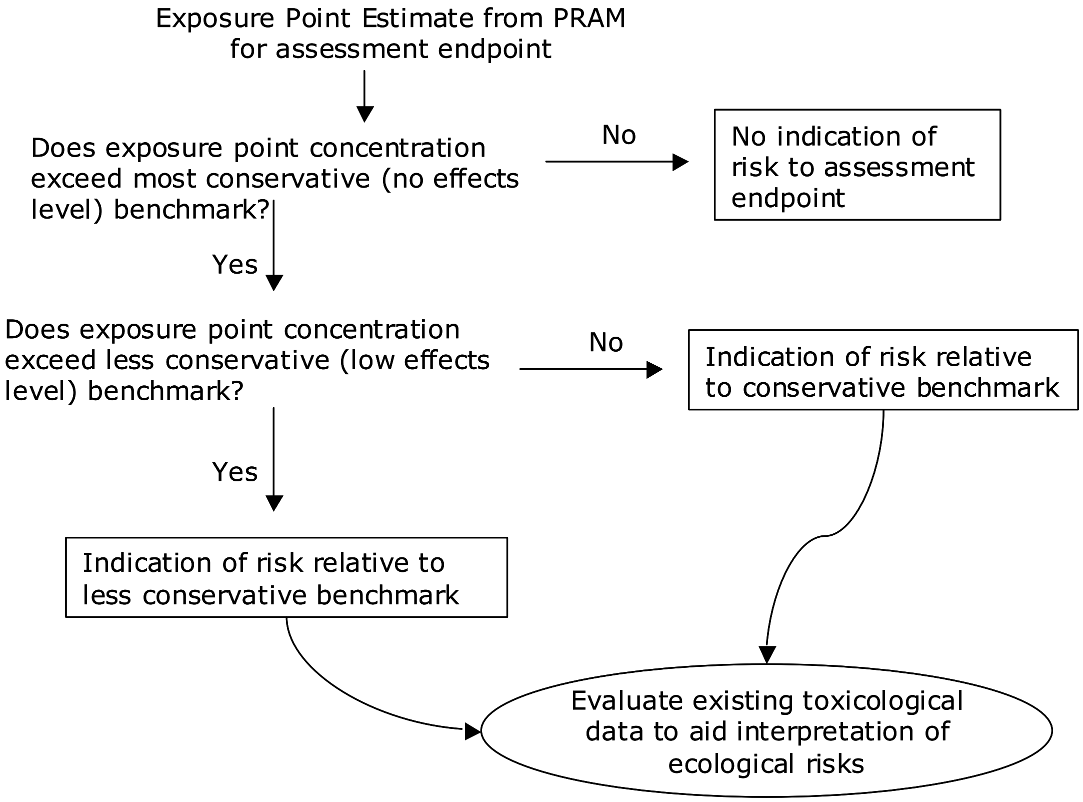
[15] Because Total PCB is really the sum of all 209 individual congeners, the hazard quotient can also be thought of as a hazard index (HI).

Where C is the exposure concentration predicted using the models and B is the benchmark concentration that, when exceeded, have been associated with causing ecological effects (i.e. values in Table 10). The HQ* is the hazard quotient adjusted for assessment factor (AF) uncertainties (see Equation [11]). When HQ or HQ* are < 1 the chemical is below potentially harmful exposure indicated by the benchmarks (B, B*) and the quotient represents the fraction of exposure relative to the benchmark. When HQ or HQ* are ≥ 1 the chemical is above potentially harmful exposure indicated by the benchmark and the quotient represents the factor above the benchmark.

6.2 Evaluation Criteria

The range of potential effects from no effect to low effect defined by the benchmarks was used to characterize risk. The exposure point concentrations estimated by PRAM were compared to the conservative and less conservative benchmarks for each applicable exposure pathway and assessment endpoint (Table 25). The following diagram depicts the evaluation criteria used for the risk analysis:



If the exposure point concentration did not exceed the most conservative benchmark (e.g. no effect level), the risk analysis concluded that there was no indication of risk to the assessment endpoint. If the exposure point concentration exceeded either the most conservative or less conservative benchmark (e.g. low effects level) an indication of risk relative to that benchmark was suggested. For example, exposure point concentrations that exceed the no effect level but not the low effect level would be an indication that the lower bound of the effect threshold had been exceeded. The available toxicological data were evaluated to aid in the interpretation of ecological risks. The evaluation was conducted by comparing the exposure point estimate from PRAM to the toxicological data from the scientific literature.

6.3 Risk from Water Exposure

The time series of Total PCB concentrations predicted by the TDM for bulk water concentrations in the upper water column (UWC), lower water column (LWC), and sediment pore water (PW) within 0 - 15 m of the ship for the first two years following sinking and the steady state concentrations predicted by PRAM with a ZOI=2 and ZOI=1 and the water quality benchmarks are shown in Figure 19. Predicted concentrations for the UWC, LWC, and PW were more than an of magnitude below the water quality benchmarks for the 0-2 yr and steady state exposure periods, and resulted in HQs < 0.1 during both exposure scenarios (see Appendix D. Media Concentrations and Hazard Quotients Calculated for 0-2 Years and Steady-State Ecological Risks). Similar results were obtained for 0-2 yr and steady state exposures from UWC, LWC, and PW modeled for 0-45 m and ZOI=5 from the ship (Figure 20, Appendix D.1). The HQs calculated for these exposure levels were also below HQ < 0.1 (data not shown).

The Total PCB concentrations simulated for the IVW were about 3 orders of magnitude higher than the LWC concentrations and were higher than the chronic (WQC-Chronic) and wildlife water quality (GLWLC-Tier1) benchmarks; the IVW concentrations did not exceed the acute water quality criteria for Total PCB (Figure 21). During the 0-2 yr period the IVW ranged from 2.4×10^{-4} to 6.74×10^{-4} mg/L, the steady-state concentration was slightly higher at 6.9×10^{-4} mg/L (Table 9). As was noted previously, the IVW steady-state concentration did not change as function of ZOI (see Appendix B), it remained constant with an HQ=23 for WQC-Chronic, HQ=9 for GLWLC-Tier1, and HQ<0.1 for WQC-Acute (see Appendix D.2 Hazard Quotients of Total PCB for Media Within 0-15 m of the Hull).

The exposure point estimate for IVW was compared to toxicological data on water exposure to PCBs. The toxicity data developed in support of WQC are shown in Figure 22 and Table 26. Figure 22 shows the lognormal cumulative distribution of effects to marine organisms from water exposure to Aroclor 1254 (magenta circles and curved line), the benchmarks for water exposure (yellow △), and the exposure point estimate for IVW (PRAM IVW, blue □) based on steady state conditions. Toxicity data (circles) are from US EPA 1980, Ambient Water Quality Criteria for Polychlorinated Biphenyl. Based on the data available, Aroclor 1254 is the most toxic Aroclor. Since the IVW exceeded the WQC-Chronic benchmark, is it appropriate to use the toxicity data used to support the criterion (U.S. EPA 1980) to evaluate potential ecological effects. The IVW concentration predicted by PRAM was at the lower end of the range of concentrations that caused toxicity in laboratory studies. The modeled IVW concentration exceeded chronic toxicity levels associated with early life cycle development and reproduction (28-day) of sheepshead minnows and community development of marine organisms (Table 26, Figure 22, U.S. EPA 1980).

It is reasonable to assume that the toxicity of technical Aroclor 1254 tested under laboratory conditions is similar to the toxicity of Total PCBs leached from the ship and modeled by PRAM, because the Aroclor mixtures were the "Total PCB" exposed during the bioassay tests and weathering or biodegradation of PCBs is not included in the PRAM model. There is also uncertainty about interspecies differences and the differences between controlled laboratory experiments and actual situations in the real world.

The IVW compartment was a necessary model construct to link PCB releases from solid materials inside the ship to water surrounding the reef. Because of the limited exchange between the interior water and the lower water column surrounding the reef, the interior compartments within the deeper recesses of the vessel would not be expected to be readily colonized by vertebrate and invertebrate reef species that need a constant source of food from the outside of the vessel. Therefore, it was assumed that the predominant route of exposure from the interior water would be from bioaccumulation and trophic transfer in the food chain rather than effects from direct toxicity. The risk of exposure from the interior water and release of PCBs from the solid materials left on the ship were evaluated by the impact on exposure levels in the lower water column, upper water column, sediment, and the accumulation of PCBs in the biota living at the reef.

Based on the HQs obtained for evaluating exposures to reef organisms from PCBs in the lower water column, upper water column, and sediment pore water (Table 27) there was no indication of risk to marine life resident at the reef. Contact with elevated exposures modeled for internal vessel water was identified as the most important pathway for bioaccumulation and trophic transfer in the food chain.

6.4 Risk from Sediment Exposure

Time series of Total PCB concentrations predicted by the TDM for sediment within 0-15 m of the ship for the first two years following sinking and the steady state concentrations predicted by PRAM with a ZOI=2, and ZOI=1 and the State of Florida sediment quality benchmarks are shown in Figure 23A. Predicted concentrations were more than 3 orders of magnitude below the sediment quality benchmarks for both the 0-2 yr and steady state exposure periods, and resulted in HQs < 0.1 (see Appendix D.2).

Similar results were obtained for sediment exposure predicted for short-term and long-term exposures modeled for 0-45 m (ZOI=5) from the ship (see Figure 23B). The HQs calculated for these exposure levels were all well below HQ < 0.1 (data not shown).

Based on the data available for evaluating sediment exposures to reef organisms, there was no indication of risk from PCBs in sediment to marine life at the reef.

6.5 Risk from Tissue Residue Exposure

The outputs of the TDM/PRAM were used to evaluate 0–2 yr risks for communities within 0 - 15 m, 0 - 45 m, and 0 - 60 m of the vessel; steady-state risks were evaluated using outputs from PRAM with ZOI=2 and ZOI=1 (0-15 m), ZOI=5 (0 - 45 m, 0 - 60 m). The modeled concentrations were compared to the ecological risk benchmarks to evaluate potentially harmful exposures to PCBs. The tissue residues predicted in reef biota were compared to the TSV and B_{CV} benchmarks to evaluate potential bioaccumulation effects to residents of the reef. The tissue residues predicted for primary consumers, secondary consumers, and tertiary consumers were compared to the NOED and LOED benchmarks protective of critical body residues for PCBs. Dietary exposure of Total PCB to reef and avian consumers was evaluated by comparing predicted prey concentrations to the dietary NOAEL and LOAEL benchmarks derived for herring gulls, cormorants, sea turtles, dolphins, and sharks/barracudas.

Estimates of TEQ exposure were obtained by assuming that dioxin-like coplanar congeners would be present in same congener:homolog proportion observed in the leachrate experiments (Table 23, George et al. 2005, 2006). Potential risks from dietary exposure of TEQs to gulls, cormorants and dolphins were evaluated by comparing modeled tissue concentrations in prey to TEQ dietary benchmarks for those species. Potential risks of TEQ exposure to fish eggs and sac-fry larvae, the most sensitive life stage of fishes to TEQ toxicity, were evaluated by predicting the maternal transfer of TEQs to fish eggs and comparing the resulting fish egg concentrations to sensitive egg residue benchmarks for TEQ exposure.

6.5.1 Exposure to Total PCB

The time series of Total PCB concentrations predicted by PRAM for the pelagic, benthic, and reef communities within 0-15 m of the reef for the first two years following sinking and the steady state concentrations with ZOI=2 and ZOI=1 are shown in Figure 24, Figure 25, and Figure 26, respectively. The figures also show the tissue concentrations of Total PCB obtained from EMAP and IMAP studies (Table 1). The data for Atlantic croaker (white symbols) and spot (yellow symbols) are average (min and max) for all data from the Louisianan Province (LP, diamond), Gulf Coast of Florida (LP-FLA large square), and Carolinian Province (CP, circles). The IMAP data are for three samples of sea trout, spot, and sea pig collected offshore from Pensacola (small squares). The most conservative benchmark, the AF-adjusted dolphin benchmark ($\text{Dolphin}_{\text{NOAEL}}$/AF, Equation [11]) for consumption of prey, is also shown.

6.5.1.1 Modeled Concentrations

The modeled tissue residues for Total PCB in the pelagic community (Figure 24) showed that the top-level predators, jack (1.0×10^{-3} mg/Kg WW) and herring (0.6×10^{-3} mg/Kg WW) had about an order of magnitude higher PCBs than zooplankton (1.0×10^{-4} mg/Kg WW) and seven orders of magnitude higher than phytoplankton (2.0×10^{-12} mg/Kg WW), reflecting the biomagnification expected for PCBs. The highest concentrations were predicted from the steady state condition modeled by PRAM (ZOI=1) which were below the background concentrations of PCBs reported from EMAP and IMAP and below the ecological risk benchmarks protective of the pelagic community and reef consumers (Figure 24, Table 9, Appendix D.1).

The models predicted slightly higher tissue concentrations for the benthic community (Figure 25, Table 9, Appendix D.1). The highest concentrations were obtained from the steady state condition predicted by PRAM with ZOI=1. The top predator for the benthic community, flounder (1.2×10^{-3} mg/Kg WW), had the highest concentrations of PCBs followed by lobster (3.5×10^{-4} mg/Kg WW), epifauna (1.5×10-4 mg/Kg WW), and infauna (5.5×10^{-5} mg/Kg WW). The tissue concentrations predicted for the benthic community within 0-15 m of the ship were also below background levels and ecological risk benchmarks (Figure 25).

The predicted tissue concentrations for the reef community are shown in Figure 26. The time dynamic pulse showed a peak in tissue concentrations after six months for TL3 and TL4 predators, but the highest concentrations were predicted for the steady state condition (PRAM with a ZOI=1). The predicted concentrations for the upper trophic level species were within the range of background concentrations reported from the EMAP and IMAP data. The highest concentrations were predicted for grouper (1.2×10^{-1} mg/Kg WW), triggerfish (6.7×10^{-2} mg/Kg WW), crab (3.7×10^{-2} mg/Kg WW), and urchin (1.7×10^{-2} mg/Kg WW). The maximum tissue concentrations predicted for grouper, triggerfish, crab, and urchin exceeded the average concentrations reported for Atlantic croaker from LP, but the modeled concentrations did not exceed the maximum PCB level reported for LP. Only the concentrations predicted for grouper exceeded the maximum PCB concentrations reported for LP-FLA (Table 1).

Sea urchin, crab, triggerfish, and grouper exceeded the AF-adjusted dolphin benchmark ($\text{Dolphin}_{\text{NOAEL}}$/AF) for consumption of prey. At two weeks, sea urchin and crab tissue concentrations were above the dolphin benchmark, after one month sea urchin, crab, and triggerfish tissue concentrations exceeded the dolphin benchmark, but after one year and two years only grouper tissue concentrations exceeded the dolphin benchmark. At steady state grouper, triggerfish, and crab tissue concentrations were above the dolphin benchmark (Figure 26).

Tissue residues for the pelagic community predicted by PRAM based on TDM output for 0-45 m and 0-60 m from the ship and steady state concentrations predicted by PRAM with a ZOI=5 were similar to the results for the pelagic, benthic, and reef communities (Appendix D.1 Media Concentrations for Total PCB). Concentrations predicted for the community within 0-45 m of the ship were very similar to the concentrations predicted for the community within 0-15 m of the ship. Likewise, concentrations predicted for the community within 0-65 m of the ship changed very little. The highest changes in PCB concentrations were in the predictions for the steady state conditions.

6.5.1.2 Hazard Quotients for Total PCB

The HQs for Total PCB obtained for all the benchmarks for 0-2 yr (0-15 m from hull) and steady-state (ZOI=1) exposures are tabulated in Appendix D.2. Potential effects from bioaccumulation were evaluated by calculating the HQs for TSV and B_{CV} (Figure 27). The HQs obtained for bioaccumulation effects showed no indication of risk. The TSV and B_{CV} were all below HQ = 0.10, except for the TSV HQ calculated for grouper (HQ = 0.26) and triggerfish (HQ = 0.15).

Effects from exceeding critical body residues of Total PCB in fish and invertebrates were evaluated by calculating the HQ*s for the NOED and LOED (the benchmarks for critical body residues were adjusted for AF uncertainties, see Equation [11]). The HQ*s for critical body residues were all below HQ*=1.0 (Figure 28, Table 27), suggesting that there is no indication of risk from harmful tissue residues to primary, secondary, and tertiary consumers at the reef.

Effects from dietary exposure to dolphins, cormorants, herring gulls, sea turtles, and sharks/barracudas were evaluated by calculating the AF-adjusted HQ*s for the NOAEL (Figure 29) and LOAEL (Figure 30). The HQ*s for dolphin consumption of crab, triggerfish, and grouper, cormorant consumption of grouper, and herring gull consumption of grouper exceeded HQ*=1.0 for the no effect level (NOAEL, Table 27). All of the HQ* obtained for the LOAEL were less than one (Figure 30). The HQ* > 1 for dolphins, cormorants, and herring gulls is an indication of risk, however, the low effect thresholds (LOAEL) were not exceeded. The dietary benchmarks are based on the assumptions that 100% of the predators' food comes from the reef and that the predators will remain on the reef for their entire life span (or at least until they reach equilibrium with the exposure levels).

Based on the data available for evaluating Total PCB tissue exposures to reef organisms, there was no indication of risk to primary producers, primary consumers, secondary consumers, tertiary consumers, loggerhead turtles, or sharks/barracudas present at the reef. Dietary exposure to dolphins, cormorants, and herring gulls exceeded the no effect threshold indicating potential risk, but because the assessment assumed that these species would be permanent reef residents feeding exclusively from the reef, it is likely that actual exposures would be much lower.

6.5.2 Exposure to Dioxin-like TEQ

The exposure to dioxin-like coplanar congeners to birds and mammals was evaluated using the dietary AF-adjusted HQ*s calculated from the modeled TEQs in prey of dolphins, cormorants, and herring gulls (Appendix D.4). The mammalian TEQs calculated in the reef biota ranged from 0.37 and 0.19 pg TEQ/g WW for grouper and triggerfish to less than 0.01 pg TEQ/g WW for the other organisms (Figure 31). The avian TEQs were slightly higher, 0.45 pg TEQ/g WW for grouper, 0.38 pg TEQ/g WW for triggerfish, and 0.27 pg TEQ/g WW for crab (Figure 32). The avian TEQs were slightly higher than those obtained for mammals because the avian TEFs for tetrachlorobiphenyl congeners PCB077 and PCB081 are higher than the mammalian TEFs (Table 21) and those congeners accounted for about 65% and 10% of the avian TEQ, respectively. The mammalian TEQ was comprised of mainly penta-congeners PCB105 (66%) and PCB114 (12%). The HQ*s calculated for dietary exposure to were < 1.0 for dolphins (Figure 33), and < 0.1 for cormorants and gulls (Figure 34 and Figure 35, respectively). These results showed no indication of risk from TEQ exposure to dolphin and avian consumers at the reef.

TEQ exposure to fish eggs and sac-fry larvae, the most sensitive life stage of fishes to TEQ toxicity, was calculated based on the maternal transfer of TEQs to fish eggs on a wet weight and lipid weight basis (Table 10B). The fish egg TEQ was highest for grouper and triggerfish for both the wet weight (Figure 36) and lipid weight calculations (Figure 37). Pentachlorobiphenyl congener PCB105 accounted for about 75% of the fish egg TEQ. The HQ*s for TEQ effects to fish eggs and sac-fry larvae were below 1.0 for both the wet weight (Figure 38) and lipid-based benchmarks (Figure 39), suggesting that there was no indication of risk from TEQ exposure to fish eggs that are laid and hatched at the reef.

Based on the data available for evaluating TEQ exposures to dolphin, birds, and fish eggs, there was no indication of risk from exposure to TEQ in the diet of dolphins and birds and the maternal transfer to fish eggs.

6.5.2.1 Uncertainty About Dioxin-Like Toxicity

The main source of uncertainty about the TEQ analysis was that coplanar congeners were not modeled directly, their concentration was estimated by assuming that the proportionality between the coplanar congeners and the homologs observed in the leachrate experiments was constant and preserved in the food chain. This hinges on the assumption that the behavior of the coplanar congeners is mostly controlled by the physiochemical properties modeled within PRAM, specifically molecular weight, solubility, vapor pressure, Henry's Law constant, K_{ow}, K_{oc}, and K_{doc}. Since these parameters are used for the homolog, which has very similar properties to the congeners within a homolog group (Hawker and Connell 1988), these are probably pretty good estimates for the individual congeners. However, PRAM does not model biotransformations or varying elimination rates that may occur and biodegradation was set to zero for the PRAM simulations conducted for this risk assessment. The proportionality assumption is a conservative estimate, if the bioaccumulation of coplanar congeners is equal to or less than what is expected for the homolog group.

Other studies have shown that coplanar and non-coplanar PCBs accumulate in relatively the same manner in marine food webs. Fisk et al. (2001) reported on food web biomagnification factors (FWMF, see EQU [38]) from the Northwater Polyna in the Arctic for 36 congeners including some of the coplanar congeners (PCB105, PCB118, PCB156, and PCB180); Mackintosh et al. (2004) described the trophic transfer of PCB018, PCB099, PCB118, PCB180, PCB194, and PCB209 for a coastal marine food web in False Creek Harbor, British Columbia; and Wan et al. (2005) reported FWMF for dioxins, furans, and dioxin-like coplanar PCBs (including one non-coplanar PCB169) in the marine food web of Bohai Bay, China. These data represent a wide range of marine systems for comparing the biomagnification factors predicted by PRAM. The average FWMFs determined for coplanar and non-coplanar congeners were similar for tetra-, penta- (Figure 40), hexa-, and heptachlorobiphenyls (Figure 41). In addition the FWMFs obtained from PRAM for the pelagic, benthic, and reef communities spanned the range of FWMFs reported for coplanar and non-coplanar congeners from the other studies cited above (Figure 42).

This bolsters the assertion that dioxin-like coplanar congeners are present in the food web in proportion to homologs, or at least, the assumption is not underestimating the presence of dioxin-like congeners. Wan et al. (2005) reported the FWMF for the coplanar PCBs were much higher than the FWMFs obtained for dioxins and furans, probably due to the metabolic transformations that lead to elimination and lower half-lives of dioxins and furans than for PCBs. Wan et al. (2005) found that the FWMF for hexachlorobiphenyl coplanar congeners PCB156, PCB157, and PCB167 were much lower (3.55, 3.7, and 3.37, respectively) than the non-coplanar PCB169 (12.26). Mackintosh et al. (2004) reported similar FWMFs for pentachlorobiphenyl of 6.98 (3.77 – 12.81 95% CL) for coplanar congener PCB118 and 4.89 (2.85 – 9.39 95% CL) for non-coplanar congener PCB099. In a study of the uptake of sediment bound PCBs by carp (*Cyprinus carpio*) Moermund et al. (2004) reported data that showed pentachlorobiphenyl coplanar congeners PCB105 and PCB118 were bioaccumulated about half as much as the non-coplanar congener PCB101, however it is not possible to tell whether this was due to differential desorption from the sediment or biotransformations in the fish.

Another source of uncertainty was that PCB123, PCB126, PCB169, and PCB189 were not detected during the leachrate experiments so these compounds did not contribute to the TEQs calculated. Because the leachrate experiments were following a chemical process (George et al. 2005, 2006), normal methods for estimating non-detected concentrations based on sampling theory are not applicable. Therefore no attempt was made to estimate concentrations for the non-dected congeners.

6.6 Summary of Findings

The outputs of the TDM/PRAM and PRAM models were used to evaluate PCB exposures to the pelagic, benthic, and reef communities as well as dolphins, sea birds, sea turtles, and shark/barracuda that may be attracted to feed and forage on the reef. Predicted sediment and water concentrations showed no indication of risk for both the 0-2 yr and steady-state exposure periods. Contact with elevated PCB concentrations modeled for the internal vessel water were identified as the most important pathway for bioaccumulation and trophic transfer in the food chain. Tissue concentrations predicted for the pelagic and benthic community were below expected background PCB concentrations determined from EMAP and IMAP data. The modeled concentrations in the upper trophic level of the reef community were within the range of background PCB values for the Gulf of Mexico.

The Total PCB exposure levels predicted by the models showed no indication of risk to plants, invertebrates, fishes, sea turtles, and sharks/barracudas that could live, feed, and forage on the reef (Table 27). The no effect threshold for Total PCB exposure in the diet of dolphins, cormorants, and herring gulls was exceeded, but, because the assessment assumed that dolphins, cormorants, and herring gulls would be life-long residents of the reef and would obtain 100% of their food requirements from the reef, it is likely that actual exposures would be much lower.

Estimates of TEQ exposure were obtained by assuming that dioxin-like coplanar congeners would be present in same congener:homolog proportion observed in the leachrate experiments. Potential risks from dietary exposure of TEQs to gulls, cormorants and dolphins were evaluated by comparing modeled tissue concentrations in prey to TEQ dietary benchmarks for those species. Potential risks of TEQ exposure to fish eggs and sac-fry larvae, the most sensitive life stage of fishes to TEQ toxicity, were evaluated by predicting the maternal transfer of TEQs to fish eggs and comparing the resulting fish egg concentrations to sensitive egg residue benchmarks for TEQ exposure. There was no indication of risk from TEQ exposure to dolphins, sea birds, or fish eggs and larvae.

Photo by Keith Mille (keith.mille@MyFWC.com)
Florida Fish & Wildlife Conservation Commission

7. Uncertainty

We demand rigidly defined areas of doubt and uncertainty!

Douglas Adams

The purpose of this section is to summarize the sources of uncertainty, identify procedures and precautions taken to reduce uncertainty, and discuss the ramifications of uncertainty in the conclusions drawn from the risk characterization. This section provides a concise summary of major sources of uncertainty identified during the risk assessment. Specific sources of uncertainty were discussed throughout the document and are, therefore, not repeated here. The major sources of uncertainty in the risk assessment arise from errors in making assumptions and conceptualizing the models, errors made during parameter estimation, errors from inaccurate model predictions, and an incomplete understanding of the ecosystem modeled.

7.1 Contaminant Source Terms for ex-ORISKANY

As was discussed in Section 3.2.5, the ex-ORISKANY underwent an extensive cleanup program in accordance with the draft Best Management Practices for Preparing Vessels Intended to Create Artificial Reefs (U.S. EPA and MARAD 2004, NAVSEA 2005a). Many PCB containing materials were removed from the ship, but some materials remained on the ship and there is uncertainty about the amount of materials, the fraction of PCBs contained in the materials, and the rate at which PCBs will be leached out. The upper bound of the mass fraction in the PCB materials was estimated using jack-knife and bootstrap methods and the 95th percentile or maximum leach rates were used for the materials so these represent the upper bound, or worst case of what could be leached from the vessel (NEHC/SSC-SD 2006a, b). The uncertainty about the materials left on board was evaluated with PRAM by varying the amount of bulkhead insulation (BHI) left onboard the ship. The BHI had the highest leach rate of any of the materials tested, so varying the amount of BHI directly affects the amount of PCBs released per day (ng/day) into the model. The default mass of BHI on the ship (14,379 Kg) was increased to the amount present before cleanup (52,478 Kg), an intermediate amount (26,000 Kg) and reduced to 10% of the precleanup mass (5,247 Kg), and removed completely (0 Kg) to evaluate the effect of PCB loadings on PRAM predictions.

Changing the amount of BHI on the ship changed the release rate and the concentrations of biotic and abiotic media changed in a linear fashion (Figure 43, Appendix E2 PCB Release Rate). The original amount of BHI onboard the vessel prior to cleaning (100% BHI) increased the biota and abiotic media by about a factor of 3 above the default levels and removing the BHI completely (0% BHI) reduced tissue concentrations by about a factor of 4.5 from the default levels. Most notably, triggerfish and flounder PCB concentrations were reduced by a factor of 7 when all BHI was removed. Removing all BHI also reduced interior vessel water and lower water column PCB concentrations by a factor of 2.6 and sediment concentrations by a factor of 2.2 from the default levels. If all the BHI were removed, the HQ* obtained for the dolphin dietary NOAEL ($\text{Dolphin}_{\text{NOAEL}}$*, the most sensitive benchmark) would change from the default value of 3.6, 2.1, and 1.1 for dolphin consumption of grouper, triggerfish, and crab, to 0.6, 0.3, and 0.2, respectively. If 100% of the BHI would have been left on the vessel the HQ* for dolphin consumption of grouper, triggerfish, and crab would be 11.4, 6.8, and 3.7, respectively. The HQ obtained for IVW divided by the chronic water quality criteria benchmark decreased from 13.8 to 8.6, when the BHI was removed, and increased to 23.0 when 100% of the BHI was left on board.

7.2 Uncertainty About Water and Sediment Exposure

Release of PCBs from the ship and build up in the water and sediment around the reef is controlled primary by the bottom currents. Higher bottom currents will increase the rate PCBs are moved out of the ship and higher bottom currents will also increase the rate that PCBs are advected out of the model domain (NEHC/SSC-SD 2005b, 2006b). On the other hand, lower currents will move less mass, but the lower currents will increase the residence time of PCBs and allow more PCBs to be sorbed onto sediments and accumulated within the food chain. The uncertainty about water and sediment exposure was evaluated as function of bottom current. In PRAM the bottom current is used to calculate the speed with which water moves through the ZOI directly affecting the residence time and the advection rate of PCBs out of the system. The default bottom current of 926 m/h was decreased by half (465 m/h) and by a factor of 10 (93 m/h) and increased by doubling (1858 m/h) and by a factor of 10 (9260 m/h) to evaluate the effect on the PCB concentrations in biotic and abiotic media of the model[16] (Figure 44, Appendix E1 Bottom Current).

Linear changes in the speed of the bottom current resulted in linear changes to the PCB concentrations of the abiotic media and the biological components of the pelagic and benthic communities. The lower the current – the higher the predicted PCB concentrations (except for IVW which did not change). Halving the bottom currents doubled the PCB concentrations in the lower water column and sediment and quadrupled the concentrations in the upper water column, which resulted in about twice the residue levels in the pelagic and benthic communities. The effect was the same in the other direction – increasing bottom currents by a factor of 2 halved the sediment and lower water column concentrations, decreased the upper water column by a factor of 4 and reduced PCB levels in the pelagic and benthic communities by about a factor of 2. The hazard quotients calculated for the pelagic and benthic communities changed by the same proportion as was applied to the bottom currents, for example, reducing the bottom currents by a factor of 10 increased pelagic and benthic hazard quotients by a factor of 10, and increasing bottom currents by a factor of 10 decreased pelagic and benthic hazard quotients by a factor of 10. The PCB levels in the upper trophic levels of the reef community did not appreciably change as a function of the bottom currents, because their residues were controlled by contact with IVW. The hazard quotients for grouper, triggerfish, crab, and urchin were reduced by 20% when the bottom current was increased by factor of 10 and increased by 3% when the bottom currents were decreased by a factor of 10.

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[16] In the PRAM documentation the exchange between interior vessel water and lower water column was defined as being proportional to the bottom currents, but in PRAM 1.4c the exchange rate between interior water and the lower water column remained constant at 9.26 m/h for all values of bottom current tested.

7.3 Uncertainty about Food Chain

The food chain modeled by PRAM is a simplification of a very complex ecosystem. Each "species" modeled by PRAM is meant to be representative of a vast range of organisms that are associated with the reef. Due to the structure of the model, the overriding factor governing PCB accumulation in the food chain is through contact with the interior water of the ship. While the interior of the vessel was not considered a viable habitat, it is certainly plausible that certain organisms may colonize the interior of the vessel and live out their lives relatively isolated from the rest of the reef. Mobile organisms, like fish, octopi, crabs, echinoderms, and other invertebrates may also use the interior of the vessel to escape predators, sleep, or just simply hang out. To address the worst-case exposure from PCBs in the interior water of the vessel, the default IVW exposure for bivalves (0%) was changed to 50% and 99%.[17]

The effect on PCB concentrations in biota as function of increasing bivalve exposure to interior vessel water is shown in Figure 45 and tabulated in Appendix E3 Bivalve Exposure to Interior Vessel Water. The bivalve tissue concentrations increased by a factor of 175 and 346 as the exposure to IVW was increased to 50% and 99%, respectively. In addition, urchin, crab, triggerfish, and grouper also increased by about a factor of 3 and 5 as a result of increasing the bivalve's exposure to IVW of 50% and 99%, respectively. This was because bivalves comprised 20% of the diet for urchins, 35% of the diet for crabs, and 19% of the triggerfish's diet, and through dietary transfers, 16% of the grouper's diet.

Increasing the IVW exposure to bivalves caused tissue residues predicted for the reef community to exceed effects benchmarks. For 99% exposure to IVW the following HQ*s were calculated (Appendix E3 Bivalve Exposure to Interior Vessel Water):

- Bivalve tissue residues exceed the $\text{Dolphin}_{\text{NOEAL}}$* benchmark (HQ*=1.7);
- The HQ*s for sea urchin tissue residues were greater than 1 for $\text{Dolphin}_{\text{NOEAL}}$*, NOED*, $\text{Corm}_{\text{NOEAL}}$*, and $\text{Gull}_{\text{NOEAL}}$*;
- Crab had HQ*s>1 for $\text{Dolphin}_{\text{NOEAL}}$*, NOED*, $\text{Corm}_{\text{NOEAL}}$*, $\text{Gull}_{\text{NOEAL}}$*, LOED*, and $\text{Dolphin}_{\text{LOEAL}}$*;
- Triggerfish had HQ*s>1 for $\text{Dolphin}_{\text{NOEAL}}$*, NOED*, $\text{Corm}_{\text{NOEAL}}$*, $\text{Gull}_{\text{NOEAL}}$*, $\text{Dolphin}_{\text{LOEAL}}$*, LOED*, $\text{Turtle}_{\text{NOEAL}}$*, and $\text{Sharkl}_{\text{NOEAL}}$*; and
- Grouper had HQ*>10 for $\text{Dolphin}_{\text{NOEAL}}$* (HQ*=16) and HQ*>1for most of all the other benchmarks.

This represents an extremely conservative upper bound estimate of potential risk.

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[17] PRAM 1.3c was not able to accept 0 as a parameter value for fraction exposure to lower water column.

7.4 Applicability of Assessment Endpoints and Effects Levels

Based on existing toxicological data, receptor species for the reef community were selected that were taxonomically similar to species for which toxicity data were available (or could be inferred) and that would most likely be sensitive to PCBs. Toxicological data were reviewed to identify available toxicological benchmarks that could be used to interpret whether exposure concentrations to the receptor species could be harmful. To the extent possible, receptor species were selected that were representative of mammals, birds, reptiles, fishes, and invertebrates that utilize reef habitats. In many cases, toxicological data were not available for reef organisms and the susceptibility of the receptor species to PCBs had to be inferred or extrapolated from species used in toxicological tests and studies.

In order to be consistent with procedures for conducting ecological effects assessments under TSCA, an "assessment factor" (AF, Zeeman 1995) was used to account for differences between the species used in toxicological studies and species expected to be at the reef. An AF of 10 was applied by dividing the appropriate benchmarks (B) by the AF before calculating a hazard quotient (HQ*). It may be possible that by applying the AF the assessment may become overly conservative, especially in cases where laboratory test species may be more sensitive than wild species. However, the ecological risk assessment seeks to be protective of all species and there is no way of knowing if the test species are truly sensitive enough. The relative level of protection from harmful body residues provided by the benchmarks, the SSD for tissue residue effects, and the modeled tissue residue exposures are show in (Figure 46). These data show that the AF-adjusted benchmarks are to the left of the SSD developed for effects from tissue residue exposures observed in fish and invertebrates. The modeled data are clearly below levels that would indicate risk from tissue residues. The AF provides an additional level of conservatism in the assessment to support regulatory decision-making (U.S. EPA 1984, Rodier and Zeeman 1994, Zeeman 1995, Nabholz 2003, Zeeman et al.1999).

7.5 Applicability of Water Quality Criteria Benchmarks

The water column, TSV, and B_{CV} benchmarks were based on Water Quality Criteria (WQC). According to EPA's Aquatic Life Criteria Guidelines Committee, which is responsible for developing the technical basis for national WQC, water quality criteria are considered to be protective of 95% of the species tested (or more precisely, of the genera tested). The standard WQC calculation results in a number that is designed to protect 95% of the species sensitivity distribution represented by the data set available. The assumption here is that the data set available is representative of the species sensitivity distribution of the potentially exposed aquatic community. To the degree that this assumption is true, WQC protect 95% of the species exposed. The data set is biased in two ways: 1) the species tested generally are among the more sensitive species that can be tested; and 2) only species that can be tested are tested – species that are more difficult to maintain in the laboratory could be more sensitive than those actually tested. By implication, a sensitive species of particular value, or of particular importance to community and ecosystems dynamics (a "keystone" species), for which no toxicity test data exist, could be adversely affected at exposure concentrations lower than the WQC.

The tissue residue concentrations modeled by PRAM and the ecological risk benchmarks used in the ecological risk assessment are for representative species that are expected to be present at the reef. The tissue concentrations and potential ecological effects inferred from the model results would also be applicable to tissue residues and exposure concentrations experienced by any keystone species present at the reef. The ecological risk assessment only addressed potential toxicological risks from PCBs, the ecological consequence of reef development was outside the bounds of the ecological risk assessment.

7.6 Applicability of Critical Body Residue Benchmarks

Critical body residues (CBR) are defined as the threshold concentration of a contaminant in the tissue of an organism above which adverse effects could occur (McCarty et al. 1992, Pabst 1999). Data obtained from the ERED database were used to develop benchmarks for effects on reproduction, growth and development, mortality and survival. The benchmarks were based whole body concentration and ingestion or absorption. In many cases, data for freshwater fish and invertebrates were used to develop the benchmarks because of the paucity of data on marine organisms in general and reef organisms in particular. The CBR benchmarks assumed that the tissue concentration causing adverse effects in an organism would be the same for both marine and freshwater organisms. This assumes that the difference between freshwater and saltwater criteria are due to differences in chemical uptake in freshwater and marine organism and not differences in tissue concentrations that would cause adverse effects.

7.7 Applicability of Dietary Benchmarks

Sample et al. (1996) reported that scaling factors, such as used for mammals, are not appropriate for avian species because an analysis of existing data showed that the scaling factor which ranged from 0.63 to 1.55 with a mean of 1.15, was not significantly different than 1. This assumes that toxicity effects to receptor species (birds of prey) would be similar to the species tested (ring-necked pheasant for PCBs) after adjusting for differences in food consumption rate and body weight of the receptor species.

It was also assumed that dietary benchmarks based on reproductive effects to mink were appropriate and applicable to dolphins. While dolphins and mink are both piscivores they have very different life histories, dietary requirements, and feeding behaviors. In a study of PCB risk to bottlenose dolphins (*Tursiops truncates*), Schwacke et al. (2002) justified the use of mink as surrogates for dolphins because mink are the most sensitive mammalian species for which PCB toxicity data are available and that mink have similar pharmokinetic pathways as dolphins (cetaceans), specifically, both have relatively lower levels of phenobarbital-type (PB-type) and 3-methylcholanthrene-type (MC-type) enzymes necessary for metabolizing PCBs than other birds or mammals. Additionally, it is very difficult to obtain toxicological data for a protected species such as dolphins (Schwacke et al. 2002).

Due to the lack of toxicity data on reptiles, the lowest TRVs obtained for mammalian species (mammals are more sensitive to PCBs than birds) was assumed to be protective of sea turtles. Using the same scaling factors used for mammals and substituting the body weight and ingestion rate of loggerhead turtles the PCB benchmarks for sea turtles were obtained. This assumed that if the benchmarks were protective of warm-blooded mammals, then they would also be protective of cold-blooded sea turtles (see Great Lakes water quality initiative technical support document for wildlife criteria, U.S. EPA 1995, for more discussion on this assumption).

Toxicological benchmarks for PCBs in shark and barracuda were developed using the ratio of food chain multiplier (FCMs) between TL4 (reef predator, e.g. shark) and TL3 (reef forager, e.g. prey) obtained from U.S. EPA (2000). The ratio between FCMs for TL4 and TL3 gives the relative increase in contaminant concentrations between a shark and its prey, assuming all the shark's dietary requirements came from TL3. This assumes that a steady state exists between the shark and its prey and that accumulation from the water through gill exchange would be negligible compared to contaminant uptake from food. The analysis also assumed that when sharks feed on TL4 prey the same FCM would be applicable. This is conservative because, generally, FCMs decrease for higher trophic levels.

7.8 Uncertainty about Risk from Dixon-like Toxicity

Estimates of dioxin-like coplanar congeners were multiplied by the respective TEFs to calculate TEQs for fish eggs and to assess dietary exposure to birds and mammals. Because no data were available for PCB081[18] the concentrations of PCB081 were estimated assuming that they were proportional to PCB077 in ratios that were measured other studies (Johnston et al. 2005a). The maternal transfer of PCBs from reef fish to egg was also assumed to be proportional to the transfer ratios reported for trout. The dioxin-like TEFs and TEQ benchmarks were assumed to be applicable to fish, birds, and mammals foraging on the reef. The potential risk estimated from TEQ exposure to fish eggs and dietary exposure to birds and mammals were based only on dioxin-like toxicity from PCBs and did not take into account any additional toxicity from the presence of dioxins and furans. Other aryl hydrocarbon receptor (AhR)-related dioxin-like chemicals (e.g., dioxins or dibenzofurans) were not identified aboard the ex-ORISKANY.

The most toxic dioxin-like PCB congener, PCB126, and other coplanar congeners PCB123, PCB169, and PCB189 were not detected during the leachrate experiments so these compounds did not contribute to the TEQs calculated. Because the leachrate experiments were following a chemical process (George et al. 2005), normal methods for estimating non-detected concentrations based on sampling theory are not applicable (Gilbert 1987). Therefore no attempt was made to estimate concentrations for them.

There is a wide range of sensitively to dioxins among fish, birds, and mammals (Gatehouse 2004). The benchmarks used in this analysis were based on data available for the most sensitive fish (salmonids), avian (order of galliformes – chicken-like birds e.g. pheasant) and mammal (mink) for which toxicity data are available (Gatehouse 2004) and it was assumed that these benchmarks would not underestimate the potential risk to receptors on the reef. Additionally, the dietary benchmarks assumed that the reef consumers dined exclusively on the

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[18] PCB081 was not tested for in the leachrate experiments.

reef throughout their whole life span with an assimilation efficiency of 90%. Reducing these parameters would increase the dietary benchmarks by the same factor.

7.9 Uncertainty About Interior Vessel Water Concentrations

The interior water concentration is very dependent on the rate of water exchange with lower water column. The default value was set at 1% of the bottom current or 9.26 m/h. There is much uncertainty about this number and it was assumed that 1% was a very conservative estimate. It is reasonable to assume that the exchange rate is proportional to the bottom current because as the bottom current increases, more water will come into contact with the ship resulting in greater ventilation of the hull. The exchange with lower water column will be dependent on how “porous” the hull is with respect to water getting in and out. Figure 47 shows the change in the concentration of pentachlorobiphenyl in the interior water simulated by the TDM at the maximum leaching rate, as a function of the interior vessel exchange rate. Pentachlorobiphenyl accounts for about half of the Total PCBs released into the interior of the ship. Because of the limited exchange between the interior water and the lower water column surrounding the reef, the interior of the vessel is not expected to be readily colonized by epibenthic organisms that need a constant source of food from outside of the vessel. Therefore, it was assumed that the predominant route of exposure from the interior water would be from organisms coming into contact with the IVW and the resulting trophic transfer through the food web.

The interior vessel water is modeled as a homogenous mixture of PCBs with a porous boundary (Figure 48 upper diagram). The "squiggly lines" in the diagrams are the cable runs and other materials with PCBs that are "non"-randomly distributed about the ship. The diagrams show the hypothetical volume of internal water (an elliptical cylinder in the model) and the openings are where the seawater can exchange. In reality the limited openings through the hull of the ship will probably create a gradient of PCB concentrations inside the ship (Figure 48 lower diagram) with lower PCB concentrations near the openings where foraging fish and invertebrates are more apt to occur. Furthermore, the thousands of compartments contained within the hull will further limit the exchange of water to the reef and make it harder for feeding and foraging fish and invertebrates to penetrate into the interior spaces of the ship.

7.10 Uncertainty About Extreme Events

Extreme events, such as hurricanes or tropical storms are likely to occur within the Northeastern Gulf of Mexico; therefore the impact of such storms needs to be considered. The frequency of catastrophic (category 4 or 5) hurricane strikes in the Pensacola area is relatively high (there is about 0.5% chance per-year of catastrophic hurricane strikes during “hyperactive” interglacial periods, Liu and Fearn 2000). Data are available on hurricane paths over the last thirty years (Figure 49, NOAA 2005) and the expected current velocities for such events (Ohlmann and Niiler 2001) have been studied.

Horn (2005) studied the structural damage to artificial reefs off the coast of Florida from the four major hurricanes that hit Florida in 2004 (Table 28). He reported that vessels and other underwater structures sustained considerable damage especially from the combined effects from *Hurricanes Frances* and *Jeanne*, two storms that occurred within three weeks of each other and made landfall at virtually the same location near Stuart, Florida on the Atlantic coast (Horn 2005). Surveys of two ex-Navy ships in the paths of *Frances* and *Jeanne* following the storms showed extensive damage. The ex-MULIPHEN (AKA 61) an amphibious cargo ship had holes scoured in her hull, a cracked bow, and was 3 m deeper than before the storms. The ex-RANKIN (AKA 103) also an amphibious cargo ship had extensive scouring under the bow that caused her bow to break off and deck to be torn away. From scouring of the bottom sediment she is also 10 m deeper than before the storms. The ex-MULIPHEN and ex-RANKIN, both cargo ships with relatively open interior structure, were sunk in 56 m (184 ft) and 43 m (141 ft) 15 and 16 years before the storms, respectively. The ex-MULIPHEN sank upright and the ex-RANKIN sank on her starboard side. The seafloor around the ships has been extensively modified from the presence of the ships. Erosion from scouring around the hulks has created holes and crevasses and uncovered limestone boulders and hard bottom areas that were buried under sediment providing new habitat for groupers and seabass. Horn (2005) concluded that slow moving hurricanes with very large swells over extended periods (> 48 hr) caused the most damage. He noted that large ships with excessive vertical surfaces are capable of deflecting rapidly moving water resulting in substantial changes to the ocean floor around the ship. He recommended sinking large ships upright with their bows facing in the predicted direction of oncoming swells from major hurricane events (Horn 2005).

Studies of other sunken vessels by the US Parks Service, including the ex-MASSACHUCETTS sunk in Pensacola Pass in 1921 in 30 ft of water – much shallower than the ex-ORISKANY's proposed depth and therefore more exposed to wave action – has shown relatively little structural damage from extreme events. "Even though the [ex-MASSACHUCETTS'] hull was stripped for scrap metal during the 1940s, the wreck is in relatively good condition for being submerged for 80 years and has reached a state of equilibrium with the environment. In fact, the Massachusetts was completely undamaged by the violent hurricanes of the summer of 1995." (U.S. Park Service 2005)

In September 2004 *Hurricane Ivan* created some of the largest waves ever recorded topping out at over 20 m (90 ft) as it moved through the Gulf of Mexico on its way to landfall on the Florida Panhandle just west of Pensacola (BBC 2005). In July of 2005 as *Hurricane Denis* swept through the Florida Keys on its way into the Gulf of Mexico, its waves, currents, and surge caused the ex-SPIEGEL GROVE (LSD-32) to turn upright. The movement of the ex-SPIEGEL GROVE was unique. A mishap during her sinking in June 2002 caused the Spiegel Grove to turnover and float upside down. When she was finally sunk, she went down landing on her starboard side in 43 m (130 ft) of water. The wave action on the submerged hull caused the sediment under her keel to erode away, until, during *Hurricane Dennis*, she "righted" herself (Key Largo 2005, Anon 2005). Very little, if any, damage to the hull's structure occurred (William Horn, FFWC, personal communication).

The passage of a hurricane could potentially damage the reef, alter rates of release of PCBs from the ship's interior, and increase releases of PCBs from the vessel. In general, a hurricane would have the net effect of diluting PCB concentrations by dissipating PCBs away from the immediate site. Increasing bottom currents (see Figure 44) resulted in a large decrease of the steady-state PCB concentrations in the pelagic and benthic communities but had little change in the PCB concentrations in the upper trophic levels of the reef community. A hurricane or tropical storm will greatly increase the current velocity in the vicinity of the reef, scouring away the surrounding sediment, and displacing many residents of the reef. Following the hurricane, the accumulation would restart with fresh material. If the ship were opened up during a storm, an initial very transient pulse (hurricane-induced currents) of PCBs would give way to the same steady-state release rate present before the storm. However, interior concentrations, which are the main source of the PCBs that are accumulated, would be much reduced since ambient flow could get into the ship. It is unknown whether hurricane damage could increase release rates by breaking up the PCB source material.

The sinking plan for the ex-ORISKANY (NAVSEA 2005b) and stability studies conducted by the State of Florida (see 3.2.1 Environmental Conditions) suggests that based on the depth and position planned for the reef, the ex-ORISKANY will be stable enough to easily withstand 50-yr storm events, and, if oriented facing oncoming swells, she should be able to withstand 100 yr storm events as well (FFWLC 2003).

7.11 Uncertainty About Multiple Ships

As of December 12, 2005, the Navy's inventory lists 8 ships under consideration for reefing http://peos.crane.navy.mil/reefing/inventory.htm. These ships include 4 aircraft carriers, 2 destroyers, an amphibious command ship, and a patrol gunboat. This raises a question about the potential cumulative risk from sinking many ships within a similar area or region (e.g. Gulf of Mexico). The current modeling framework could only address multiple ships if they were sunk within the same zone of influence (i.e. adjacent to each other). If that were the case, the PRAM and TDM model geometry and source terms could be easily modified to include the cumulative releases of two or more ships within the same ZOI. However, if the ships are sunk in separate locations, the potential cumulative impact on the environment could only be evaluated on a larger scale.

Both PRAM and TDM assume there is no reduction of PCBs in the source materials from leaching and biodegradation and other loss terms were set to zero for the simulations conducted for the ex-ORISKANY. The TDM calculated the total release of PCBs from the ex-ORISKANY during the first two years after sinking (see Fig C 30 - Total PCB Mass Budget, in NEHC/SSC-SD 2006b) as about 873 g of Total PCB (99.88% of the mass released) that were exported into the Gulf of Mexico. By the end of the 2 yr period the model estimated that ~0.8 g/day was transported from the site. Just to put this number into context, data reported by Rostad et al. (1994) were used to estimate the mean Total PCB discharge from the mouth of the Mississippi River from 1987-1990 at about 15650 ± 3330 g/day (Table 29).

Assuming a first order release rate equal to the release used in the steady state version of PRAM, the amount of PCBs released and the amount of PCBs remaining on the vessel over a specified period of time can be calculated:

$$C_t = C_0 e^{-rt} \qquad [32]$$

Where

C_t = The total amount of PCBs remaining on the ship
C_0 = The initial amount of PCBs when the ship was sunk
$-r$ = The release rate of PCBs [g PCB/g PCB day^{-1}], these were the rates used in the steady state version of PRAM
t = Time in days

Equation [30] was used to calculate the “half-life” of the PCBs in each of the types of materials and estimate the amount of PCB released from the ship and left remaining on the ship after ten years (Table 30). The calculation shows that half of the PCBs would leach out of Bulkhead Insulation after 28 years, Aluminum Paint would take 170 years, Ventilation Gaskets and Black Rubber Material would take 1,204 years, and it would take the Electrical Cable 6,807 years before its concentration of PCBs would be reduced to 50% of the initial concentration. After 10 years 2557.4 g of PCBs (2.56 Kg, 5.64 lbs) would have been released from the ship and 99.55% of the original mass of PCBs would still be on the ship. The majority of the PCBs leached came from the bulkhead insulation (66%). This calculation overestimates the amount of PCBs released because the release rates remain constant with time and do not decrease, as the source materials are depleted, contrary to what was suggested by the laboratory leachrate study (Figure 4). Additionally, there is no loss from biodegradation of PCBs.

Based on these results it appears the ship will effectively sequester the PCBs onboard releasing only small amounts of PCB into the environment surrounding the reef and into the larger Gulf of Mexico ecosystem.

7.12 Other Sources of Uncertainty

The uncertainties associated with the assumption used in PRAM and TDM and their implication in predicting PCB concentrations are provided in the model documentation reports (NEHC/SSC-SD 2006a, b). Sources of Uncertainty in the estimates of PCB mass onboard the ship, the estimate of PCB release rates, the predictions of abiotic exposure conditions during the time dynamic release by TDM, and exposure conditions during steady state simulations by PRAM, and a sensitivity analysis of some of the PRAM input parameters are also discussed in the uncertainty section of the human health risk assessment (NEHC/SSC-SD 2006c).

Photo by Keith Mille (keith.mille@MyFWC.com) Florida Fish & Wildlife Conservation Commission

8. Conclusions

The purpose of this report is to assess the ecological risks of polychlorinated biphenyls (PCBs) released after sinking the aircraft carrier ex-ORISKANY (CVA-34, Figure 1) to create an artificial reef off the coast of Pensacola, FL (Figure 2) within the Escambia East Large Area Artificial Reef Site (Figure 3). Because the ex-ORISKANY contains solid materials such as electrical cabling, gaskets, rubber products, insulation, and paints that contain concentrations ≥ 50 ppm, the vessel is regulated as PCB Bulk Product Waste under 40 CFR 761.62(c) and a risk-based disposal approval is required prior to sinking the vessel.

8.1 Summary of Findings

The outputs of the TDM/PRAM and PRAM models were used to evaluate PCB exposures to the pelagic, benthic, and reef communities as well as dolphins, sea birds, sea turtles, and shark/barracuda that may be attracted to feed and forage on the reef. Predicted sediment and water concentrations showed no indication of risk for both short-term and long-term exposure. Contact with elevated PCB concentrations modeled for the internal vessel water were identified as the predominant route of exposure and trophic transfer of PCBs through the food web. Tissue concentrations predicted for the pelagic and benthic community were below background PCB concentrations expected for the northeastern Gulf of Mexico and the modeled concentrations in the upper trophic level of the reef community were within the range of background PCB values for the Gulf of Mexico.

The Total PCB exposure levels predicted by the models showed no indication of risk to plants, invertebrates, fishes, sea turtles, and sharks/barracudas that could live, feed, and forage on the reef. The no effect threshold was exceeded for dietary exposure to dolphins, cormorants, and herring gulls indicating risk, but, because the assessment assumed that dolphins, cormorants, and herring gulls would be life-long residents of the reef and would obtain 100% of their food requirements from the reef, it is likely that actual exposures would be much lower.

Estimates of TEQ exposure were obtained by assuming that dioxin-like coplanar congeners would be present in same congener **:** homolog proportion observed in the leachrate experiments. Potential risks from dietary exposure of TEQs to gulls, cormorants and dolphins were evaluated by comparing modeled tissue concentrations in prey to TEQ dietary benchmarks for those species. Potential risks of TEQ exposure to fish eggs and sac-fry larvae, the most sensitive life stage of fishes to TEQ toxicity, were evaluated by predicting the maternal transfer of TEQs to fish eggs and comparing the resulting fish egg concentrations to sensitive egg residue benchmarks for TEQ exposure. There was no indication of risk from TEQ exposure to dolphins, sea birds, or fish eggs and larvae.

Based on the data available for evaluating tissue exposures to organisms living, feeding, and foraging at the reef, the Total PCB concentrations in water, sediment, and tissues of organisms associated with the reef and in the diet of reef consumers are below levels that would indicate unacceptable risk (Table 27). Based on the data available for evaluating TEQ exposures to dolphin, birds, and fish eggs, the risk of exposure from TEQ in the diet of dolphins and birds and the maternal transfer of TEQ to fish eggs is also acceptable

8.2 Uncertainty

The major sources of uncertainty were the assumptions and parameters used in the models, the applicability and sensitivity of the benchmarks used in the assessment, and uncertainty about the sources of PCBs on the vessel. Due to the conservative estimates used in this analysis, it is very unlikely that potential risks were under estimated.

8.3 Conclusions

The potential ecological risks of sinking the ex-ORISKANY were evaluated using model predictions of future PCB exposure levels in the environment surrounding the reef. The model predictions were judged to be plausible and reasonably good estimates of what would occur given that the other model assumptions and input procedures were also accurate. The ecological risk assessment showed that the risks of exposure from Total PCB and dioxin-like TEQs in tissues of organisms associated with the reef and in the diet of reef consumers are acceptable. Therefore, it is unlikely that PCBs released from sinking the ex-ORISKANY to create an underwater reef will harm the environment.

Photo # KN-15081 USS Oriskany en route to the Western Pacific, 23 June 1967

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10. Tables

Table 1. The average and range of total PCB concentrations measured in fish samples from the EMAP and IMAP monitoring studies for the SE U.S.

			ng/g Dry Weight				mg/Kg Wet Weight			
Location	Species	n	Average	Std	Min	Max	Average	Std	Min	Max
EMAP Louisanian Provience (All)	Croaker	219	40.4	103.8	3.4	866.3	1.01E-02	2.59E-02	8.39E-04	2.17E-01
EMAP Louisanian Provience (FL)	Croaker	14	34.2	72.9	4.4	283.1	8.56E-03	1.82E-02	1.09E-03	7.08E-02
IMAP (Pensacola)	Sea Robin, Spot, Pigfish	3	107.2	101.9	24.7	221.1	2.68E-02	2.55E-02	6.18E-03	5.53E-02
EMAP Carolianian Provience	Croaker	18	98.7	87.2	19.4	343.4	2.47E-02	2.18E-02	4.84E-03	8.59E-02
EMAP Carolianian Provience	Spot	8	55.0	42.9	15.9	141.7	1.37E-02	1.07E-02	3.99E-03	3.54E-02

Table 2. Data Provided by PRAM and TDM/PRAM that was used in the ecorisk assessment. (A) Abiotic concentrations and (B) tissue concentrations.

(A) Abiotic PCB exposure point concentrations provided by PRAM and TDM/PRAM

Outside the Vessel	Compartment(s)
Freely dissolved in water[a]	Upper and lower water column
Suspended solids[a]	Upper and lower water column
Dissolved organic carbon[a]	Upper and lower water column
Bedded sediment	Sediment
Sediment porewater	Sediment
Inside the Vessel	
Freely dissolved in water[b]	Interior water
Suspended solids[b]	Interior water
Dissolved organic carbon[b]	Interior water

(B) Exposure point tissue concentrations for representative species in the food chain of the reef provided by PRAM (from Table 8 in PRAM documentation, NEHC/SSC-SD 2006a).

Exposure Point Tissue Concentration	Representative Species
Pelagic Community	
Phytoplankton (TL1)	algae
Zooplankton (TL-II)	copepods
Planktivore (TL-III)	herring
Piscivore (TL-IV)	jack
Reef / Vessel Community	
Attached algae (TL-I)	encrusting algae
Sessile filter feeder (TL-II)	bivalves
Grazing / foraging omnivore (TL-II)	urchin
Invertebrate forager (TL-III)	crab
Vertebrate forager (TL-III)	triggerfish
Predator (TL-IV)	grouper
Benthic Community	
Infaunal invertebrate (TL-II)	polychaete
Epifaunal invertebrate (TL-II)	nematode
Forager (TL-III)	lobster
Predator (TL-IV)	flounder

[a] Data used to calculate upper and lower bulk water concentration

[b] Data used to calculate interior bulk water concentration

Table 3. Ecorisk assessment endpoints. Assessment endpoints evaluated using (A) media and (B) dietary exposure point concentrations modeled by PRAM and TDM/PRAM.

Table 3(A). Assessment endpoints, attributes, and receptor species for compartments modeled by PRAM and TDM/PRAM.

		Media Exposure Point	
Assessment Endpoint	Attributes	PCB Concentration from Model	Receptor Species
Water Quality	Protective of aquatic life	Bulk water concentration	aquatic species
Sediment Quality	Protective of aquatic life	Bulk sediment concentration	aquatic species
Pelagic Community			
Primary Producers	Growth, Reproduction, and Survival	Phytoplankton (TL1)	diatom
Primary Consumers	Growth, Reproduction, and Survival	Zooplankton (TL-II)	copepod
Secondary Consumers	Growth, Reproduction, and Survival	Planktivore (TL-III)	herring
Tertiary Consumers	Growth, Reproduction, and Survival	Piscivore (TL-IV)	jack
Benthic Community			
Primary Consumers	Growth, Reproduction, and Survival	Infaunal invert. (TL-II)	polychaete
Primary Consumers	Growth, Reproduction, and Survival	Epifaunal invert. (TL-II)	nematode
Secondary Consumers	Growth, Reproduction, and Survival	Forager (TL-III)	lobster
Tertiary Consumers	Growth, Reproduction, and Survival	Predator (TL-IV)	flounder
Reef Community			
Primary Producers	Growth, Reproduction, and Survival	Attached algae (TL1)	algae
Primary Consumers	Growth, Reproduction, and Survival	Sessile filter feeder (TL-II)	bivalves
Primary Consumers	Growth, Reproduction, and Survival	Grazer (TL-II)	urchin
Secondary Consumers	Growth, Reproduction, and Survival	Forager (TL-III)	triggerfish
Tertiary Consumers	Growth, Reproduction, and Survival	Predator (TL-IV)	grouper

Table 3. Cont.

Table 3(B) Assessment endpoints evaluated by inferring risk from dietary exposures.

Assessment Endpoint	Attributes	Dietary Exposure Prey Concentration from PRAM	Dietary Exposure Receptor Species
Reef Consumers			
Dolphin	Growth, Reproduction, and Survival	Reef/Predator (TL-IV)	grouper
		Reef/Vertebrate forager (TL-III)	triggerfish
		Reef/Invertebrate forager (TL-III)	crab
		Benthic/Predator (TL-IV)	flounder
		Benthic/Forager (TL-III)	lobster
		Pelagic/Planktivore (TL-III)	herring
		Pelagic/Piscivore (TL-IV)	jack
Reef Shark/Barracuda	Growth, Reproduction, and Survival	Reef/Predator (TL-IV)	grouper
		Reef/Vertebrate forager (TL-III)	triggerfish
		Benthic/Predator (TL-IV)	flounder
		Pelagic/Planktivore (TL-III)	herring
		Pelagic/Piscivore (TL-IV)	jack
Sea Turtle	Growth, Reproduction, and Survival	Benthic/Forager (TL-III)	lobster
		Reef/Invertebrate Forager (TL-III)	crab
		Reef/Grazer (TL-II)	urchin
		Reef/Sessile filter feeder	bivalves
Avian Consumers			
Cormorant	Growth, Reproduction, and Survival	Pelagic/Planktivore (TL-III)	herring
		Pelagic/Piscivore (TL-IV)	jack
		Reef/Forager (TL-III)	triggerfish
		Reef/Predator (TL-IV)	grouper
		Benthic/Predator (TL-IV)	flounder
Herring Gull	Growth, Reproduction, and Survival	Pelagic/Planktivore (TL-III)	herring
		Pelagic/Piscivore (TL-IV)	jack
		Reef/Sessile filter feeder (TL-II)	bivalves
		Reef/Grazer (TL-II)	urchin
		Reef/Invertebrate Forager (TL-III)	crab
		Reef/Vertebrate Forager (TL-III)	triggerfish
		Reef/Predator (TL-IV)	grouper
		Benthic/Epifaunal invert. (TL-II)	nematode
		Benthic/Forager (TL-III)	lobster
		Benthic/Predator (TL-IV)	flounder

Table 4. The average and 95% upper confidence level (UCL) of PCB containing material and mass of PCBs estimated to be onboard the ex-ORISKANY before and after vessel preparations. Data from Pape 2004.

A. PCB containing materials before vessel preparation

	Units	Ventilation Gaskets	Black Rubber Material	Electrical Cable[b]	Bulkhead Insulation Material	Aluminized Paint	Lubricants	Total Mass
[a] Weight on ship when built	lbs	2680.0	11989.0	558538.6	115695.0	298999.0	208140.0	
[a] Weight on ship when built	kg	1215.6	5438.1	253348.9	52478.4	135623.7	94410.7	
Factor gained during lifecycle		1.2	1.0	1.3	1.0	3.0	1.0	
Total weight on ship	lbs	3216.0	11989.0	726100.2	115695.0	896997.0	208140.0	
Total weight on ship	kg	1458.8	5438.1	329353.5	52478.4	406871.0	94410.7	
Averge PCB Concn.	ppm	20.3	37.3	1079.49	215.1	11.6	60.3	
95% UCL Concn.	ppm	33.5	50.9	1998.71	587.7	19.7	22.2	
Mass of PCBs (avg)	lbs	0.07	0.45	783.82	24.9	10.41	12.55	832.17
Mass of PCBs (95% UCL)	lbs	0.11	0.61	1451.26	68.0	17.67	4.62	1542.27
Mass of PCBs (avg)	kg	0.03	0.20	355.53	11.29	4.72	5.69	377.47
Mass of PCBs (95% UCL)	kg	0.05	0.28	658.28	30.84	8.02	2.10	699.56
fraction PCB (avg)		0.0000203	0.0000373	0.0010795	0.0002151	0.0000116	0.0000603	
fraction PCB (max)		0.0000335	0.0000509	0.0019987	0.0005877	0.0000197	0.0000222	
% of total mass (avg)		0.01%	0.05%	94.19%	2.99%	1.25%	1.51%	
% of total mass (max)		0.01%	0.04%	94.10%	4.41%	1.15%	0.30%	

B. PCB containing materials after vessel preparation

	Units	Ventilation Gaskets	Black Rubber Material	Electrical Cable[b]	Bulkhead Insulation Material	Aluminized Paint	Lubricants	Total Mass
[a] Weight on ship when built	lbs	2680.0	11989.0	502684.7	31700.4	284049.1	0.0	
[a] Weight on ship when built	kg	1215.6	5438.1	228014.0	14379.1	128842.5	0.0	
Factor gained during lifecycle		1.2	1.0	1.3	1.0	3.0	1.0	
Total weight on ship	lbs	3216.0	11989.0	653490.2	31700.4	852147.2	0.0	
Total weight on ship	kg	1458.8	5438.1	296418.2	14379.1	386527.4	0.0	
Averge PCB Concn.	ppm	20.3	37.3	1079.49	215.1	11.6	60.3	
95% UCL Concn.	ppm	33.5	50.9	1998.71	587.7	19.7	22.2	
Mass of PCBs (avg)	lbs	0.07	0.45	705.44	6.8	9.88	0.00	722.65
Mass of PCBs (95% UCL)	lbs	0.11	0.61	1306.14	18.6	16.79	0.00	1342.27
Mass of PCBs (avg)	kg	0.03	0.20	319.98	3.09	4.48	0.00	327.79
Mass of PCBs (95% UCL)	kg	0.05	0.28	592.45	8.45	7.61	0.00	608.85
fraction PCB (avg)		0.0000203	0.0000373	0.0010795	0.0002151	0.0000116	0.0000603	
fraction PCB (max)		0.0000335	0.0000509	0.0019987	0.0005877	0.0000197	0.0000222	
% of total mass (avg)		0.01%	0.06%	97.62%	0.94%	1.37%	0.00%	
% of total mass (max)		0.01%	0.05%	97.31%	1.39%	1.25%	0.00%	

[a] Final Weight Report, Aircraft Carrier CV9 USS ESSEX, Office of Supervisor of Shipbuilding for US Navy, Newport News Shipbuilding and Dry Dock Company, Newport New, VA

[b] Electrical cable normalized to intact electrical cable (0.7226 g insulation/g cable)

Table 5. The mass of materials, fraction of PCBs, and total PCB release rates used to calculate PCB loading from the ex-ORISKANY for PRAM defaults (A), input to the TDM model (B), and the average (C) and 95% UCL (D) from Pape 2004.

A. PRAM Defaults	**Ventilation Gaskets**	**Black Rubber Material**	**Electrical Cable**	**Bulkhead Insulation Material**	**Aluminized Paint**	**Total**
Fraction PCB in Material(wt/wt)	0.0000314	0.0000529	0.00185	0.000537	0.00002	
Material Mass Onboard(kg)	1,459	5,397	296,419	14,379	386,528	704,182
Total PCBs (kg)	0.0458126	0.2855013	548.37515	7.721523	7.73056	564.2
Total PCB Release rate(ng/g-PCB per day)	1577.1	1577.1	279.0	67635.4	11148.3	
Material Mass Onboard(lb)	3216.54	11898.35	653492.03	31700.27	852148.37	1,552,455.57
Total PCBs (lb)	0.100999494	0.629422624	1208.96026	17.02304427	17.04296744	1,243.76
Daily PCB Release Rate (ng/day)	7.23E+04	4.50E+05	1.53E+08	5.22E+08	8.62E+07	7.62E+08

B. TDM Inputs	**Ventilation Gaskets**	**Black Rubber Material**	**Electrical Cable**	**Bulkhead Insulation Material**	**Aluminized Paint**	**Total**
Fraction PCB in Material (wt/wt)	0.0000314	0.0000529	0.00185	0.000537	0.00002	
Material Mass Onboard (kg)	1,459	5,397	296,419	14,379	386,528	704,182
Total PCBs (kg)	0.0458126	0.2855013	548.37515	7.721523	7.73056	564.2
Total PCB Release rate (ng/g-PCB per day)	1577.1	1577.1	279.0	67635.4	11148.3	
Material Mass Onboard(lb)	3216.54	11898.35	653492.03	31700.27	852148.37	1,552,455.57
Total PCBs (lb)	0.100999494	0.629422624	1208.96026	17.02304427	17.04296744	1,243.76
Daily PCB Release Rate (ng/day)	7.23E+04	4.50E+05	1.53E+08	5.22E+08	8.62E+07	7.62E+08

C. Pape 2004 average	**Ventilation Gaskets**	**Black Rubber Material**	**Electrical Cable (intact)**	**Bulkhead Insulation Material**	**Aluminized Paint**	**Total**
Fraction PCB in Material (wt/wt) average	0.0000203	0.0000373	0.001079492	0.0002151	0.0000116	
Material Mass Onboard (kg)	1,459	5,397	296,418	14,379	386,527	704,180
Total PCBs (kg)	0.029612687	0.201302207	319.981	3.092938642	4.48371837	327.8
Total PCB Release rate (ng/g-PCB per day)	1577.1	1577.1	279.0	67635.4	11148.3	82216.9
Material Mass Onboard (lb)	3216.00	11898.00	653490.17	31700.43	852147.15	1,552,451.75
Total PCBs (lb)	0.0652848	0.4437954	705.4375068	6.818762493	9.88490694	722.65
Daily PCB Release Rate (ng/day)	4.67E+04	3.17E+05	8.93E+07	2.09E+08	5.00E+07	3.49E+08

D. Pape 2004 95% UCL	**Ventilation Gaskets**	**Black Rubber Material**	**Electrical Cable (intact)**	**Bulkhead Insulation Material**	**Aluminized Paint**	**Total**
Fraction PCB in Material (wt/wt) 95% UCL	0.0000335	0.0000509	0.001998712	0.0005877	0.0000197	
Material Mass Onboard (kg)	1,459	5,397	296,418	14,379	386,527	704,180
Total PCBs (kg)	0.048868228	0.274699259	592.4544093	8.450581311	7.61459068	608.8
Total PCB Release rate (ng/g-PCB per day)	1577.1	1577.1	279.0	67635.4	11148.3	
Material Mass Onboard (lb)	3216.00	11898.00	653490.17	31700.43	852147.15	1,552,451.75
Total PCBs (lb)	0.107736	0.6056082	1306.1384	18.63034271	16.78729886	1,342.27
Daily PCB Release Rate (ng/day)	7.71E+04	4.33E+05	1.65E+08	5.72E+08	8.49E+07	8.22E+08

Table 6. The default water exposures modeled by PRAM.

Default Water Exposures in PRAM		UWC	LWC	IVW	PW	
		Upper Water Column	Lower Water Column	Interior Vessel Water	Sediment Pore Water	Total
Pelagic Community						
Phytoplankton (TL1)	algae	100%				100%
Zooplankton (TL-II)	copepods	50%	50%			100%
Planktivore (TL-III)	herring	80%	20%			100%
Piscivore (TL-IV)	jack	80%	20%			100%
Reef / Vessel Community						
Attached Algae	encrusting algae	0%	100%			100%
Sessile filter feeder (TL-II)	bivalves (w/o shell)	0%	100%	0%		100%
Invertebrate Omnivore (TL-II)	urchin	0%	80%	20%		100%
Invertebrate Forager (TL-III)	crab	0%	70%	30%		100%
Vertebrate Forager (TL-III)	triggerfish	0%	70%	30%		100%
Predator (TL-IV)	grouper	0%	80%	20%		100%
Benthic Community						
Infaunal invert. (TL-II)	polychaete	0%	20%		80%	100%
Epifaunal invert. (TL-II)	nematode	0%	50%		50%	100%
Forager (TL-III)	lobster	0%	75%		25%	100%
Predator (TL-IV)	flounder	0%	90%		10%	100%

Note: Shaded cells can not be changed within PRAM.

Table 7. The default dietary preferences used by PRAM (version 1.4C) and the Trophic Level determined by diet for each compartment modeled in the food chain.

PRAM Default Dietary Preferences

	Suspended Solids (UWC)	Suspended Solids (LWC)	Sediment	Phyto plankton	Zoo plankton	Pelagic Plankitivore herring	Attached Algae	Reef Sessile Filter Feeder bivalve	Invertebrate Omnivore sea urchin	Reef Invertebrate Forager crab	Reef Vertebrate Forager triggerfish	Infaunal Benthos	Epifaunal Benthos	Benthic Forager lobster	**TROPHIC LEVEL**	% Diet
Trophic Level	1.125	1.250	1.500	1.000	2.056	3.056	1.000	2.131	2.226	3.177	2.965	2.461	2.702	3.521		
Pelagic Community																
Phytoplankton (TL1)															1.0000	
Zooplankton (TL-II)	15.0%	15.0%		70.0%											2.0563	100%
Planktivore (TL-III)					100.0%										3.0563	100%
Piscivore (TL-IV)					10.0%	90.0%									3.9563	100%
Reef / Vessel Community																
Attached Algae															1.0000	
Sessile filter feeder (TL-II)		10.0%		80.0%	10.0%										2.1306	100%
Invertebrate Omnivore (TL-I							80.0%	20.0%							2.2261	100%
Invertebrate Forager (TL-III)		5.0%			5.0%	5.0%		35.0%	50.0%						3.1769	100%
Vertebrate Forager (TL-III)						19.0%		19.0%	15.0%	22.0%		12.5%	12.5%		2.9648	100%
Predator (TL-IV)[1]										15.0%	60.0%	8.0%	8.0%	8.0%	3.9501	99%
Benthic Community																
Infaunal invert. (TL-II)			50.0%	30.0%	20.0%										2.4613	100%
Epifaunal invert. (TL-II)			25.0%	30.0%	20.0%							25.0%			2.7016	100%
Forager (TL-III)			5.0%									50.0%	45.0%		3.5213	100%
Predator (TL-IV)			2.0%									20.0%	20.0%	58.0%	4.1049	100%

[1] Note that the default setting in PRAM only accounts for 99% of the diet (reef invertebrate forager should be 16%); This error has minimal impact on the model results.

Table 8. Dietary preferences for the reef community during the first two years of development.

			Suspended Solids (UWC)	Suspended Solids (LWC)	Phyto-plankton	Zoo-plankton	Pelagic Planktivore (herring)	Encrusting Algae	Reef Sessile Filter Feeder (mussel)	Invertebrate Omnivore (urchin)	Reef Invertebrate Forager (crab)	Reef Vertebrate Forager (triggerfish)	Infaunal Benthos (polychaete)	Epifaunal Benthos (nematode)	Benthic Forager (lobster)	**Total**
Sessile filter feeder (TL-II mussel)																
Day	1	day	0%	10%	80%	10%		0%								100%
Day	7	week	0%	10%	80%	10%		0%								100%
Day	14	2 week	0%	10%	80%	10%		0%								100%
Day	28	month	0%	10%	80%	10%		0%								100%
Day	180	6 mon	0%	10%	80%	10%		0%								100%
Day	360	yr	0%	10%	80%	10%		0%								100%
Day	720	2 yr	0%	10%	80%	10%		0%								100%
Invertebrate Omnivore (TL-II urchin)																
Day	1	day	0%	0%	0%	0%		80%	20%					0%		100%
Day	7	week	0%	0%	0%	0%		80%	20%					0%		100%
Day	14	2 week	0%	0%	0%	0%		80%	20%					0%		100%
Day	28	month	0%	0%	0%	0%		80%	20%					0%		100%
Day	180	6 month	0%	0%	0%	0%		80%	20%					0%		100%
Day	360	yr	0%	0%	0%	0%		80%	20%					0%		100%
Day	720	2 yr	0%	0%	0%	0%		80%	20%					0%		100%
Invertebrate Forager (TL-III crab)																
Day	1	day		10%	0%	5%	5%	0%	0%	0%			50%	30%		100%
Day	7	week		10%	0%	5%	5%	0%	5%	5%			45%	25%		100%
Day	14	2 week		10%	0%	5%	5%	0%	10%	10%			35%	25%		100%
Day	28	month		5%	0%	5%	5%	0%	20%	20%			25%	20%		100%
Day	180	6 month		5%	0%	5%	5%	0%	30%	30%			15%	10%		100%
Day	360	yr		5%	0%	5%	5%	0%	30%	40%			10%	5%		100%
Day	720	2 yr		5%	0%	5%	5%	0%	35%	50%			0%	0%		100%
Vertebrate Forager (TL-III triggerfish)																
Day	1	day		0%	0%	0%	25%	0%	0%	0%	0%		10%	30%	35%	100%
Day	7	week		0%	0%	0%	25%	0%	0%	0%	0%		10%	30%	35%	100%
Day	14	2 week		0%	0%	0%	25%	0%	0%	0%	0%		10%	30%	35%	100%
Day	28	month		0%	0%	0%	25%	0%	5%	5%	0%		10%	25%	30%	100%
Day	180	6 month		0%	0%	0%	22%	0%	12.5%	12.5%	8%		15%	15%	15%	100%
Day	360	yr		0%	0%	0%	22%	0%	18%	12.5%	12.5%		12.5%	12.5%	10%	100%
Day	720	2 yr		0%	0%	0%	19%	0%	19%	15%	22%		12.5%	12.5%	0%	100%
Reef Predator (TL-IV grouper)																
Day	1	day		0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	20%	60%	100%
Day	7	week		0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	20%	60%	100%
Day	14	2 week		0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	20%	60%	100%
Day	28	month		0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	20%	60%	100%
Day	180	6 month		0%	0%	0%	20%	0%	0%	0%	10%	10%	0%	20%	40%	100%
Day	360	yr		0%	0%	0%	10%	0%	0%	0%	15%	25%	0%	10%	40%	100%
Day	720	2 yr		0%	0%	0%	0%	0%	0%	0%	15%	60%	8%	8%	8%	99%

Table 9. Concentrations of Total PCB in tissues and abiotic compartments predicted by TDM/PRAM at 0-15 m from the hull for day 0 - 2 yr and steady state concentrations predicted by PRAM with a ZOI=2 and ZOI=1.

									steady state	
	Distance From Reef	0-15 m from Reef							14.7 m	0 m
		1 d	1 wk	2 wk	1 mon	6 mon	1 yr	2 yr	ZOI=2	ZOI=1
	Days Since Sinking	1	7	14	28	180	365	730	> 2yrs	> 2yrs
TL	Compartment	Tissue Conc. Total PCB (mg/kg-WW)								
	Pelagic Community									
1.00	Phytoplankton	3.13E-11	4.16E-11	5.35E-11	5.83E-11	4.66E-11	2.14E-11	1.47E-11	1.67E-09	1.86E-09
2.06	Zooplankton	4.94E-05	5.75E-05	7.26E-05	6.76E-05	5.34E-05	2.35E-05	1.82E-05	7.72E-05	1.21E-04
3.06	Herring	2.36E-04	2.74E-04	3.73E-04	3.74E-04	3.12E-04	1.32E-04	8.95E-05	3.74E-04	5.88E-04
3.96	Jack	3.03E-04	3.42E-04	4.85E-04	5.28E-04	4.81E-04	1.93E-04	1.35E-04	5.80E-04	9.13E-04
	Reef / Vessel Community									
1.00	Encrusting Algae	4.41E-06	5.17E-06	6.64E-06	6.42E-06	5.21E-06	2.24E-06	1.73E-06	7.23E-06	1.14E-05
2.13	Bivalve	1.04E-04	1.21E-04	1.53E-04	1.42E-04	1.10E-04	4.89E-05	3.77E-05	1.58E-04	2.49E-04
2.23	Urchin	2.12E-02	2.48E-02	3.37E-02	3.32E-02	2.70E-02	1.16E-02	7.74E-03	1.69E-02	1.72E-02
3.18	Crab	1.87E-02	2.49E-02	3.75E-02	4.55E-02	4.44E-02	2.21E-02	1.66E-02	3.62E-02	3.67E-02
2.96	Triggerfish	1.45E-02	1.70E-02	2.37E-02	3.20E-02	5.68E-02	3.04E-02	3.01E-02	6.55E-02	6.66E-02
3.95	Grouper	1.35E-02	1.57E-02	2.23E-02	2.37E-02	4.84E-02	3.52E-02	5.15E-02	1.13E-01	1.15E-01
	Benthic Community									
2.46	Infauna	3.61E-05	4.22E-05	5.37E-05	5.01E-05	3.92E-05	1.74E-05	1.32E-05	5.48E-05	8.62E-05
2.70	Epifauna	1.00E-04	1.17E-04	1.52E-04	1.44E-04	1.14E-04	5.03E-05	3.64E-05	1.51E-04	2.37E-04
3.52	Lobster	2.29E-04	2.68E-04	3.61E-04	3.54E-04	2.87E-04	1.24E-04	8.42E-05	3.45E-04	5.42E-04
4.10	Flounder	7.22E-04	8.44E-04	1.20E-03	1.25E-03	1.08E-03	4.49E-04	2.92E-04	1.18E-03	1.86E-03

Compartment	Abiotic Conc. Total PCB								
Air concentration (g/m^3)								6.68E-17	5.26E-17
Upper Water Column									
Water Dissolved (mg/L)	1.90E-14	2.53E-14	3.25E-14	3.54E-14	2.83E-14	1.30E-14	8.91E-15	1.02E-12	1.13E-12
Suspended Solids (mg/kg)	2.81E-10	3.68E-10	4.62E-10	5.53E-10	5.50E-10	2.32E-10	1.92E-10	1.33E-08	1.48E-08
Dissolved Organic Carbon (mg/kg)	1.87E-09	2.45E-09	3.08E-09	3.69E-09	3.66E-09	1.55E-09	1.28E-09	1.78E-07	1.98E-07
Bulk Upper Water Col (mg/L)	3.95E-12	5.18E-12	6.50E-12	7.78E-12	7.72E-12	3.27E-12	2.70E-12	2.40E-10	2.67E-10
Lower Water Column									
Water Dissolved (mg/L)	2.68E-09	3.14E-09	4.03E-09	3.89E-09	3.16E-09	1.36E-09	1.05E-09	4.39E-09	6.90E-09
Suspended Solids (mg/kg)	4.42E-05	4.46E-05	5.67E-05	6.04E-05	6.17E-05	2.37E-05	2.20E-05	1.08E-04	1.70E-04
Dissolved Organic Carbon (mg/kg)	2.95E-04	2.97E-04	3.78E-04	4.03E-04	4.11E-04	1.58E-04	1.47E-04	9.88E-04	1.55E-03
Bulk Lower Water Col (mg/L)	6.22E-07	6.27E-07	7.98E-07	8.49E-07	8.67E-07	3.33E-07	3.09E-07	1.68E-06	2.64E-06
Interior Vessel Water									
Water Dissolved (mg/L)	2.08E-06	2.44E-06	3.13E-06	3.03E-06	2.46E-06	1.06E-06	8.16E-07	1.80E-06	1.80E-06
Suspended Solids (mg/kg)	3.44E-02	3.47E-02	4.41E-02	4.70E-02	4.80E-02	1.84E-02	1.71E-02	4.44E-02	4.44E-02
Dissolved Organic Carbon (mg/kg)	2.30E-01	2.31E-01	2.94E-01	3.13E-01	3.20E-01	1.23E-01	1.14E-01	4.06E-01	4.06E-01
Bulk Water Inside Vessel (mg/L)	4.84E-04	4.88E-04	6.21E-04	6.61E-04	6.74E-04	2.59E-04	2.40E-04	6.89E-04	6.89E-04
Sediment Bed									
Pore Water (mg/L)	2.68E-09	3.14E-09	4.03E-09	3.89E-09	3.16E-09	1.36E-09	1.05E-09	4.39E-09	6.90E-09
Sediment (mg/kg)	1.62E-06	2.39E-06	3.06E-06	4.58E-06	4.79E-06	3.94E-06	3.75E-06	7.19E-06	1.13E-05

Table 10. Ecorisk benchmark concentrations for Total PCB (A) and dioxin-like PCB congener TEQs (B). Benchmark concentrations are given for water (W_B), sediment (S_B), tissue residues of fish (T_{FISH}) and invertebrates (T_{INVERT}), dietary benchmarks for reef predators (D_{PREY}), and benchmarks for maternal transfer to fish eggs (C_{EGG}).

A. Benchmarks for exposure to Total PCB.

Media	Exposure Pathway		Benchmark (B)				Basis for Criterion
Water	Water	W_B		Water		units	Water Quality Criteria
		WQC-Chronic		0.000030		mg/L	U.S. EPA 1999a Saltwater CCC (chronic)
		GLWLC-Tier1		0.000074		mg/L	Great Lakes Wildlfie Citeria Tier1, U.S. EPA 1995
		WQC-Acute		0.010000		mg/L	U.S. EPA 1999a Saltwater CCM (acute)
Sediment	Sediment	S_B		Sediment		units	State of Florida Sediment Assessment Guidelines (SQAGs)
		TEL		0.0216		mg/Kg dry	Threshold Effects Level (TEL)
		PEL		0.1890		mg/Kg dry	Probable Effects Level (PEL)
Tissue	Food Chain	T_{INVET}, T_{FISH}	Invertebrate	Fish		units	Potential Effects from Bioaccumulation
Residue		TSV	0.4368	0.4368		mg/Kg wet	Tissue Screening Value (URS 1996, 2000, Dyer et al 2000)
		Bcv	0.9360	7.4463		mg/Kg wet	Bioaccumulation Critical Value (Johnston 1999, Johnston et al. 2001)
Tissue	Food Chain	T_{INVET}, T_{FISH}	Invertebrate	Fish	AF[1]	units	Critical Body Residues
Residue		NOED	0.6000	1.5000	10	mg/Kg wet	No Observed Effects Dose
		LOED	1.1000	1.8000	10	mg/Kg wet	Lowest Observed Effects Dose
Tissue	Food Chain	D_{PREY}	Invertebrate	Fish	AF[1]	units	Dietary Exposure
Residue	Herring Gull	Gull$_{NOAEL}$	0.8333	0.8333	10	mg/Kg wet	No Observed Adverse Effects Level
	Herring Gull	Gull$_{LOAEL}$	8.3333	8.3333	10	mg/Kg wet	Lowest Observed Adverse Effects Level
	Cormorant	Corm$_{NOAEL}$		0.8000	10	mg/Kg wet	No Observed Adverse Effects Level
	Cormorant	Corm$_{LOAEL}$		8.0000	10	mg/Kg wet	Lowest Observed Adverse Effects Level
	Dolphin	Dolphin$_{NOAEL}$	0.3166	0.3166	10	mg/Kg wet	No Observed Adverse Effects Level
	Dolphin	Dolphin$_{LOAEL}$	1.5828	1.5828	10	mg/Kg wet	Lowest Observed Adverse Effects Level
	Sea Turtle	Turtle$_{NOAEL}$	2.1792		10	mg/Kg wet	No Observed Adverse Effects Level
	Sea Turtle	Turtle$_{LOAEL}$	10.8959		10	mg/Kg wet	Lowest Observed Adverse Effects Level
	Shark/Barracuda	Shark$_{NOAEL}$		2.5196	10	mg/Kg wet	No Observed Adverse Effects Level
	Shark/Barracuda	Shark$_{LOAEL}$		4.0658	10	mg/Kg wet	Lowest Observed Adverse Effects Level

1. In risk characterization the benchmark (B) was divided by the Assessment Factor (AF) to adjust for uncertainty in species-to-species toxicity: B* = B/AF.

B. Benchmarks for exposure to dioxin-like TEQs.

Media	Exposure Pathway	Benchmark					Basis for Criterion
Tissue	Maternal Transfer to Egg	C_{EGG}		Fish	AF[1]	units	Critical Body Residues
Residue	Fish	NOED_Rainbow		0.300	10	pg TEQ/g Egg wet	No Observed Effects Dose (Rainbow Trout)
	Fish	NOED_Laketrout		5.000	10	pg TEQ/g Egg wet	No Observed Effects Dose (Lake Trout)
	Fish	LOEL_Laketrout		30.000	10	pg TEQ/g Egg wet	Lowest Observed Effects Dose (Lake Trout)
	Fish	LOEL_Rainbow(lipid)		3.000	10	pg TEQ/g Egg lipid	Lowest Observed Effects Dose (Rainbow Trout)
Tissue	Food Chain	D_{PREY}	Invertebrate	Fish	AF[1]		Dietary Exposure
Residue	Herring Gull	$Gull_{NOAEL}$	64.815	64.815	10	pg TEQ/g wet	No Observed Adverse Effects Level
	Herring Gull	$Gull_{LOAEL}$	648.148	648.148	10	pg TEQ/g wet	Lowest Observed Adverse Effects Level
	Cormorant	$Corm_{NOAEL}$		62.222	10	pg TEQ/g wet	No Observed Adverse Effects Level
	Cormorant	$Corm_{LOAEL}$		622.222	10	pg TEQ/g wet	Lowest Observed Adverse Effects Level
	Dolphin	$Dolphin_{NOAEL}$	3.928	3.928	10	pg TEQ/g wet	No Observed Adverse Effects Level
	Dolphin	$Dolphin_{LOAEL}$	17.792	17.792	10	pg TEQ/g wet	Lowest Observed Adverse Effects Level

1. In risk characterization the benchmark (B) was divided by the Assessment Factor (AF) to adjust for uncertainty in species-to-species toxicity: B* = B/AF.

Table 11. Tissue Screening value (TSV) for tPCB (from URS 1996, 2002).

				dry:wet=	0.25	0.2
					TSV	
	AWQC[a]		BCF_{Lipid}[b]		Fish[c]	Shellfish[d]
	ug/L	Criterion Basis	L/kg wet	ug/g wet	ug/g dry	ug/g dry
tPCB	0.014	Freshwater Chronic	31200	0.437	1.75	2.18

[a] Ambient Water Quality Criteria used in derivation (URS 1996, 2002)

[b] Lipid normalized BCF for aquatic species (URS 1996, 2002)

[c] Assumes that fish contain 75% moisture resulting in a dry : wet ratio of 0.25

[d] Assumes that shellfish contain 80% moisture resulting in a dry : wet ratio of 0.2

Table 12. The calculation of bioaccumulation critical values (B_{CV}) from bioconcentration factors (BCF) and water benchmarks (W_B) for Total PCB in fish and invertebrates.

		dry:wet= 0.2			dry:wet= 0.25		
Total PCB		Shellfish[a]			Fish[b]		
Chemical	W_B ug/L	BCF[c] (L/kg wet)	ug/g wet	ug/g dry	BCF[d] (L/kg wet)	ug/g wet	ug/g dry
Total PCB	0.030 [e]	31200	0.936	4.68	248209	7.446	29.79
Total PCB	0.074 [f]	31200	2.309	11.54	248209	18.367	73.47
Total PCB	0.120 [g]	31200	3.744	18.72	248209	29.785	119.14

[a] Assumes that invertebrates contain 80% moisture resulting in a dry : wet ratio of 0.2

[b] Assumes that fish contain 75% moisture resulting in a dry : wet ratio of 0.25

[c] Bioaccumulation in aquatic organisms from URS (1996)

[d] Bionconcentration factor (wet weight) for PCB based on REEFEX fish see Table 13

[e] Saltwater continuous (chronic) concentrations (U.S. EPA 1998b, 1999b, summarized in Buchman 1999).

[f] Water benchmark set to Tier I Great Lakes Wildlife Criteria (USEPA 1995)

[g] Water benchmark set to Great Lakes Water Quality Criteria for Protection of Wildlife (USEPA 1995)

Table 13. Calculation of fish bioconcentration factor (BCF) for Total PCB using the fraction of Total PCB (f_{PCB}) present for each homologue group measured in fish from the ex-VERMILLION and reference reef (REEFEX Fish, Johnston et al. 2005a).

A. Percent dry weight and lipid content from REEFEX fish (Johnston et al. 2005a).

sample#	average
%dry	25.34
% lipid (wet weight)	3.51

B. Average fraction of homologues measured in REEFEX fish (see Figure 15)

Homolog	fraction of Total PCB (f_{PCB}) average
Monochlorobiphenyls	0.000021
Dichlorobiphenyls	0.000480
Trichlorobiphenyls	0.007594
Tetrachlorobiphenyls	0.091651
Pentachlorobiphenyls	0.354637
Hexachlorobiphenyls	0.392479
Heptachlrobiphenyls	0.104417
Octachlorobiphenyls	0.040305
Nonachlorobiphenyls	0.007858
209 - Decachlorobiphenyl	0.000557
	1.000000

C. The weighted sum of the BCF was normalized to 3% lipid for aquatic organisms (US EPA 1994).

Homolog	$\log(K_{ow})^a$	f_{PCB}	$\log(BCF_{ww})^b$	BCF_{ww}	$BCF_{ww}*f_{PCB}$
Monochlorobiphenyls	4.7	0.0000	3.38	2398.8	0.0
Dichlorobiphenyls	5.1	0.0005	3.78	6025.6	2.9
Trichlorobiphenyls	5.5	0.0076	4.18	15135.6	114.9
Tetrachlorobiphenyls	5.9	0.0917	4.58	38018.9	3484.5
Pentachlorobiphenyls	6.3	0.3546	4.98	95499.3	33867.6
Hexachlorobiphenyls	6.7	0.3925	5.38	239883.3	94149.3
Heptachlrobiphenyls	7.1	0.1044	5.78	602559.6	62917.7
Octachlorobiphenyls	7.5	0.0403	6.18	1513561.2	61004.3
BCF_{PBC}					290270.4
		% Lipid	factor		
BCF_{PBC} Normalized to 3% Lipid		3.51	0.8551		248208.8

[a] Mackay et al. 1992.

[b] wet weight; log(BCFww) = -1.32 + log(Kow) Mackay (1982) cited in Petersen and Kristensen (1998)

Table 14. Critical body burdens for (A) fish and (B) invertebrate no observed (adverse) effect dose (NOED, ug/g dry weight) obtained from US Army Corps of Engineers Environmental Residue-Effects Database (ERED).

(A) Fish **Chemical**	dry weight μg/g **NOED**	**UF**	dry weight mg/Kg **NOED$_{ERED}$**	wet weight mg/Kg **NOED$_{ERED}$**	**ERED Citation**
Total Polychorinated Biphenyls (tPCB)	6.00	1.00	6.00	1.50	NOED URS103 1975 Hansen, D.J., S.C. Schimmel and J. Forester Trans. Amer. Fish. Soc. 104:584-588. Sheepshead minnow
TEQ (dioxin toxicity equvalent)				5 pg TEQ/g Egg	Cook, P. M.; et al. 2003. *Environ. Sci. Technol.;* 3864-3877. Lake Trout Sac Fry mortality
TEQ (dioxin toxicity equvalent)				0.3 pg TEQ/g Roe (egg)	deBruyn, et al. 2004. Environ. Sci. Technol.; 2004; 38(23) pp 6217 - 6224; Mortality in salmon eqgs

(B) Invertebrate **Chemical**	**NOED**	**UF**	**NOED$_{ERED}$**	**NOED$_{ERED}$**	**ERED Citation**
Total Polychorinated Biphenyls (tPCB)	3.00	1.00	3.00	0.60	NOED URS223 1991 Velduizen-Tsoerkan, M.B., Holwerda, D.A., Zandee, D.I. Arch. Environ. Contam. Toxicol. 20: 259-265 Mussel

Table 15. Critical body burdens for (A) fish and (B) invertebrate lowest observed (adverse) effect dose (LOED, ug/g dry weight) obtained from US Army Corps of Engineers Environmental Residue-Effects Database (ERED).

(A) Fish

Chemical	dry weight µg/g LOED	UF	dry weight mg/Kg $\text{LOED}_{\text{ERED}}$	wet weight mg/Kg $\text{LOED}_{\text{ERED}}$	ERED Citation
Total Polychorinated Biphenyls (tPCB)	7.20	1.00	7.20	1.80	LOED URS173 1981 Mac, M.J. and J.G. Seelye Bull. Environ. Contam. Toxicol. 27:359-367. Trout -Lake
TEQ (dioxin toxicity equvalent)				30 pg TEQ/g Egg	Cook, P. M.; et al. 2003. *Environ. Sci. Technol.; 37* (17); 3864-3877. Lake Trout Sac Fry mortality
TEQ (dioxin toxicity equvalent)				3 pg TEQ/g lipid Roe(egg)	deBruyn, et al. 2004. Environ. Sci. Technol.; 2004; 38(23) pp 6217 - 6224; Mortality in salmon eqgs

(B) Invertebrate

Chemical	LOED	UF	$\text{LOED}_{\text{ERED}}$	$\text{LOED}_{\text{ERED}}$	ERED Citation
Total Polychorinated Biphenyls (tPCB)	5.50	1.00	5.5	1.10	ED10 URS102 1974 Hansen, D.J., P.R. Parrish and J. Forester Environ. Res. 7:363-373. Grass shrimp

Table 16. Calcuation of dietary benchmark for herring gull (D_{PRE}). The dietary benchmarks were derived from literature toxicity reference values (TRV_{lit}) for ring-neck pheasant for herring gull (*Larus argentatus*) consumption of fish and invertebrates.

Omnivore - Herring Gull food injestion rate (g) = 264
Herring Gull body weight bw (g) = 1100
fish dry:wet = 0.25
invert dry:wet = 0.2

R= 0.24
a= 0.9
L= 1.0
d= 1.0

Chemical	Source of TRV	Literature TRV_{lit} $NOAEL_{lit}$ ug/g *bw* /day (wet weight)	UF	Herring Gull TRV_{HG} $NOAEL_{HG}$ ug/g *bw* /day (wet weight)	*F*	D_{PREY} wet ug/g (wet)	D_{PREY} fish[a] ug/g (dry)	D_{PREY} shellfish[b] ug/g (dry)
Total PCB	Ring-neck pheasant NOAEL (Sample et al. 1996)	0.1800	1	0.18	0.2160	0.83	3.33	4.17
Total PCB	Ring-neck pheasant **LOAEL** (Sample et al. 1996)	1.8000	1	1.80	0.2160	8.33	33.33	41.67
		pg/g bw/d	UF	pg/g *bw* /day (wet weight)	*F*	pg/g (wet)	pg/g (dry)	pg/g (dry)
[c] TEQ_{PCB}	Max concn. that can occur in diet without harmful effects to predator species (CCME 2003).					2.4	9.6	12.0
[d] TEQ	Ring-neck pheasant NOAEL (Nosek et al. 1992, cited in Weston Inc. 2003)	14	1	14	0.2160	64.8	259.3	324.1
[d] TEQ	Ring-neck pheasant **LOAEL** (Nosek et al. 1992, cited in Weston Inc. 2003)	140	1	140	0.2160	648.1	2592.6	3240.7
[d] TEQ	American kestral threshold for reproductive effects (Weston Inc. 2003)	25000	1	25000	0.2160	115740.7	462963.0	578703.7

[a] Assumes that fish contain 75% moisture resulting in a dry : wet ratio of 0.25

[b] Assumes that shellfish contain 80% moisture resulting in a dry : wet ratio of 0.2

[c] Total dioxin toxicity equivalent quotient TEQ = sum of toxicity equivalent concentration (TEC) for dioxin-like PCBs in pg/g diet.

[d] Total dioxin toxicity equivalent quotient TEQ = sum of toxicity equivalent concentration TEC for dioxin-like TCDDs, PCDFs, and PCBs

Table 17. Calcuation of dietary benchmark for cormorant (D_{PREY}), based on benchmarks derived from literature toxicity reference values (TRV_{lit}) for rink-neck pheasant for double-crested cormorant (*Phalacrocorax auritus*) consumption of fish.

Piscivore (cormorant) food injestion rate (g) = 475 R= 0.25
cormorant body weight bw (g) = 1900 a= 0.9
fish dry:wet = 0.25 L= 1.0
invert dry:wet = 0.2 d= 1.0

Chemical	Source of TRV	Literature TRV_{lit} $NOAEL_{lit}$ ug/g *bw*/day (wet weight)	UF	Cormorant $TRV_{Cormorant}$ NOAELcomorant ug/g *bw*/day (wet weight)	*F*	**D_{PREY}** wet ug/g (wet)	**D_{PREY}** fish[a] ug/g (dry)
tPCB	Aroclor Ring-neck pheasant NOAEL (Sample et al. 1996)	0.18	1	0.18	0.2250	0.80	3.20
tPCB	Aroclor Ring-neck pheasant **LOAEL** (Sample et al. 1996)	1.8	1	1.80	0.2250	8.00	32.00
		pg/g bw/d	UF	pg/g *bw*/day (wet weight)	*F*	pg/g (wet)	pg/g (dry)
[b] TEQ_{PCB}	Max concn. that can occur in diet without harmful effects to predator species (CCME 2003).					2.40	9.60
[c] TEQ	Ring-neck pheasant NOAEL (Nosek et al. 1992, cited in Weston Inc. 2003)	14	1	14	0.2250	62.2	248.9
[c] TEQ	Ring-neck pheasant **LOAEL** (Nosek et al. 1992, cited in Weston Inc. 2003)	140	1	140	0.2250	622.2	2488.9
[c] TEQ	American kestral threshold for reproductive effects (Weston Inc. 2003)	25000	1	25000	0.2250	111111.1	444444.4

[a] Assumes that fish contain 75% moisture resulting in a dry : wet ratio of 0.25

[b] Total dioxin toxicity equivalent quotient TEQ = sum of toxicity equivalent concentration (TEC) for dioxin-like PCBs in pg/g of diet.

[c] Total dioxin toxicity equivalent quotient TEQ = sum of toxicity equivalent concentration TEC for dioxin-like TCDDs, PCDFs, and PCBs

Table 18. Calcuation of dietary benchmark for dolphin (D_{PREY}), based on literature toxicity reference values (TRV_{lit}) for mink (*Mustela vison*) to derive TRV for dolphin (*Tursiops truncatus)* consumption of fish and shellfish prey.

Dolphin food injestion rate (g/day) =	27000	R=	0.125581
Dolphin bw (g) =	215000	a=	0.9
fish dry:wet =	0.25	L=	1.0
invert dry:wet =	0.2	d=	1.0

		Mink		TRV Dolphin				
	food ingestion rate (g/d)	137		27000				
	body weight (g)	1000		215000				
		TRV_{lit}		NOAEL		D_{PREY}		
		$NOAEL_{lit}$		NOAELlit*(bwtest/bwtarget)^.25		wet	fish[a]	shellfish[b]
Chemical	Source of TRV	ug/g *bw* /day (wet weight)	UF	ug/g *bw* /day (wet weight)	*F*	ug/g (wet)	ug/g (dry)	ug/g (dry)
tPCB	Aroclor 1254 Mink NOAEL (Sample et al. 1996)	0.137	1	0.036	0.1130	0.32	1.27	1.58
tPCB	Aroclor 1254 Mink **LOAEL** (Sample et al. 1996)	0.685	1	0.179	0.1130	1.58	6.33	7.91
tPCB	Weathered PCBs feed to Mink NOAEL decrease in male kit bw (Halbrook et al. 1999)	0.120	1	0.031	0.1130	0.28	1.11	1.39
tPCB	Weathered PCBs feed to Mink **LOAEL** decrease in male kit bw (Halbrook et al. 1999)	0.230	1	0.060	0.1130	0.53	2.13	2.66
tPCB	Weathered PCBs feed to Mink NOAEL decreased kit survival (Bursian et al. 2003)	0.170	1	0.044	0.1130	0.39	1.57	1.96
tPCB	Weathered PCBs feed to Mink **LOAEL** decreased kit survival (Bursian et al. 2003)	0.410	1	0.107	0.1130	0.95	3.79	4.74
		pg/g bw/d	UF	pg/g *bw* /day (wet weight)	*F*	pg/g (wet)	pg/g (dry)	pg/g (dry)
[c] TEQ_{PCB}	Mammalian max concn. that can occur in diet without harmful effects to predator species (Environ. Canada 2004a).					0.79	3.16	3.95
[d] tTEQ	Weathered PCBs feed to Mink NOAEL decreased kit survival (Bursian et al. 2003)	1.70	1	0.44396	0.1130	3.93	15.71	19.64
[d] tTEQ	Weathered PCBs feed to Mink **LOAEL** decreased kit survival (Bursian et al. 2003)	7.70	1	2.01086	0.1130	17.79	71.17	88.96
[d] tTEQ	Decreased kit survivability NOEAL (Heaton et al. 1995)	1.10	1	0.28727	0.1130	2.54	10.17	12.71
[d] tTEQ	Decreased kit survivability **LOEAL** (Heaton et al. 1995)	4.50	1	1.17518	0.1130	10.40	41.59	51.99
[d] tTEQ	Mink NOEAL (Brunstrom et al. 2001)	0.35	1	0.09140	0.1130	0.81	3.23	4.04
[d] tTEQ	Mink **LOEAL** (Brunstrom et al. 2001)	2.40	1	0.62676	0.1130	5.55	22.18	27.73

[a] Assumes that fish contain 75% moisture resulting in a dry : wet ratio of 0.25

[b] Assumes that shellfish contain 80% moisture resulting in a dry : wet ratio of 0.2

[c] Total dioxin toxicity equivalent quotient TEQ = sum of toxicity equivalent concentration TEC for dioxin-like PCBs

Table 19. Estimate of dietary benchmarks for loggerhead sea turtle (D_{PREY}) based on literature toxicity reference values (TRVlit)for mink (*Mustela vison*) and normalized to loggerhead (*Caretta caretta*) consumption rate 2421 g/day and body weight 113 kg.

food injestion rate (g/day) = 2421 R= 0.02142478
sea turtle body weight bw (g) = 113000 a= 0.9
fish dry:wet = 0.25 L= 1.0
invert dry:wet = 0.2 d= 1.0

Chemical	Source of TRV	Mink	UF	TRV Turtle	F	D_{PREY}		
	body weight (g)	1000		113000				
		TRV_{lit} $NOAEL_{lit}$ ug/g *bw* /day (wet weight)		NOAEL NOAELlit*(bwtest/bwtarget)^.25 ug/g *bw* /day (wet weight)	*F*	wet ug/g (wet)	fish[a] ug/g (dry)	shellfish[b] ug/g (dry)
tPCB	Aroclor 1254 Mink NOAEL (Sample et al. 1996)	0.137	1	0.042	0.0193	2.18	8.72	10.90
tPCB	Aroclor 1254 Mink **LOAEL** (Sample et al. 1996)	0.685	1	0.210	0.0193	10.90	43.58	54.48
tPCB	Weathered PCBs feed to Mink NOAEL decrease in male kit bw (Halbrook et al. 1999)	0.120	1	0.037	0.0193	1.91	7.64	9.54
tPCB	Weathered PCBs feed to Mink **LOAEL** decrease in male kit bw (Halbrook et al. 1999)	0.230	1	0.071	0.0193	3.66	14.63	18.29
tPCB	Weathered PCBs feed to Mink NOAEL decreased kit survival (Bursian et al. 2003)	0.170	1	0.052	0.0193	2.70	10.82	13.52
tPCB	Weathered PCBs feed to Mink **LOAEL** decreased kit survival (Bursian et al. 2003)	0.410	1	0.126	0.0193	6.52	26.09	32.61
[c] tTEQ	Weathered PCBs feed to Mink NOAEL decreased kit survival (Bursian et al. 2003)	0.00170	1	0.00052	0.0193	0.0270	0.1082	0.1352
[c] tTEQ	Weathered PCBs feed to Mink **LOAEL** decreased kit survival (Bursian et al. 2003)	0.00770	1	0.00236	0.0193	0.1225	0.4899	0.6124
[c] tTEQ	Decreased kit survivability NOEAL (Heaton et al. 1995)	0.00110	1	0.00034	0.0193	0.0175	0.0700	0.0875
[c] tTEQ	Decreased kit survivability**LOEAL** (Heaton et al. 1995)	0.00450	1	0.00138	0.0193	0.0716	0.2863	0.3579
[c] tTEQ	Mink NOEAL (Brunstrom et al. 2001)	0.00035	1	0.00011	0.0193	0.0056	0.0223	0.0278
[c] tTEQ	Mink **LOEAL** (Brunstrom et al. 2001)	0.00240	1	0.00074	0.0193	0.0382	0.1527	0.1909
[d] TEQ_{PCB}	Mammal max concn. that can occur without harmful effects to predator species (Environ. Canada 2004a).	0.00079	1	0.00024	0.0193	0.0126	0.0503	0.0628

[a] Assumes that fish contain 75% moisture resulting in a dry : wet ratio of 0.25

[b] Assumes that shellfish contain 80% moisture resulting in a dry : wet ratio of 0.2

[c] Total dioxin toxicity equivalent quotient TEQ = sum of toxicity equivalent concentration TEC for dioxin-like TCDDs, PCDFs, and PCBs

[d] Total dioxin toxicity equivalent quotient TEQ = sum of toxicity equivalent concentration TEC for dioxin-like PCBs

Table 20. Calculation of dietary PCB benchmark for shark/barracuda based on ratio of food chain multipliers (FCM) between trophic level IV (TL-IV shark - FCM4) and Trophic Level III (TL-III prey - FCM3) obtained from USEPA (2000) and weighted by the fraction of PCB homologs (f_{PCB}) observed in REEFEX fish (Johnston et al. 2005a).

Homologue	Log(Kow)[a]	f_{PCB}[b]	Reef Forager (TL-III) FCM3[c]	Reef Predator (TL-IV) FCM4[d]	ratio FCM4/ FCM3[e]	wFCM[f]	FCM_{TPCB}[g]
Monochlorobiphenyls	4.5	0.0000	1.70	1.32	0.78	0.00002	
Dichlorobiphenyls	5.2	0.0005	3.93	3.68	0.94	0.00045	
Trichlorobiphenyls	5.5	0.0076	5.85	6.65	1.14	0.00863	
Tetrachlorobiphenyls	5.9	0.0917	9.01	13.00	1.44	0.13224	
Pentachlorobiphenyls	6.5	0.3546	12.60	22.80	1.81	0.64172	
Hexachlorobiphenyls	7.0	0.3925	13.20	24.30	1.84	0.72252	
Heptachlrobiphenyls	7.2	0.1044	12.80	22.50	1.76	0.18355	
Octachlorobiphenyls	7.7	0.0403	10.10	13.30	1.32	0.05308	
Nonachlorobiphenyls	8.4	0.0079	4.33	2.20	0.51	0.00399	
209 - Decachlorobiphenyl[h]	9.6	0.0006	1.38	0.21	0.15	0.00008	
homolog average rFCM		1.0000			1.17		
TPCB	6.7	1.0000	13.20	24.40	1.85		
weighted food chain multiplier for TPCB							1.75

				D_{PREY}	
			ratio	prey (fish)	
Enpoint	Source	ug/g wet	$wFCM_{TPCB}$	mg/kg wet	ug/g dry
NOED	Westin et al. 1983, striped bass	4.4	1.75	2.520	10.079
LOED	Black et al. 1988, winter flounder	7.1	1.75	4.066	16.263

[a] Log(Kow) used in PRAM 1.4a (NEHC/SSC-SD 2005a)

[b] fraction of tPCB (f_{PCB}) measured in representative samples of reefex fish (see Table 9)

[c] food chain multiplier (FCM3) obtained from Trophic Level - III prey (USEPA 2000)

[d] food chain multiplier (FCM4) obtained from Trophic Level - III predator (USEPA 2000)

[e] ratio of FCM4/FCM3

[f] weighted food chain multiplier for each homolog group (wFCM)

[g] weighted food chain multiplier for TPCB (FCM_{TPBC}) .

[h] estimated using FCM for Kow=9.0

Table 21. Coplanar dixon-like PCB congeners and Toxicity Equivalent Factors (TEF) for mammals, birds, and fish.

		Ahlborg et al. 1994	Van den Berg et al. 1998*			Cook et al. 2003
Homolog	congener	All Species	Mammal_TEF	Bird_TEF	Fish_TEF	Fish
Tetrachlorobiphenyl	PCB077	0.0005	0.0001	0.05	0.0001	0.00016
Tetrachlorobiphenyl	PCB081		0.0001	0.1	0.0005	0.00056
Pentachlorobiphenyl	PCB105	0.0001	0.0001	0.0001	0.000005	0.000005
Pentachlorobiphenyl	PCB114	0.0005	0.0005	0.0001	0.000005	
Pentachlorobiphenyl	PCB118	0.0001	0.0001	0.00001	0.000005	0.000005
Pentachlorobiphenyl	PCB123	0.0001	0.0001	0.00001	0.000005	
Pentachlorobiphenyl	PCB126	0.1	0.1	0.1	0.005	0.005
Hexachlorobiphenyl	PCB156	0.0005	0.0005	0.0001	0.000005	0.000005
Hexachlorobiphenyl	PCB157	0.0005	0.0005	0.0001	0.000005	
Hexachlorobiphenyl	PCB167	0.00001	0.00001	0.00001	0.000005	
Hexachlorobiphenyl	PCB169	0.01	0.01	0.001	0.00005	0.01
Heptachlorobiphenyl	PCB170a	0.0001	0.0001	0.00001	0.000005	
Heptachlorobiphenyl	PCB180a	0.00001	0.0001	0.00001	0.000005	
Heptachlorobiphenyl	PCB189	0.0001	0.0001	0.00001	0.000005	

*TEFs used in this report (see http://www.epa.gov/toxteam/pcbid/tefs.htm)

Shaded cells indicated that TEFs are assumed to be equal to PCB189

Table 22. (A) The total mass and the fraction of homolog that was composed of dioxin-like PCB congeners released during the leachrate experiments normalized to the mass of shipboard solids containing PCBs onboard the ex-ORISKANY.
(B) The observed time series of PCBs released from materials tested in the leachrate study that are expected to be on the ex-ORISKANY.

A. Total PCBs released from all materials

	Cl1	Cl2	PCB8	Cl3	PCB18	PCB28	Cl4	PCB44	PCB49	PCB52	PCB66	PCB077	Cl5	PCB87
Sum Mass Released by Analyte (g PCB)	9.30E-03	2.01E+00	2.06E-01	6.98E+00	5.73E-01	2.18E+00	1.87E+02	3.09E+01	9.61E+00	5.32E+01	8.87E+00	6.29E-02	3.72E+02	2.80E+01
Dioxin-like Congeners: Fraction of Homolog												3.36E-04		

B. Time series of PCBs released from materials expected to be on the ex-ORISKANY

Paints

Leaching Time (days)	ex-Oriskany 95% UCL Total Vessel Mass Release (g PCB) Cl1	Cl2	PCB8	Cl3	PCB18	PCB28	Cl4	PCB44	PCB49	PCB52	PCB66	PCB77	Cl5	PCB87
0.008	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.101	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7.022	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.33E-02	0.00E+00	7.93E-03	1.05E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21.076	0.00E+00	0.00E+00	0.00E+00	2.84E-02	0.00E+00	4.60E-03	1.11E-01	1.22E-02	8.38E-03	1.76E-02	0.00E+00	0.00E+00	2.43E-01	1.24E-02
42.044	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.87E-02	0.00E+00	0.00E+00	2.30E-02	0.00E+00	0.00E+00	3.11E-01	1.35E-02
71.241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.15E-02	1.70E-02	6.93E-03	2.75E-02	0.00E+00	0.00E+00	3.92E-01	2.09E-02
105.081	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.48E-02	0.00E+00	0.00E+00	2.60E-02	0.00E+00	0.00E+00	3.01E-01	2.19E-02
147.088	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.78E-01	2.19E-02	8.20E-03	3.55E-02	0.00E+00	0.00E+00	5.88E-01	2.60E-02
189.030	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-01	1.76E-02	0.00E+00	3.25E-02	0.00E+00	0.00E+00	4.46E-01	2.30E-02
231.006	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.20E-02	0.00E+00	0.00E+00	3.65E-02	0.00E+00	0.00E+00	3.92E-01	0.00E+00
273.125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-02	0.00E+00	0.00E+00	3.28E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
315.042	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.28E-02	0.00E+00	0.00E+00	2.87E-02	0.00E+00	0.00E+00	2.19E-02	0.00E+00
357.008	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.24E-01	2.05E-02	0.00E+00	4.24E-02	0.00E+00	0.00E+00	5.06E-01	0.00E+00
399.022	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.69E-02	0.00E+00	0.00E+00	3.01E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
469.032	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.79E-02	1.78E-02	0.00E+00	2.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Bulkhead Insulation

Leaching Time (days)	ex-Oriskany 95% UCL Total Vessel Mass Release (g PCB) Cl1	Cl2	PCB8	Cl3	PCB18	PCB28	Cl4	PCB44	PCB49	PCB52	PCB66	PCB77	Cl5	PCB87
0.007	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.170	0.00E+00	0.00E+00	0.00E+00	2.38E-02	0.00E+00	1.64E-02	5.57E-01	6.50E-02	2.75E-02	1.08E-01	1.33E-02	0.00E+00	5.26E-01	0.00E+00
7.076	0.00E+00	2.72E-01	3.06E-02	3.75E-01	4.07E-02	1.03E-01	4.69E+00	7.82E-01	2.56E-01	1.22E+00	2.35E-01	0.00E+00	4.38E+00	3.75E-01
14.083	0.00E+00	4.43E-01	2.94E-02	3.79E-01	4.74E-02	1.26E-01	7.27E+00	1.17E+00	3.79E-01	1.86E+00	3.16E-01	1.33E-02	7.90E+00	6.32E-01
21.097	0.00E+00	2.15E-02	2.12E-02	3.48E-01	3.48E-02	1.17E-01	8.53E+00	1.33E+00	4.43E-01	2.09E+00	5.06E-01	0.00E+00	1.55E+01	1.14E+00
42.226	0.00E+00	3.16E-02	3.16E-02	5.37E-01	6.64E-02	1.96E-01	1.20E+01	2.05E+00	6.64E-01	3.16E+00	6.32E-01	0.00E+00	1.80E+01	1.52E+00
69.301	0.00E+00	2.87E-02	2.75E-02	5.99E-01	2.75E-02	1.92E-01	2.03E+01	2.72E+00	8.08E-01	4.19E+00	9.58E-01	0.00E+00	4.79E+01	2.99E+00
83.139	0.00E+00	0.00E+00	0.00E+00	3.75E-01	4.07E-02	1.56E-01	1.13E+01	2.00E+00	6.57E-01	3.13E+00	6.88E-01	0.00E+00	2.85E+01	2.16E+00
118.135	0.00E+00	2.47E-02	2.47E-02	5.63E-01	6.25E-02	2.13E-01	1.44E+01	2.69E+00	8.76E-01	4.38E+00	6.57E-01	2.56E-02	2.78E+01	2.31E+00
167.104	0.00E+00	2.35E-02	2.29E-02	5.57E-01	6.19E-02	2.26E-01	2.69E+01	3.71E+00	1.11E+00	6.19E+00	1.36E+00	0.00E+00	7.42E+01	4.33E+00
209.131	0.00E+00	1.63E-02	1.63E-02	4.38E-01	4.38E-02	1.56E-01	1.25E+01	2.35E+00	7.51E-01	4.07E+00	7.51E-01	0.00E+00	2.56E+01	2.50E+00
251.192	0.00E+00	0.00E+00	0.00E+00	4.95E-01	5.88E-02	1.61E-01	1.48E+01	2.69E+00	7.73E-01	4.95E+00	8.66E-01	0.00E+00	3.09E+01	2.32E+00
286.150	0.00E+00	0.00E+00	0.00E+00	3.09E-01	0.00E+00	1.18E-01	1.05E+01	1.76E+00	5.88E-01	3.09E+00	3.71E-01	0.00E+00	1.52E+01	1.67E+00
328.092	0.00E+00	0.00E+00	0.00E+00	3.71E-01	3.71E-02	8.66E-02	8.66E+00	1.76E+00	4.95E-01	3.09E+00	3.71E-01	0.00E+00	1.79E+01	1.45E+00
370.117	0.00E+00	0.00E+00	0.00E+00	4.02E-01	4.33E-02	1.24E-01	1.02E+01	1.86E+00	6.19E-01	3.71E+00	4.02E-01	0.00E+00	1.55E+01	1.61E+00
398.079	0.00E+00	0.00E+00	0.00E+00	5.32E-01	0.00E+00	7.51E-02	8.13E+00	1.44E+00	3.75E-01	2.72E+00	2.88E-01	0.00E+00	1.44E+01	1.16E+00
454.319	0.00E+00	0.00E+00	0.00E+00	5.94E-01	0.00E+00	8.13E-02	7.19E+00	1.22E+00	3.75E-01	2.28E+00	2.25E-01	0.00E+00	1.22E+01	1.03E+00

Table 22. Cont.

Rubber Products	ex-Oriskany 95% UCL Total Vessel Mass Release (g PCB)												
Leaching Time (days)	Cl1	Cl2	PCB8	Cl3	PCB18	PCB28	Cl4	PCB44	PCB49	PCB52	PCB66	PCB77	Cl5	PCB87
0.006	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.169	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7.074	3.10E-04	8.46E-04	4.17E-05	3.55E-04	5.53E-05	7.89E-05	1.24E-03	1.69E-04	1.02E-04	3.21E-04	1.97E-05	0.00E+00	1.02E-03	0.00E+00
14.081	0.00E+00	2.54E-03	5.65E-05	4.78E-04	6.91E-05	1.04E-04	1.84E-03	3.28E-04	1.56E-04	6.34E-04	4.72E-05	0.00E+00	9.22E-04	5.01E-05
28.153	4.78E-04	6.34E-04	6.34E-05	5.76E-04	6.91E-05	1.04E-04	2.77E-03	4.44E-04	1.73E-04	9.22E-04	6.34E-05	0.00E+00	2.30E-03	1.04E-04
49.204	5.59E-04	9.12E-05	9.12E-05	4.67E-04	1.14E-04	2.05E-04	3.93E-03	6.27E-04	2.62E-04	1.25E-03	1.08E-04	0.00E+00	2.28E-03	1.48E-04
69.272	0.00E+00	8.18E-05	7.64E-05	6.55E-04	8.73E-05	1.42E-04	5.13E-03	6.55E-04	2.51E-04	1.31E-03	1.31E-04	0.00E+00	3.66E-03	2.29E-04
104.181	7.98E-04	9.69E-04	1.08E-04	7.98E-04	1.60E-04	1.88E-04	4.85E-03	7.98E-04	3.31E-04	1.54E-03	1.71E-04	0.00E+00	4.56E-03	2.34E-04
146.122	8.07E-04	1.09E-03	1.21E-04	1.21E-03	1.44E-04	4.72E-04	4.96E-03	8.07E-04	3.00E-04	1.56E-03	1.33E-04	0.00E+00	4.96E-03	2.48E-04
188.072	6.84E-04	6.84E-04	7.98E-05	7.41E-04	1.03E-04	1.25E-04	3.53E-03	6.27E-04	2.28E-04	1.20E-03	8.55E-05	0.00E+00	2.96E-03	1.60E-04
230.109	6.20E-04	7.33E-05	7.33E-05	2.59E-03	1.18E-04	3.21E-04	3.27E-03	5.13E-04	1.69E-04	1.07E-03	1.13E-04	0.00E+00	2.99E-03	1.47E-04
286.142	1.02E-03	1.18E-04	1.07E-04	2.59E-03	1.13E-04	0.00E+00	2.20E-03	4.12E-04	1.30E-04	9.02E-04	2.31E-05	0.00E+00	8.46E-04	0.00E+00
328.083	6.84E-04	4.16E-04	7.41E-05	3.93E-04	9.69E-05	0.00E+00	2.17E-03	4.28E-04	1.20E-04	9.12E-04	3.42E-05	0.00E+00	1.54E-03	7.98E-05
370.110	6.84E-04	6.27E-04	9.12E-05	5.47E-04	1.03E-04	1.08E-04	2.45E-03	4.22E-04	1.54E-04	8.55E-04	5.70E-05	0.00E+00	1.31E-03	1.03E-04
398.072	4.05E-04	9.12E-04	7.41E-05	6.84E-04	1.20E-04	7.41E-05	2.17E-03	3.99E-04	1.31E-04	7.98E-04	9.12E-05	0.00E+00	1.77E-03	0.00E+00
475.124	9.69E-04	7.41E-04	1.20E-04	1.25E-03	1.60E-04	0.00E+00	3.59E-03	5.64E-04	1.71E-04	1.14E-03	6.84E-05	0.00E+00	2.45E-03	0.00E+00

Cable Insulation	ex-Oriskany 95% UCL Total Vessel Mass Release (g PCB)												
Leaching Time (days)	Cl1	Cl2	PCB8	Cl3	PCB18	PCB28	Cl4	PCB44	PCB49	PCB52	PCB66	PCB77	Cl5	PCB87
0.003	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.077	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6.009	0.00E+00	7.60E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.33E-01	2.75E-02	1.54E-02	4.85E-02	0.00E+00	0.00E+00	2.75E-01	0.00E+00
20.035	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-01	6.74E-02	2.66E-02	1.32E-01	1.30E-02	0.00E+00	5.01E-01	2.98E-02
40.989	0.00E+00	9.50E-02	0.00E+00	9.82E-03	6.49E-03	0.00E+00	6.18E-01	8.08E-02	3.01E-02	1.58E-01	1.90E-02	0.00E+00	1.01E+00	4.59E-02
62.235	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.91E-01	9.66E-02	2.85E-02	1.74E-01	2.22E-02	0.00E+00	9.66E-01	5.86E-02
90.010	0.00E+00	2.81E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.33E-01	8.88E-02	2.81E-02	1.63E-01	1.10E-02	0.00E+00	9.33E-01	5.48E-02
125.028	0.00E+00	0.00E+00	0.00E+00	3.04E-02	0.00E+00	2.40E-02	6.40E-01	1.02E-01	3.04E-02	2.24E-01	1.60E-02	2.40E-02	1.07E+00	7.52E-02
166.998	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.88E-01	1.06E-01	2.72E-02	2.08E-01	2.40E-02	0.00E+00	1.41E+00	6.72E-02
208.968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.29E-01	9.74E-02	3.56E-02	2.14E-01	2.73E-02	0.00E+00	1.43E+00	5.23E-02
250.982	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.18E-01	8.87E-02	3.17E-02	1.90E-01	1.90E-02	0.00E+00	8.39E-01	6.02E-02
300.024	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.54E-01	6.81E-02	0.00E+00	1.74E-01	1.41E-02	0.00E+00	3.48E-01	0.00E+00
341.964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.23E-01	8.23E-02	2.06E-02	1.90E-01	1.74E-02	0.00E+00	7.92E-01	5.07E-02
383.993	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.16E-01	1.22E-01	4.32E-02	2.88E-01	2.56E-02	0.00E+00	1.02E+00	1.06E-01
411.955	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.36E-01	8.80E-02	2.88E-02	1.92E-01	2.56E-02	0.00E+00	1.17E+00	7.36E-02
474.981	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.08E-01	7.84E-02	3.20E-02	1.76E-01	0.00E+00	0.00E+00	6.72E-01	3.68E-02

Vent. Gaskets	ex-Oriskany 95% UCL Total Vessel Mass Release (g PCB)												
Leaching Time (days)	Cl1	Cl2	PCB8	Cl3	PCB18	PCB28	Cl4	PCB44	PCB49	PCB52	PCB66	PCB77	Cl5	PCB87
0.006	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.169	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7.074	4.98E-05	1.36E-04	6.70E-06	5.70E-05	8.87E-06	1.27E-05	1.99E-04	2.71E-05	1.63E-05	5.16E-05	3.17E-06	0.00E+00	1.63E-04	0.00E+00
14.081	0.00E+00	4.07E-04	9.06E-06	7.67E-05	1.11E-05	1.66E-05	2.96E-04	5.27E-05	2.50E-05	1.02E-04	7.58E-06	0.00E+00	1.48E-04	8.04E-06
28.153	7.67E-05	1.02E-04	1.02E-05	9.24E-05	1.11E-05	1.66E-05	4.44E-04	7.12E-05	2.77E-05	1.48E-04	1.02E-05	0.00E+00	3.70E-04	1.66E-05
49.204	8.96E-05	1.46E-05	1.46E-05	7.50E-05	1.83E-05	3.29E-05	6.31E-04	1.01E-04	4.21E-05	2.01E-04	1.74E-05	0.00E+00	3.66E-04	2.38E-05
69.272	0.00E+00	1.31E-05	1.23E-05	1.05E-04	1.40E-05	2.28E-05	8.23E-04	1.05E-04	4.03E-05	2.10E-04	2.10E-05	0.00E+00	5.86E-04	3.68E-05
104.181	1.28E-04	1.55E-04	1.74E-05	1.28E-04	2.56E-05	3.02E-05	7.77E-04	1.28E-04	5.30E-05	2.47E-04	2.74E-05	0.00E+00	7.32E-04	3.75E-05
146.122	1.29E-04	1.76E-04	1.94E-05	1.94E-04	2.31E-05	7.58E-05	7.95E-04	1.29E-04	4.81E-05	2.50E-04	2.13E-05	0.00E+00	7.95E-04	3.98E-05
188.072	1.10E-04	1.10E-04	1.28E-05	1.19E-04	1.65E-05	2.01E-05	5.67E-04	1.01E-04	3.66E-05	1.92E-04	1.37E-05	0.00E+00	4.76E-04	2.56E-05
230.109	9.95E-05	1.18E-05	1.18E-05	4.16E-04	1.90E-05	5.16E-05	5.25E-04	8.23E-05	2.71E-05	1.72E-04	1.81E-05	0.00E+00	4.80E-04	2.35E-05
286.142	1.63E-04	1.90E-05	1.72E-05	4.16E-04	1.81E-05	0.00E+00	3.53E-04	6.60E-05	2.08E-05	1.45E-04	3.71E-06	0.00E+00	1.36E-04	0.00E+00
328.083	1.10E-04	6.68E-05	1.19E-05	6.31E-05	1.55E-05	0.00E+00	3.48E-04	6.86E-05	1.92E-05	1.46E-04	5.49E-06	0.00E+00	2.47E-04	1.28E-05
370.110	1.10E-04	1.01E-04	1.46E-05	8.78E-05	1.65E-05	1.74E-05	3.93E-04	6.77E-05	2.47E-05	1.37E-04	9.15E-06	0.00E+00	2.10E-04	1.65E-05
398.072	6.49E-05	1.46E-04	1.19E-05	1.10E-04	1.92E-05	1.19E-05	3.48E-04	6.40E-05	2.10E-05	1.28E-04	1.46E-05	0.00E+00	2.84E-04	0.00E+00
475.124	1.55E-04	1.19E-04	1.92E-05	2.01E-04	2.56E-05	0.00E+00	5.76E-04	9.05E-05	2.74E-05	1.83E-04	1.10E-05	0.00E+00	3.93E-04	0.00E+00

Table 22. Cont.

A. Total PCBs released fr

	PCB101	PCB105	PCB114	PCB118	PCB123	PCB126	Cl6	PCB128	PCB138	PCB153	PCB156	PCB157	PCB167	PCB169	Cl7
Sum Mass Released by Analyte (g PCB)	4.41E+01	1.04E+01	3.62E-01	2.37E+01	0.00E+00	0.00E+00	8.09E+01	2.37E+00	1.09E+01	8.79E+00	6.29E-01	2.63E-02	9.63E-02	0.00E+00	3.71E+00
Dioxin-like Congeners: Fraction of Homolog		2.79E-02	9.72E-04	6.36E-02	0.00E+00	0.00E+00					7.78E-03	3.25E-04	1.19E-03	0.00E+00	

B. Time series of PCBs re

Paints

Leaching Time (days)	PCB101	PCB105	PCB114	PCB118	PCB123	PCB126	Cl6	PCB128	PCB138	PCB153	PCB156	PCB157	PCB167	PCB169	Cl7
0.008	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.101	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.08E-02
7.022	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.02E-02
21.076	2.16E-02	6.49E-03	0.00E+00	1.04E-02	0.00E+00	0.00E+00	1.20E-01	0.00E+00	8.52E-03	1.33E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-01
42.044	2.30E-02	8.25E-03	0.00E+00	1.76E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
71.241	3.53E-02	0.00E+00	0.00E+00	2.22E-02	0.00E+00	0.00E+00	3.01E-01	0.00E+00	1.96E-02	1.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
105.081	3.83E-02	0.00E+00	0.00E+00	3.28E-02	0.00E+00	0.00E+00	2.19E-01	0.00E+00	3.28E-02	3.28E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
147.088	4.10E-02	1.50E-02	0.00E+00	3.01E-02	0.00E+00	0.00E+00	3.83E-01	0.00E+00	2.60E-02	3.96E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
189.030	3.38E-02	1.15E-02	0.00E+00	2.70E-02	0.00E+00	0.00E+00	2.57E-01	0.00E+00	2.03E-02	3.11E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
231.006	4.46E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
273.125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
315.042	2.05E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
357.008	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
399.022	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
469.032	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Bulkhead Insulation

Leaching Time (days)	PCB101	PCB105	PCB114	PCB118	PCB123	PCB126	Cl6	PCB128	PCB138	PCB153	PCB156	PCB157	PCB167	PCB169	Cl7
0.007	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.170	2.26E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.09E-01
7.076	5.00E-01	1.16E-01	0.00E+00	2.41E-01	0.00E+00	0.00E+00	7.19E-01	0.00E+00	5.94E-02	3.44E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.69E-01
14.083	1.04E+00	2.21E-01	0.00E+00	5.37E-01	0.00E+00	0.00E+00	8.85E-01	4.43E-02	1.20E-01	7.90E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.99E-01
21.097	1.80E+00	4.43E-01	2.88E-02	1.07E+00	0.00E+00	0.00E+00	2.28E+00	7.59E-02	2.97E-01	1.58E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
42.226	2.50E+00	6.01E-01	3.79E-02	1.52E+00	0.00E+00	0.00E+00	2.81E+00	1.39E-01	4.43E-01	6.01E-01	4.43E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
69.301	4.79E+00	1.50E+00	8.98E-02	3.29E+00	0.00E+00	0.00E+00	1.11E+01	4.19E-01	1.47E+00	6.28E-01	1.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
83.139	3.44E+00	1.00E+00	5.63E-02	2.38E+00	0.00E+00	0.00E+00	5.00E+00	2.38E-01	9.38E-01	5.94E-01	6.88E-02	0.00E+00	0.00E+00	0.00E+00	4.69E-01
118.135	3.75E+00	1.06E+00	0.00E+00	2.47E+00	0.00E+00	0.00E+00	5.63E+00	2.47E-01	9.69E-01	5.32E-01	8.44E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
167.104	7.42E+00	2.04E+00	9.59E-02	5.26E+00	0.00E+00	0.00E+00	1.89E+01	4.95E-01	2.41E+00	1.30E+00	2.01E-01	0.00E+00	6.19E-02	0.00E+00	1.39E+00
209.131	3.75E+00	1.13E+00	5.32E-02	2.25E+00	0.00E+00	0.00E+00	5.94E+00	2.69E-01	1.09E+00	1.22E+00	8.13E-02	2.63E-02	3.44E-02	0.00E+00	5.94E-01
251.192	3.40E+00	6.19E-01	0.00E+00	1.33E+00	0.00E+00	0.00E+00	6.19E+00	1.73E-01	7.42E-01	8.35E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
286.150	2.38E+00	4.64E-01	0.00E+00	8.97E-01	0.00E+00	0.00E+00	2.41E+00	0.00E+00	5.88E-01	8.35E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
328.092	2.13E+00	3.40E-01	0.00E+00	6.50E-01	0.00E+00	0.00E+00	4.33E+00	1.36E-01	4.95E-01	5.26E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
370.117	2.38E+00	2.54E-01	0.00E+00	4.64E-01	0.00E+00	0.00E+00	3.09E+00	9.90E-02	3.40E-01	4.64E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
398.079	1.75E+00	2.03E-01	0.00E+00	3.13E-01	0.00E+00	0.00E+00	4.07E+00	0.00E+00	4.07E-01	3.75E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
454.319	1.47E+00	1.28E-01	0.00E+00	2.00E-01	0.00E+00	0.00E+00	4.07E+00	0.00E+00	2.47E-01	3.03E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 22. Cont.

Rubber Products

Leaching Time (days)	PCB101	PCB105	PCB114	PCB118	PCB123	PCB126	Cl6	PCB128	PCB138	PCB153	PCB156	PCB157	PCB167	PCB169	Cl7
0.006	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.99E-04
1.169	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.76E-04
7.074	3.55E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.24E-04
14.081	1.04E-04	0.00E+00	0.00E+00	2.94E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.44E-04
28.153	2.25E-04	0.00E+00	0.00E+00	9.80E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
49.204	2.79E-04	4.50E-05	0.00E+00	1.43E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
69.272	3.93E-04	8.73E-05	0.00E+00	2.51E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
104.181	4.56E-04	0.00E+00	0.00E+00	2.68E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
146.122	4.32E-04	1.15E-04	0.00E+00	2.65E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
188.072	2.68E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
230.109	2.59E-04	0.00E+00	0.00E+00	1.07E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
286.142	1.18E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
328.083	1.43E-04	3.08E-05	0.00E+00	5.47E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
370.110	1.37E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
398.072	7.98E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
475.124	1.43E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Cable Insulation

Leaching Time (days)	PCB101	PCB105	PCB114	PCB118	PCB123	PCB126	Cl6	PCB128	PCB138	PCB153	PCB156	PCB157	PCB167	PCB169	Cl7
0.003	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.077	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6.009	1.42E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.50E-02
20.035	5.17E-02	1.33E-02	0.00E+00	2.82E-02	0.00E+00	0.00E+00	4.23E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.39E-01
40.989	8.55E-02	2.06E-02	0.00E+00	5.70E-02	0.00E+00	0.00E+00	2.53E-01	0.00E+00	1.20E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
62.235	1.05E-01	2.53E-02	0.00E+00	6.97E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
90.010	1.04E-01	2.52E-02	0.00E+00	7.85E-02	0.00E+00	0.00E+00	3.26E-01	0.00E+00	3.26E-02	2.81E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.22E-02
125.028	1.54E-01	4.80E-02	0.00E+00	1.04E-01	0.00E+00	0.00E+00	6.40E-01	3.68E-02	4.16E-02	4.80E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
166.998	1.12E-01	2.40E-02	0.00E+00	7.04E-02	0.00E+00	0.00E+00	4.48E-01	0.00E+00	2.56E-02	4.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
208.968	9.03E-02	0.00E+00	0.00E+00	4.16E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
250.982	8.55E-02	2.22E-02	0.00E+00	4.59E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
300.024	5.86E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
341.964	8.23E-02	1.74E-02	0.00E+00	3.80E-02	0.00E+00	0.00E+00	1.90E-01	0.00E+00	1.90E-02	1.74E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
383.993	1.60E-01	4.16E-02	0.00E+00	7.84E-02	0.00E+00	0.00E+00	3.20E-01	0.00E+00	4.64E-02	4.16E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
411.955	8.64E-02	0.00E+00	0.00E+00	3.36E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
474.981	6.08E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Vent. Gaskets

Leaching Time (days)	PCB101	PCB105	PCB114	PCB118	PCB123	PCB126	Cl6	PCB128	PCB138	PCB153	PCB156	PCB157	PCB167	PCB169	Cl7
0.006	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.80E-05
1.169	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.43E-05
7.074	5.70E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.41E-05
14.081	1.66E-05	0.00E+00	0.00E+00	4.71E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.12E-05
28.153	3.61E-05	0.00E+00	0.00E+00	1.57E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
49.204	4.48E-05	7.23E-06	0.00E+00	2.29E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
69.272	6.30E-05	1.40E-05	0.00E+00	4.03E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
104.181	7.32E-05	0.00E+00	0.00E+00	4.30E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
146.122	6.93E-05	1.85E-05	0.00E+00	4.25E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
188.072	4.30E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
230.109	4.16E-05	0.00E+00	0.00E+00	1.72E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
286.142	1.90E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
328.083	2.29E-05	4.94E-06	0.00E+00	8.78E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
370.110	2.20E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
398.072	1.28E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
475.124	2.29E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 22. Cont.

A. Total PCBs released fr

	PCB170	PCB180	PCB183	PCB184	PCB187	PCB189	Cl8	PCB195	Cl9	PCB206	Cl10	PCB209	tPCBs
Sum Mass Released by Analyte (g PCB)	7.73E-02	1.43E-01	7.95E-02	1.63E-01	1.53E-01	0.00E+00	0.00E+00	0.00E+00	4.00E-02	2.56E-02	2.24E-02	2.24E-02	6.53E+02
Dioxin-like Congeners: Fraction of Homolog	2.08E-02	3.85E-02				0.00E+00							

B. Time series of PCBs re

Paints

Leaching Time (days)	PCB170	PCB180	PCB183	PCB184	PCB187	PCB189	Cl8	PCB195	Cl9	PCB206	Cl10	PCB209	tPCBs
0.008	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.101	0.00E+00	0.00E+00	0.00E+00	1.05E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.08E-02
7.022	0.00E+00	0.00E+00	0.00E+00	9.16E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-01
21.076	0.00E+00	0.00E+00	0.00E+00	1.15E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.03E-01
42.044	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.60E-01
71.241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.55E-01
105.081	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.04E-01
147.088	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.15E+00
189.030	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.52E-01
231.006	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.84E-01
273.125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-02
315.042	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E-02
357.008	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.30E-01
399.022	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.69E-02
469.032	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.79E-02

Bulkhead Insulation

Leaching Time (days)	PCB170	PCB180	PCB183	PCB184	PCB187	PCB189	Cl8	PCB195	Cl9	PCB206	Cl10	PCB209	tPCBs
0.007	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.170	0.00E+00	0.00E+00	0.00E+00	2.94E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.42E+00
7.076	0.00E+00	0.00E+00	0.00E+00	2.00E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E+01
14.083	0.00E+00	0.00E+00	0.00E+00	2.43E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.71E+01
21.097	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.67E+01
42.226	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.34E+01
69.301	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.99E+01
83.139	0.00E+00	0.00E+00	3.00E-02	2.56E-02	2.88E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.56E+01
118.135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.84E+01
167.104	7.73E-02	8.35E-02	4.95E-02	0.00E+00	6.81E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E+02
209.131	0.00E+00	5.94E-02	0.00E+00	0.00E+00	5.63E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.51E+01
251.192	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.25E+01
286.150	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.84E+01
328.092	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.13E+01
370.117	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.92E+01
398.079	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.71E+01
454.319	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E+01

Table 22. Cont.

Rubber Products

Leaching Time (days)	PCB170	PCB180	PCB183	PCB184	PCB187	PCB189	Cl8	PCB195	Cl9	PCB206	Cl10	PCB209	tPCBs
0.006	0.00E+00	0.00E+00	0.00E+00	4.62E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.99E-04
1.169	0.00E+00	0.00E+00	0.00E+00	4.51E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.76E-04
7.074	0.00E+00	0.00E+00	0.00E+00	5.08E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.29E-03
14.081	0.00E+00	0.00E+00	0.00E+00	6.34E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.22E-03
28.153	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E-03
49.204	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.33E-03
69.272	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.52E-03
104.181	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-02
146.122	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-02
188.072	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.61E-03
230.109	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.55E-03
286.142	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.77E-03
328.083	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.20E-03
370.110	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.62E-03
398.072	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.93E-03
475.124	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.01E-03

Cable Insulation

Leaching Time (days)	PCB170	PCB180	PCB183	PCB184	PCB187	PCB189	Cl8	PCB195	Cl9	PCB206	Cl10	PCB209	tPCBs
0.003	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.077	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6.009	0.00E+00	0.00E+00	0.00E+00	1.16E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E+00
20.035	0.00E+00	0.00E+00	0.00E+00	1.02E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E+00
40.989	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.99E+00
62.235	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E+00
90.010	0.00E+00	0.00E+00	0.00E+00	1.05E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.13E+00
125.028	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-02	2.56E-02	2.24E-02	2.24E-02	2.45E+00
166.998	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.55E+00
208.968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.05E+00
250.982	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E+00
300.024	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.03E-01
341.964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E+00
383.993	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.16E+00
411.955	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E+00
474.981	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.28E+00

Vent. Gaskets

Leaching Time (days)	PCB170	PCB180	PCB183	PCB184	PCB187	PCB189	Cl8	PCB195	Cl9	PCB206	Cl10	PCB209	tPCBs
0.006	0.00E+00	0.00E+00	0.00E+00	7.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.80E-05
1.169	0.00E+00	0.00E+00	0.00E+00	7.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.43E-05
7.074	0.00E+00	0.00E+00	0.00E+00	8.14E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.89E-04
14.081	0.00E+00	0.00E+00	0.00E+00	1.02E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.98E-04
28.153	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-03
49.204	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E-03
69.272	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-03
104.181	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.92E-03
146.122	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.09E-03
188.072	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E-03
230.109	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-03
286.142	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-03
328.083	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.34E-04
370.110	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.02E-04
398.072	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.52E-04
475.124	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.45E-03

Table 23. Summary of the g PCB of total homolog released and fraction that was contributed by dioxin-like coplanar congeners. See Table 22 for raw data.

	Tetrachlorobiphenyl HOMOCL04		Pentachlorobiphenyl HOMOCL05		Hexachlorobiphenyl HOMOCL06		Heptachlorobiphenyl HOMOCL07	
	Total g PCB Released	Fraction Dioxin-like Congener	Total g PCB Released	Fraction Dioxin-like Congener	Total g PCB Released	Fraction Dioxin-like Congener	Total g PCB Released	Fraction Dioxin-like Congener
homolog	187.14722		372.12908		80.86429		3.71210	
PCB077	0.06293	0.00034						
PCB081[a]	0.00500	0.00003						
PCB105			10.39506	0.02793				
PCB114			0.36182	0.00097				
PCB118			23.66006	0.06358				
PCB123			0.00000	0.00000				
PCB126			0.00000	0.00000				
PCB156					0.62949	0.00778		
PCB157					0.02627	0.00032		
PCB167					0.09627	0.00119		
PCB169					0.00000	0.00000		
PCB170							0.07734	0.02083
PCB180							0.14294	0.03851
PCB189							0.00000	0.00000

a Congener was not measured, concentration of PCB081 was estimated assuming it was present in proportion to PCB077 using the proptionality observered in REEFEX fish

Table 24. Parameters from the literature used for calculating transfer from female to egg (A) and estimating concentrations of congeners (B) and the lip content of eggs (C).

A. Conversion factors from female to egg (roe) from literature.

	Female (Muscle)			Egg (Roe)			(EF) egg/female ratio			
	pg/g wet	f_lipid wet	pg/g lipid	pg/g wet	f_lipid wet	pg/g lipid	ratio	average	Source	Species
PCB077	3870.0	0.1690	22899.4	1340.0	0.0820	16341.5	0.714		Cook et al. 2003.	lake trout
PCB077	7.9	0.0613	129.5	15.1	0.1426	105.5	0.815		deBruyn et al. 2004	premigrating sockeye salmon
PCB077	14.1	0.0101	1391.1	38.7	0.1028	376.3	0.270		deBruyn et al. 2004	postmigrating sockeye salmon
								0.600		
PCB081	319.0	0.1690	1887.6	99.7	0.0820	1215.9	0.644		Cook et al. 2003.	lake trout
PCB081	0.7	0.0613	11.9	1.4	0.1426	10.0	0.836		deBruyn et al. 2004	premigrating sockeye salmon
PCB081	0.9	0.0101	89.1	2.8	0.1028	26.8	0.301		deBruyn et al. 2004	postmigrating sockeye salmon
								0.594		
PCB105	135000.0	0.1690	798816.6	43600.0	0.0820	531707.3	0.666		Cook et al. 2003.	lake trout
PCB105	162.9	0.0613	2657.4	336.2	0.1426	2357.4	0.887		deBruyn et al. 2004	premigrating sockeye salmon
PCB105	144.2	0.0101	14281.2	537.1	0.1028	5224.7	0.366		deBruyn et al. 2004	postmigrating sockeye salmon
								0.640		
PCB114	12.2	0.0613	198.2	26.2	0.1426	184.0	0.928		deBruyn et al. 2004	premigrating sockeye salmon
PCB114	11.0	0.0101	1093.1	40.9	0.1028	398.1	0.364		deBruyn et al. 2004	postmigrating sockeye salmon
								0.646		
PCB118	342000.0	0.1690	2023668.6	111000.0	0.0820	1353658.5	0.669		Cook et al. 2003.	lake trout
PCB118	409.9	0.0613	6687.3	818.3	0.1426	5738.4	0.858		deBruyn et al. 2004	premigrating sockeye salmon
PCB118	348.8	0.0101	34533.7	1282.4	0.1028	12475.0	0.361		deBruyn et al. 2004	postmigrating sockeye salmon
								0.629		
PCB123	13.6	0.0613	222.5	20.7	0.1426	145.0	0.652		deBruyn et al. 2004	premigrating sockeye salmon
PCB123	8.8	0.0101	875.2	30.6	0.1028	297.3	0.340		deBruyn et al. 2004	postmigrating sockeye salmon
								0.496		
PCB126	2470.0	0.1690	14615.4	731.0	0.0820	8914.6	0.610		Cook et al. 2003.	lake trout
PCB126	2.5	0.0613	40.5	4.1	0.1426	29.0	0.718		deBruyn et al. 2004	premigrating sockeye salmon
PCB126	2.0	0.0101	200.0	6.6	0.1028	63.8	0.319		deBruyn et al. 2004	postmigrating sockeye salmon
								0.549		
PCB156c	60500.0	0.1690	357988.2	16200.0	0.0820	197561.0	0.552		Cook et al. 2003.	lake trout
PCB156	28.5	0.0613	464.6	47.9	0.1426	335.9	0.723		deBruyn et al. 2004	premigrating sockeye salmon
PCB156	24.8	0.0101	2457.4	70.3	0.1028	684.2	0.278		deBruyn et al. 2004	postmigrating sockeye salmon
								0.518		
PCB157	7.9	0.0613	128.5	14.2	0.1426	99.6	0.775		deBruyn et al. 2004	premigrating sockeye salmon
PCB157	6.6	0.0101	657.4	19.8	0.1028	192.6	0.293		deBruyn et al. 2004	postmigrating sockeye salmon
								0.534		
PCB167	18.1	0.0613	295.4	31.6	0.1426	221.7	0.750		deBruyn et al. 2004	premigrating sockeye salmon
PCB167	17.0	0.0101	1687.1	43.2	0.1028	420.3	0.249		deBruyn et al. 2004	postmigrating sockeye salmon
								0.500		

Table 24. Cont.

	Female (Muscle)			Egg (Roe)			(EF) egg/female ratio			
	pg/g wet	f_lipid wet	pg/g lipid	pg/g wet	f_lipid wet	pg/g lipid	ratio	average	Source	Species
PCB169	143.0	0.1690	846.2	38.3	0.0820	467.1	0.552		Cook et al. 2003.	lake trout
PCB169	0.7	0.0613	11.4	0.6	0.1426	3.9	0.344		deBruyn et al. 2004	premigrating sockeye salmon
PCB169	0.5	0.0101	46.5	0.9	0.1028	8.9	0.192		deBruyn et al. 2004	postmigrating sockeye salmon
								0.363		
PCB189	1.5	0.0613	24.3	2.2	0.1426	15.4	0.632		deBruyn et al. 2004	premigrating sockeye salmon
PCB189	1.5	0.0101	151.5	2.2	0.1028	21.5	0.142		deBruyn et al. 2004	postmigrating sockeye salmon
								0.387		

B. Conversion factors for estimating tissue concentrations based on available data.

Ratio of	to	wet weight basis	Site	Species	congener average	Source	Comment
PCB081	PCB077	0.0824		Lake Trout		Cook et al. 2003.	lake trout
PCB081	PCB077	0.0919		Sockeye Salmon		deBruyn et al. 2004	premigrating sockeye salmon
PCB081	PCB077	0.0641		Sockeye Salmon		deBruyn et al. 2004	postmigrating sockeye salmon
					0.0795		
PCB156	PCB167	2.43	Reference	Black Sea Bass		Johnston et al. 2005	REEFEX fish
PCB156	PCB167	2.41	Target	Black Sea Bass		Johnston et al. 2005	REEFEX fish
PCB156	PCB167	2.22	Reference	Vermillion Snapper		Johnston et al. 2005	REEFEX fish
PCB156	PCB167	2.57	Target	Vermillion Snapper		Johnston et al. 2005	REEFEX fish
PCB156	PCB167	2.19	Reference	White Grunt		Johnston et al. 2005	REEFEX fish
PCB156	PCB167	2.78	Target	White Grunt		Johnston et al. 2005	REEFEX fish
PCB156	PCB167	2.50	all fish		2.5000	Johnston et al. 2005	REEFEX fish
PCB157	PCB167	0.69	Reference	Black Sea Bass		Johnston et al. 2005	REEFEX fish
PCB157	PCB167	0.62	Target	Black Sea Bass		Johnston et al. 2005	REEFEX fish
PCB157	PCB167	0.64	Reference	Vermillion Snapper		Johnston et al. 2005	REEFEX fish
PCB157	PCB167	0.61	Target	Vermillion Snapper		Johnston et al. 2005	REEFEX fish
PCB157	PCB167	0.68	Reference	White Grunt		Johnston et al. 2005	REEFEX fish
PCB157	PCB167	0.59	Target	White Grunt		Johnston et al. 2005	REEFEX fish
PCB157	PCB167	0.64	all fish		0.6400	Johnston et al. 2005	REEFEX fish
						Johnston et al. 2005	REEFEX fish

C. Average lipid content of eggs (roe) reported from literature.

%lipid content (wet weight)	mass fraction lipid/wet weight	f_eggLIPIDw Average		
8.2	0.0820		Cook et al. 2003.	lake trout
14.26	0.1426		deBruyn et al. 2004	premigrating sockeye salmon
10.28	0.1028		deBruyn et al. 2004	postmigrating sockeye salmon
		0.1091		

Table 25. Summary of media, exposure pathways, benchmarks, endpoints, and stressors evaluated for the ecorisk analysis. The attributes evaluated for each assessment enpoint were growth, reproduction, and survival.

Media	**Exposure Pathway**	**Benchmarks**[a]	**Endpoint**	**Stressor**
Water	Water	Water Quality Criteria WQC-Chronic, WQC-Acute	Primary Producer	Total PCB
			Primary Consumer	Total PCB
			Secondary Consumer	Total PCB
			Tertiary Consumer	Total PCB
Sediment	Sediment	Potential Sediment Effects TEL, PEL	Primary Producer	Total PCB
			Primary Consumer	Total PCB
			Secondary Consumer	Total PCB
Tissue Residue	Food Chain	Potential Bioaccumulation Effects TSV, Bcv	Primary Producer	Total PCB
			Primary Consumer	Total PCB
			Secondary Consumer	Total PCB
			Tertiary Consumer	Total PCB
Tissue Residue	Food Chain	Critical Body Residues NOED, LOED	Primary Consumer	Total PCB
			Secondary Consumer	Total PCB, TEQ
			Tertiary Consumer	Total PCB, TEQ
Tissue Residue	Food Chain	Dietary Exposure NOAEL, LOAEL	Avian Omnivore (Herring Gull)	Total PCB, TEQ
			Avian Piscivore (Cormorant)	Total PCB, TEQ
			Tertiary Consumer (Sea Turtle)	Total PCB
			Tertiary Consumer (Dolphin)	Total PCB, TEQ
			Tertiary Consumer (Shark)	Total PCB

[a] Benchmarks listed are for conservative and less conservative, respectively.

Table 26. Data on the effects of water exposure to PCBs (as Technical Aroclors) reported in U.S. EPA 1980.

Table[1]	Water	Species	Aroclor	Duration	Effect	Effect	Reference	mg/L
2	saltwater	Sheepshead minnow	1254	96 hr	chronic	early life cycle test	Schimmel et al. 1974	0.00010
6	saltwater	Sheepshead minnow	1254	28 days	chronic	affected reproduction	Hansen et al. 1973	0.00014
6	saltwater	Communities of Organisms	1254	4 mos	chronic	affected community composition	Hansen 1974	0.00060
6	saltwater	Sheepshead minnow	1254	21 days	chronic	LC50 survival	Schimmel et al. 1974	0.00093
6	saltwater	Pink Shrimp	1254	15 days	chronic	51% mortality	Nimmo et al. 1971	0.00094
6	saltwater	Ciliate protozoans	1254	96 hour	chronic	reduced growth	Cooley et al. 1973	0.00100
6	saltwater	Pink Shrimp	1254	15 days	chronic	LC50 survival	Nimmo & Bahner 1976	0.00100
6	saltwater	Eastern oyster	1254	24 weeks	chronic	reduced growth	Lowe undated	0.00500
6	saltwater	Pinfish	1254	14-35 days	chronic	41 to 66% mortality	Hansen et al. 1971	0.00500
6	saltwater	Spot	1254	20-45 days	chronic	51 to 62 % mortality	Hansen et al. 1971	0.00500
6	saltwater	Spot	1254	15 days[2]	chronic	liver pathogenesis	Nimmo et al. 1971	0.00500
2	saltwater	Sheepshead minnow	1016	96 hr	chronic	early life cycle test	Hansen et al. 1975	0.00714
6	saltwater	Fiddler Crab	1254	38 days	chronic	inhibited molting	Finerman & Fingerman 1978	0.00800
6	saltwater	Amphipod	1254	30 days	chronic	mortality	Wildish 1970	0.01000
6	saltwater	Grass shrimp	1254	1 hour	chronic	avoidance	Hansen et al. 1974b	0.01000
6	saltwater	Pinfish	1254	1 hour	chronic	avoidance	Hansen et al. 1974b	0.01000
6	saltwater	Sheepshead minnow	1254	28 days	chronic	lethargy, reduced feeding, fin rot, mortality	Hansen et al. 1973	0.01000
6	saltwater	Sheepshead minnow	1254	21 days	chronic	mortality	Schimmel et al. 1974	0.01000
1	saltwater	Eastern oyster	1016	24 hr	acute	EC50 growth	Hansen et al. 1974a	0.01020
1	saltwater	brown shrimp	1016	24 hr	acute	LC50 survival	Hansen et al. 1974a	0.01050
1	saltwater	grass shrip	1016	24 hr	acute	LC50 survival	Hansen et al. 1974a	0.01250
1	saltwater	Eastern oyster	1254	24 hr	acute	EC50 growth	Lowe undated	0.01400
1	saltwater	Eastern oyster	1248	24 hr	acute	EC50 growth	Lowe undated	0.01700
6	saltwater	Pinfish	1016	42 days	chronic	50% mortality	Hansen et al. 1974a	0.02100
6	saltwater	Grass shrimp	1254	4 days	chronic	water efflux affected and altered metabolic state	Roesijadi et al. 1976a,b	0.02500
6	saltwater	Pink Shrimp	1248	48 hrs	chronic	LC	Lowe undated	0.03200
6	saltwater	Pink Shrimp	1254	48 hrs	chronic	LC	Lowe undated	0.03200
1	saltwater	Eastern oyster	1260	24 hr	acute	EC50 growth	Lowe undated	0.06000
6	saltwater	Ciliate protozoans	1248	96 hour	chronic	reduced growth	Cooley et al. 1973	1.00000
6	saltwater	Ciliate protozoans	1260	96 hour	chronic	reduced growth	Cooley et al. 1973	1.00000
6	saltwater	fiddler crab	1242	4 days	chronic	greater dispersion of melanin	Finerman & Fingerman 1978	2.00000

1 The table the data were reported in U.S. EPA 1980.

2 A 15-day exposure was assumed

Table 27. Summary of ecorisk HQs obtained for maximum exposure to Total PCB (days since sinking > 730, steady state, ZOI=1).

A. Hazard Quotients for abiotic media modeled by PRAM.

	Water Benchmarks		
	WQC-Chronic	GLWLC-Tier1	WQC-Acute
Upper Water Column	0.000	0.000	0.000
Lower Water Column	0.088	0.036	0.000
Internal Vessel Water	22.980	9.316	0.069
Sediment Pore Water	0.000	0.000	0.000

	Sediment Benchmarks	
	TEL	PEL
Bulk sediment	0.377	0.153

B. Hazard Quotients for tissue residues modeled by PRAM for each Trophic Level (TL).

	Tissue Residue Benchmarks							
					Dietary Exposure			
	Bioaccumulation Effects		Critical Body Residues		Dolphin		Cormorant	
Assessment Factor (AF)[1]	na	na	10	10	10	10	10	10
	TSV	Bcv	NOED	LOED	NOAEL	LOAEL	NOAEL	LOAEL
Pelagic Community								
Phytoplankton (TL1)	0.000	0.000						
Zooplankton (TL-II)	0.000	0.000	0.002	0.001				
Planktivore (TL-III) Herring	0.001	0.000	0.004	0.003	0.019	0.004	0.007	0.001
Piscivore (TL-IV) Jack	0.002	0.000	0.006	0.005	0.029	0.006	0.011	0.001
Reef / Vessel Community								
Attached Algae (TL1)	0.000	0.000						
Sessile filter feeder (TL-II) Bivalve	0.001	0.000	0.004	0.002	0.008	0.002		
Invertebrate Omnivore (TL-II) Urchin	0.039	0.018	0.287	0.157	0.544	0.109		
Invertebrate Forager (TL-III) Crab	0.084	0.039	0.612	0.334	1.161	0.232		
Vertebrate Forager (TL-III) Triggerfish	0.152	0.009	0.444	0.370	2.103	0.421	0.832	0.083
Predator (TL-IV) Grouper	0.262	0.015	0.764	0.637	3.622	0.724	1.433	0.143
Benthic Community								
Infauna invert. (TL-II) Polychaete	0.000	0.000	0.001	0.001				
Epifaunal invert. (TL-II) Nematode	0.001	0.000	0.004	0.002	0.007	0.001		
Forager (TL-III) Lobster	0.001	0.001	0.009	0.005	0.017	0.003		
Predator (TL-IV) Flounder	0.004	0.000	0.012	0.010	0.059	0.012	0.023	0.002

1. The benchmark was divided by the Assessment Factor to account for species-to-species differences.

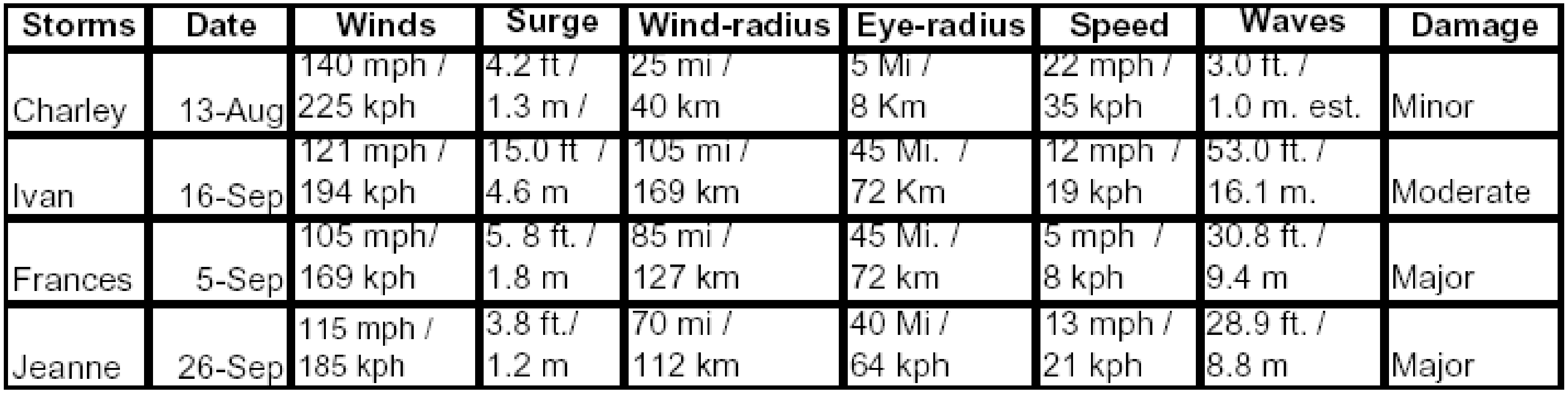
Table 27. Summary of ecorisk HQs c continued.

B. Hazard Quotients for tissue residue continued.

	Tissue Residue Benchmarks cont.					
	Dietary Exposure					
	Herring Gull		Loggerhead Turtle		Shark	
Assessment Factor (AF)[1]	10	10	10	10	10	10
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Pelagic Community						
Phytoplankton (TL1)						
Zooplankton (TL-II)						
Planktivore (TL-III) Herring	0.007	0.001			0.002	0.001
Piscivore (TL-IV) Jack	0.011	0.001			0.004	0.002
Reef / Vessel Community						
Attached Algae (TL1)						
Sessile filter feeder (TL-II) Bivalve	0.003	0.000	0.001	0.000		
Invertebrate Omnivore (TL-II) Urchin	0.207	0.021	0.079	0.016		
Invertebrate Forager (TL-III) Crab	0.441	0.044	0.169	0.034		
Vertebrate Forager (TL-III) Triggerfish	0.799	0.080			0.264	0.164
Predator (TL-IV) Grouper	1.376	0.138			0.455	0.282
Benthic Community						
Infauna invert. (TL-II) Polychaete	0.001	0.000	0.000	0.000		
Epifaunal invert. (TL-II) Nematode	0.003	0.000	0.001	0.000		
Forager (TL-III) Lobster	0.007	0.001	0.002	0.000		
Predator (TL-IV) Flounder	0.022	0.002			0.007	0.005

1. The benchmark was divided by the Assessment Factor to account for species-to-species differences.

Table 28. Major hurricanes making landfall in Florida during 2004 (from Horn 2005).



Storms	Date	Winds	Surge	Wind-radius	Eye-radius	Speed	Waves	Damage
Charley	13-Aug	140 mph / 225 kph	4.2 ft / 1.3 m /	25 mi / 40 km	5 Mi / 8 Km	22 mph / 35 kph	3.0 ft. / 1.0 m. est.	Minor
Ivan	16-Sep	121 mph / 194 kph	15.0 ft / 4.6 m	105 mi / 169 km	45 Mi. / 72 Km	12 mph / 19 kph	53.0 ft. / 16.1 m.	Moderate
Frances	5-Sep	105 mph/ 169 kph	5. 8 ft. / 1.8 m	85 mi / 127 km	45 Mi. / 72 km	5 mph / 8 kph	30.8 ft. / 9.4 m	Major
Jeanne	26-Sep	115 mph / 185 kph	3.8 ft./ 1.2 m	70 mi / 112 km	40 Mi / 64 kph	13 mph / 21 kph	28.9 ft. / 8.8 m	Major

Table 29. Total suspended solids (TSS) concentration, water discharge and TSS discharge near the mouth of the Mississippi River (A) and Homolog and total PCB discharge near the mouth of the Mississippi River (B). Data from Rostad et al. 1994.

A.

	Jun-88	**Apr-89**	**Jun-89**	**Mar-90**	**Jun-90**
TSS conc g day^{-1}	18	146	170	140	183
water discharge m^{3} sec^{-1}	5600	22500	20100	26700	23300
TSS discharge g day^{-1}	8709120000	2.83824E+11	2.95229E+11	3.22963E+11	3.68401E+11

B.

PCB discharge g day^{-1}	**Jun-88**	**Apr-89**	**Jun-89**	**Mar-90**	**Jun-90**
cl5	280.6272	710.1327	4155.017	4173.481	2302.887
cl6	793.4976	19853.17	13355.41	13644.07	14901.03
cl7	106.4448	1069.017	682.6099	674.1777	812.7836
cl8	21.28896	259.6184	118.7148	208.674	223.5155
total	**1201.859**	**21891.94**	**18311.75**	**18700.4**	**18240.22**

NOTES:

The United States Geological Survey measured concentrations of penta-, hexa-, hepta-, and octachlorobiphenyls across various transects along the Mississippi River (Rostad et al, 1994). PCB concentrations in fine (<63 um), suspended sediments were measured, as well as fine, suspended sediment concentrations, and river flow rates. PCB flux rates were calculated from these measurements. Dissolved PCB concentrations and concentrations of other PCB homologs were not measured.

The river flow, suspended sediment load, and PCBs released for the four measured homologs and total PCBs at Belle Chase, Louisiana, near the mouth of the Mississippi River are shown in the tables above. Measurements were taken from 1988 to 1990 during spring flow conditions. Mean total PCB discharge across the sampling dates was 15650 g day^{-1}. Bootstrapping, a statistical resampling technique (Efron and Gong, 1983), was used to estimate a mean standard error of +/- 3330 g day^{-1} in the discharge rate.

The river estimate probably under predicts the actual load because only the four most prominent of the possible ten homologs were measured, and PCBs dissolved in the water or adsorbed to larger suspended particles were ignored. The average was also impacted by exceptional drought conditions in 1988 (Rostad et al, 1994).

Table 30. Estimate of half-life of PCBs on the ex-ORISKANY and amount of PCBs leached from the vessel over ten years assuming a first-order constant release rate.

Material	PCB fraction g PCB/g material	PCB release rate ng PCB/gPCB day	PCB release rate g PCB/gPCB day	Material on board Kg	PCBs on Board g
Ventilation Gasket	0.0000314	1577.140	1.57714E-06	1459	45.8
Black Rubber Material	0.0000529	1577.140	1.57714E-06	5397	285.5
Electrical Cable	0.0018500	278.987	2.78987E-07	296419	548375.2
Bulkhead Insulation	0.0005370	67635.360	6.76354E-05	14379	7721.5
Aluminum Paint	0.0000200	11148.298	1.11483E-05	386528	7730.6

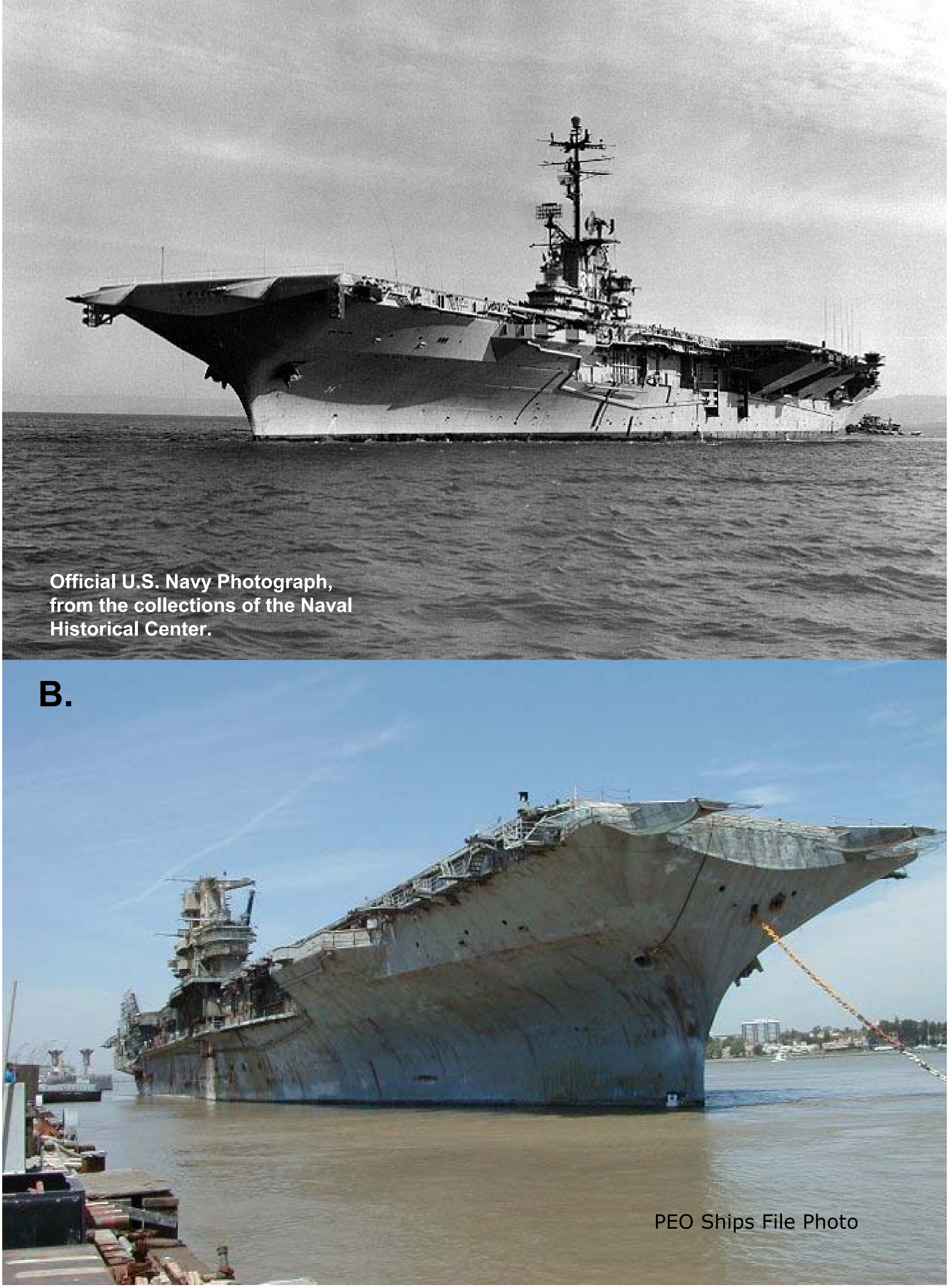
564158.55	**g PCB**
564.16	**Kg PCB**
1243.74	**lbs PCB**

PCBs remaining after 10 years

Material	half-life year	t (ten years) d	PCBs remaining g	amount leached g	% Leached %
Ventilation Gasket	1,204	3650	45.5	0.263	0.57%
Black Rubber Material	1,204	3650	283.9	1.639	0.57%
Electrical Cable	6,807	3650	547817.0	558.128	0.10%
Bulkhead Insulation	28	3650	6032.4	1689.137	21.88%
Aluminum Paint	170	3650	7422.3	308.252	3.99%

561601.13	**2557.42**	**g PCB**
561.60	**2.56**	**Kg PCB**
1238.11	**5.64**	**lbs PCB**

11. Figures



Official U.S. Navy Photograph, from the collections of the Naval Historical Center.

PEO Ships File Photo

Figure 1. The aircraft carrier ORISKANY as she left San Francisco Naval Shipyard, CA, on 27 April 1959, following installation of her new angled flight deck and hurricane bow (A) and pier side at Port of Pensacola March 2005 undergoing preparations for possible beneficial reuse as an artificial reef (B).

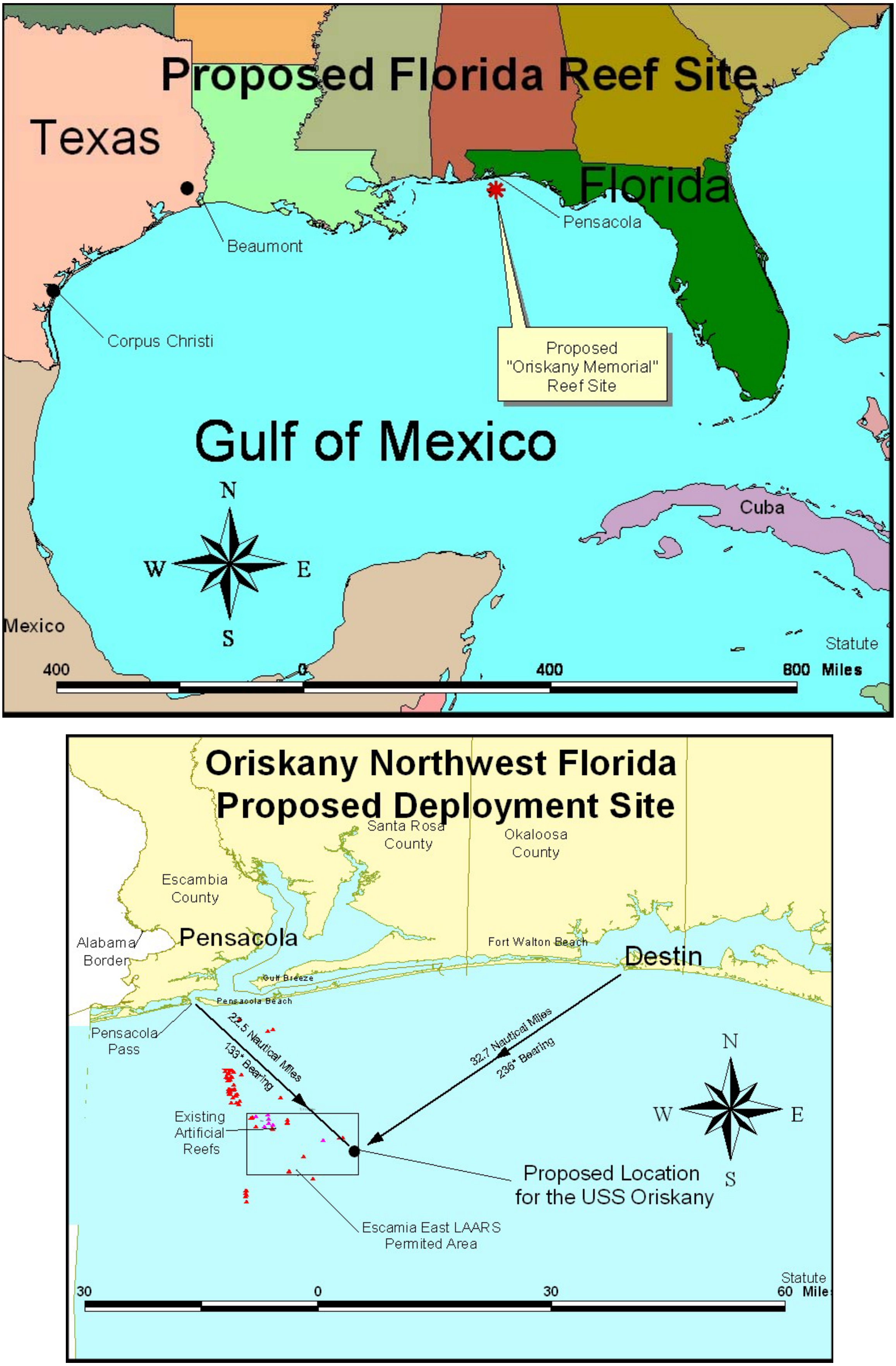


Figure 2. The proposed location for sinking the ex-ORISKANY to create an artificial reef off the coast of Pensacola, FL (from FFWCC 2003).

Green and Red points indicate Public Reefs
Purple points are private deployments
Blue symbols denote refugia reefs

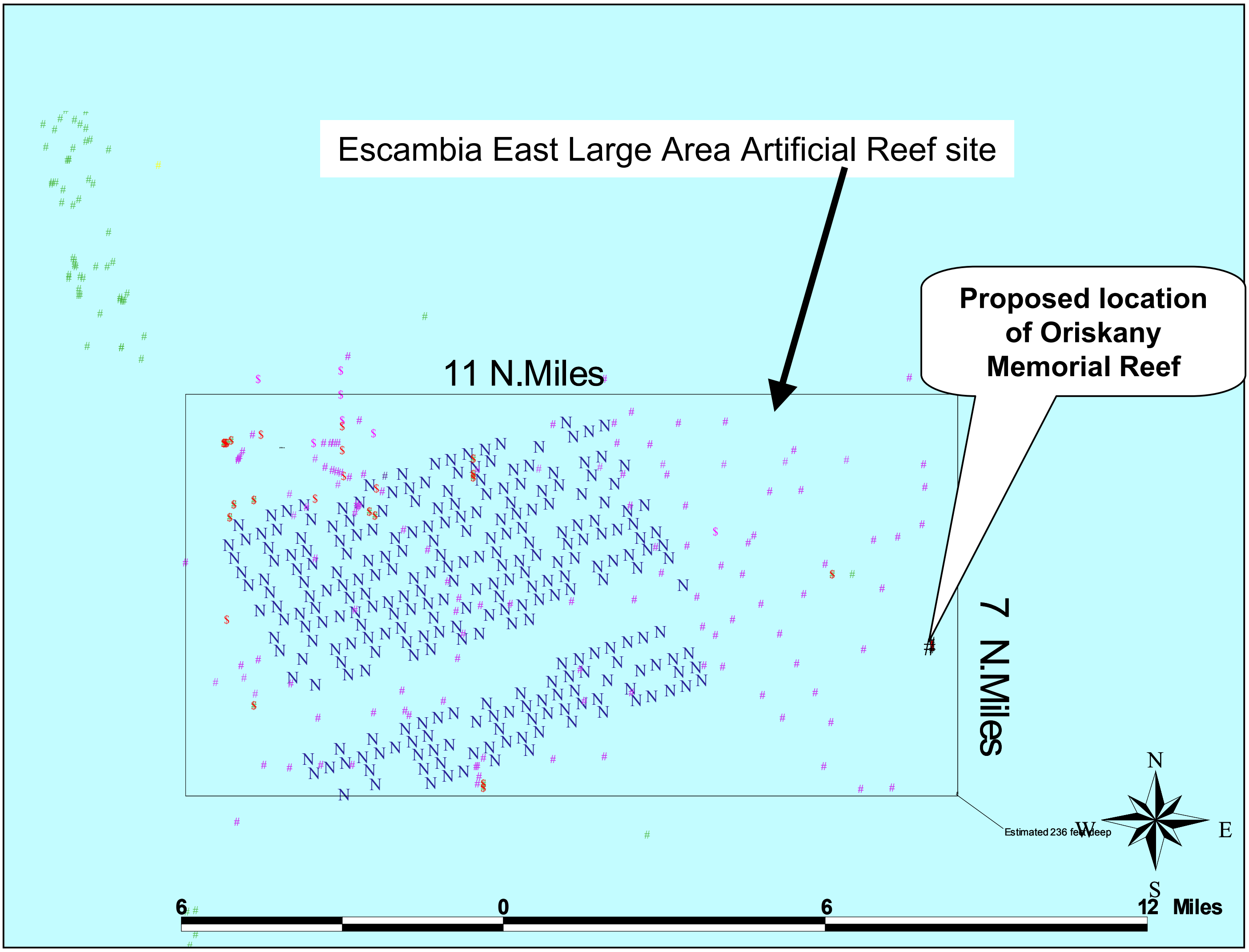


Figure 3. The proposed location of ex-ORISKANY artificial reef within the Escambia East Large Area Artificial Reef site and the location of existing public, private, and refugia reefs within the area (from FFWCC 2004).

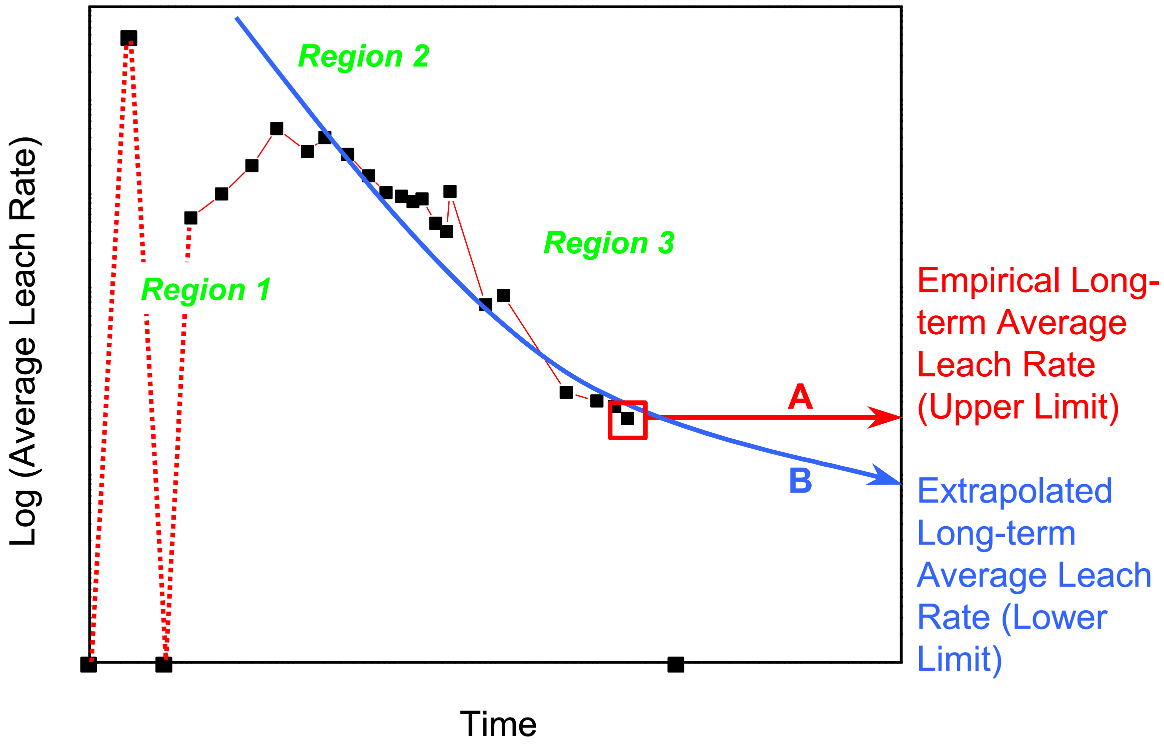
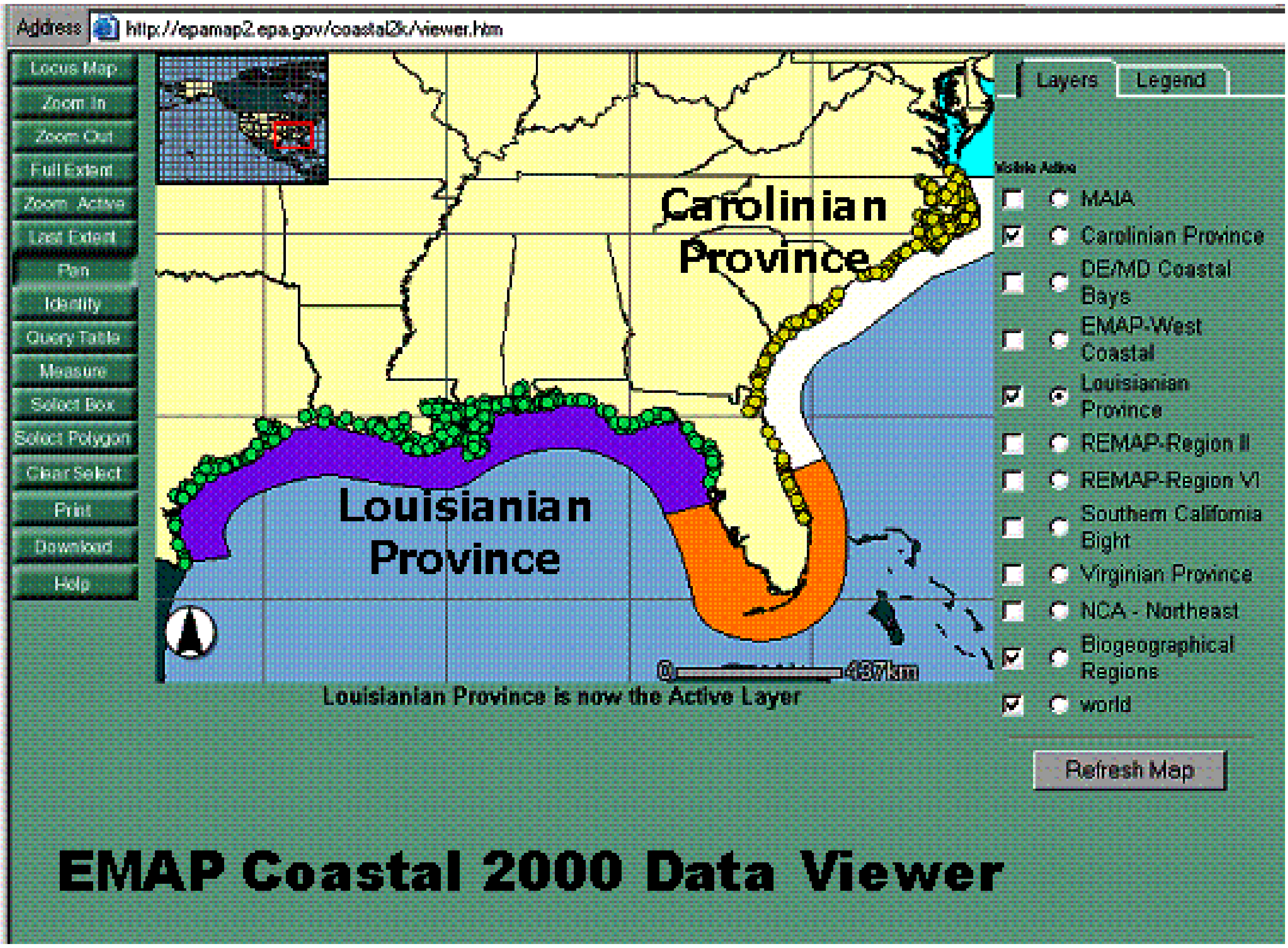


Figure 4. The conceptualized leaching behavior of PCBs from ship-board solids tested under laboratory conditions that mimicked (ambient pressure and temperature) shallow water artificial reef conditions (from George et al. 2005).



http://epamap2.epa.gov/coastal2k/viewer.htm

☐ ○ MAIA
☑ ○ Carolinian Province
☐ ○ DE/MD Coastal Bays
☐ ○ EMAP-West Coastal
☑ ● Louisianian Province
☐ ○ REMAP-Region II
☐ ○ REMAP-Region VI
☐ ○ Southern California Bight
☐ ○ Virginian Province
☐ ○ NCA - Northeast
☑ ○ Biogeographical Regions
☑ ○ world

Louisianian Province is now the Active Layer

Figure 5. A screen shot of data from coastal areas of the SE U.S. from the US EPA EMAP Program used to estimate background. http://epamap2.epa.gov/coastal2k/viewer.htm

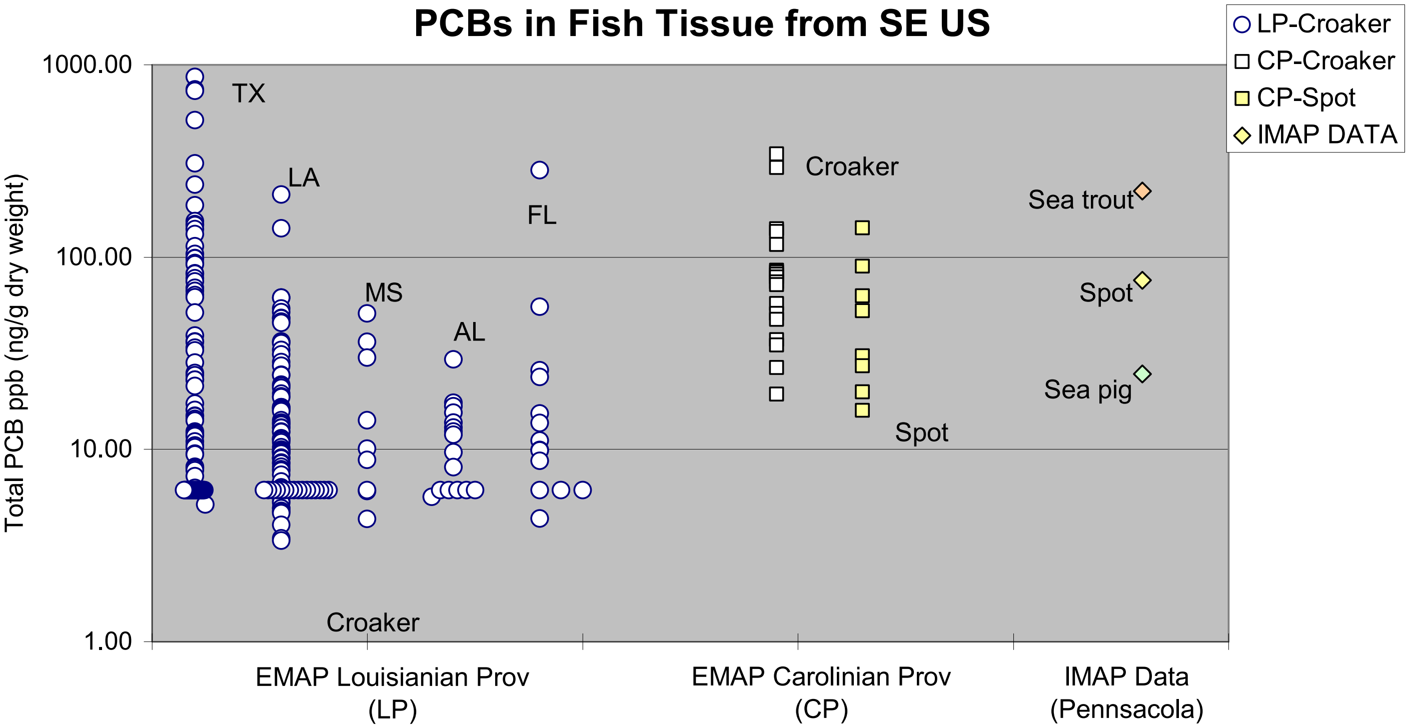


Figure 6. The range of Total PCB concentrations observed in fish tissue sampled as part of EMAP along the Gulf Coast (Louisianan Province), SE Atlantic Coast (Carolinian Province) and IMAP data for three samples collected offshore of Pensacola, Fl.

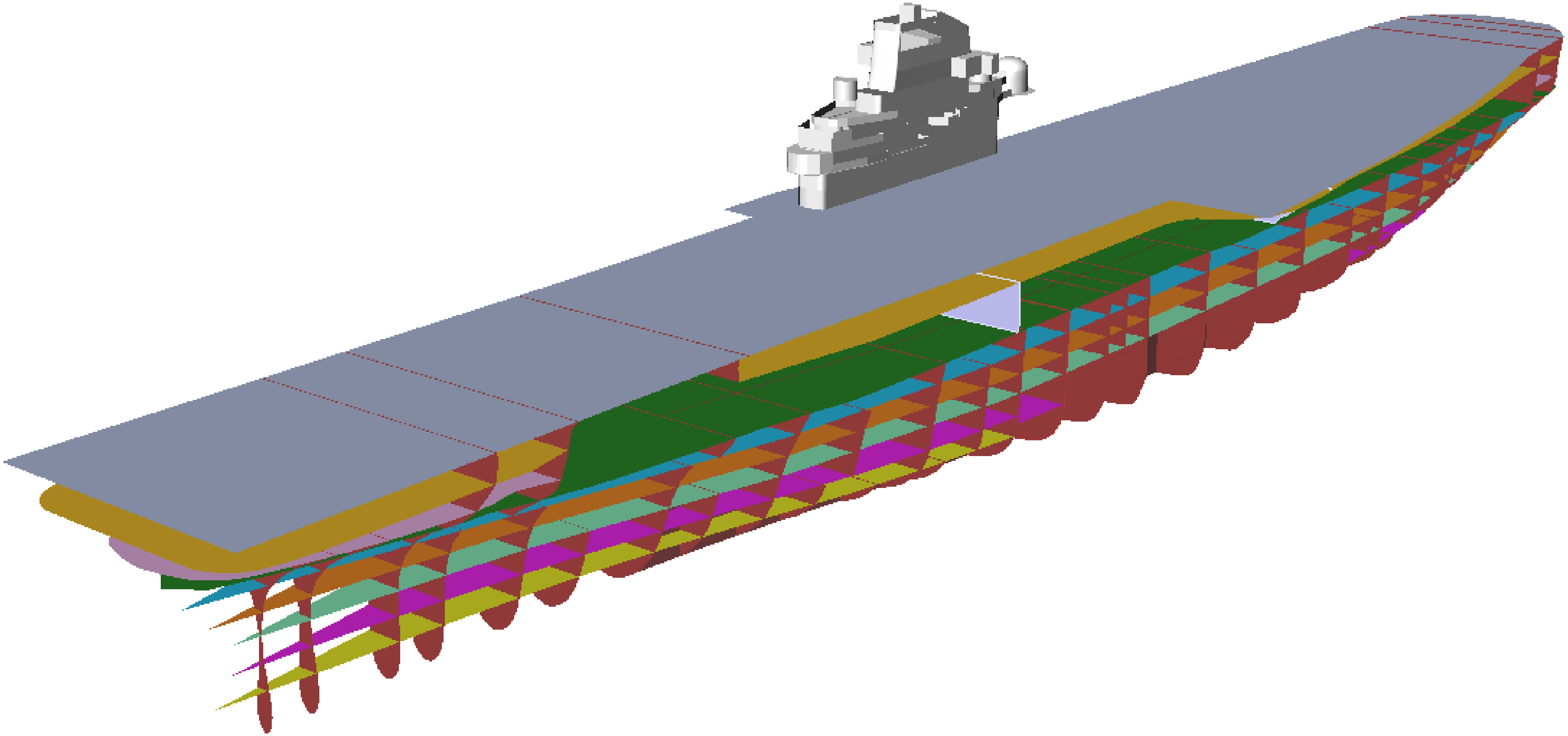


Figure 7. Computer model of the Virtual Oriskany with the shell plating removed to show decks and bulkheads (Bartlett et al. 2005).

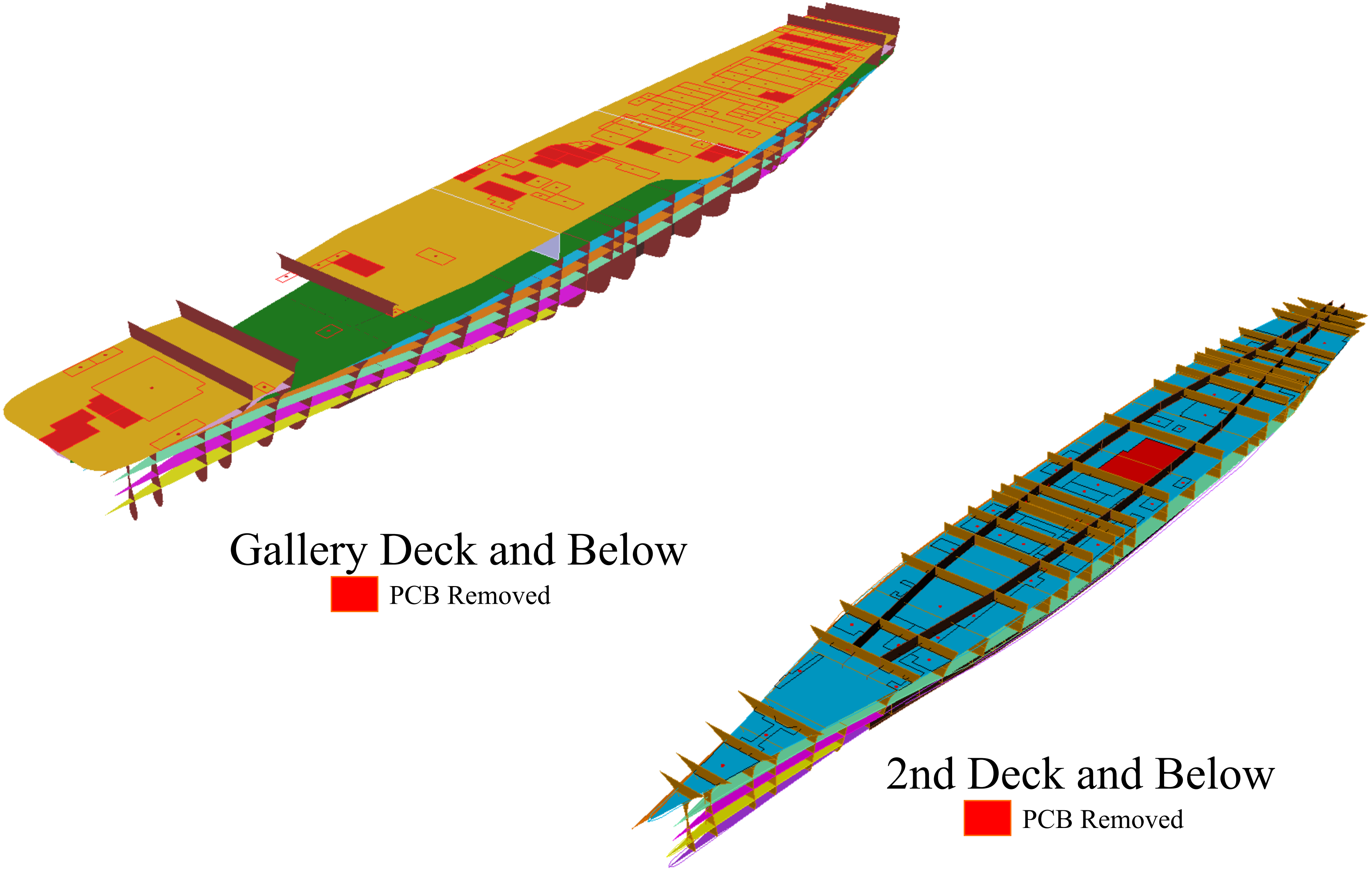


Fig. 8. Cutaway of Virtual Oriskany showing some of the areas where PCBs were removed (Bartlett et al. 2005).

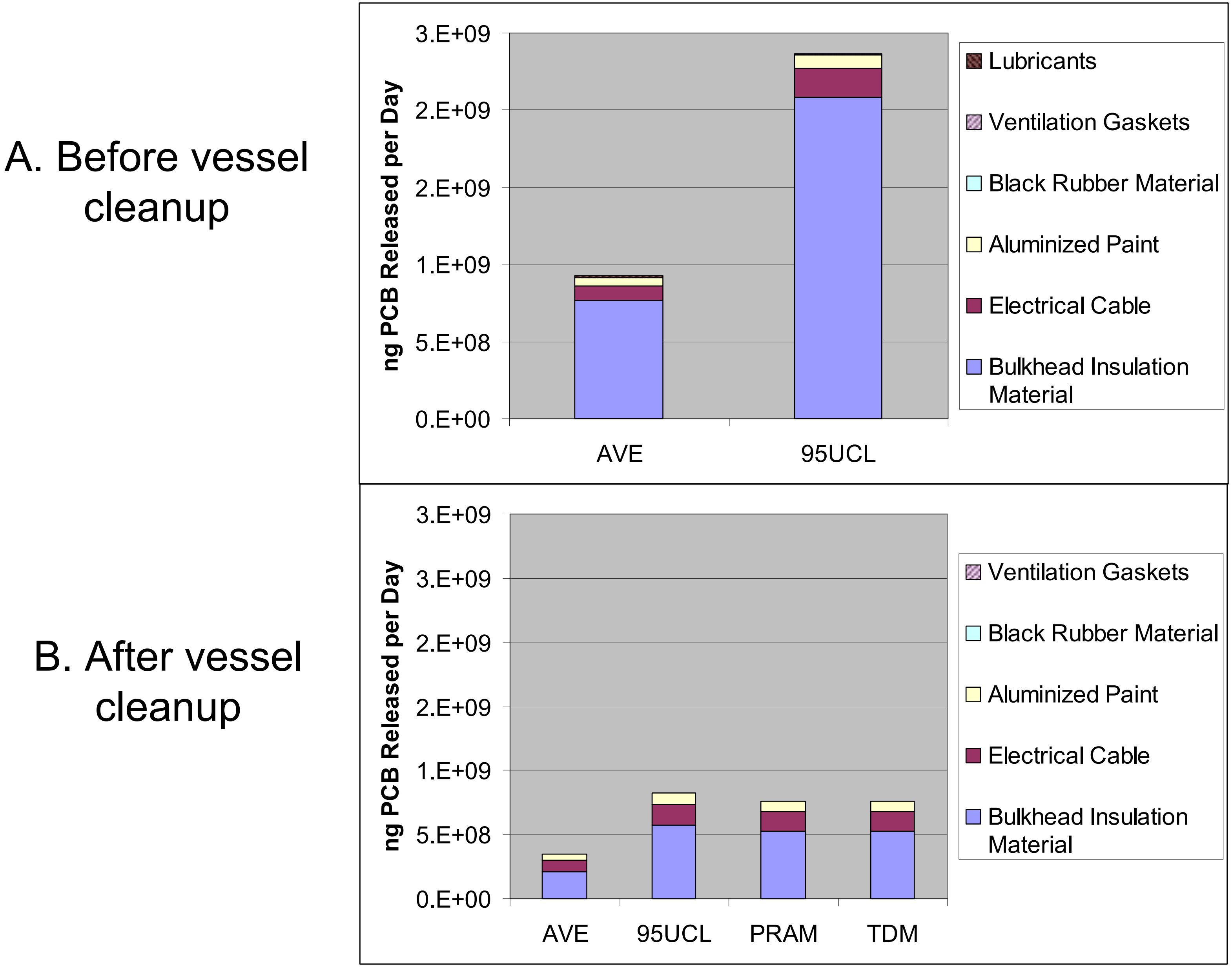


Fig. 9. The average (AVE) and 95% upper confidence level (95UCL) PCB release rates from solid materials onboard the ex-ORISKANY before (A) and after (B) vessel cleanup and the release rates used in the PRAM and TDM models.

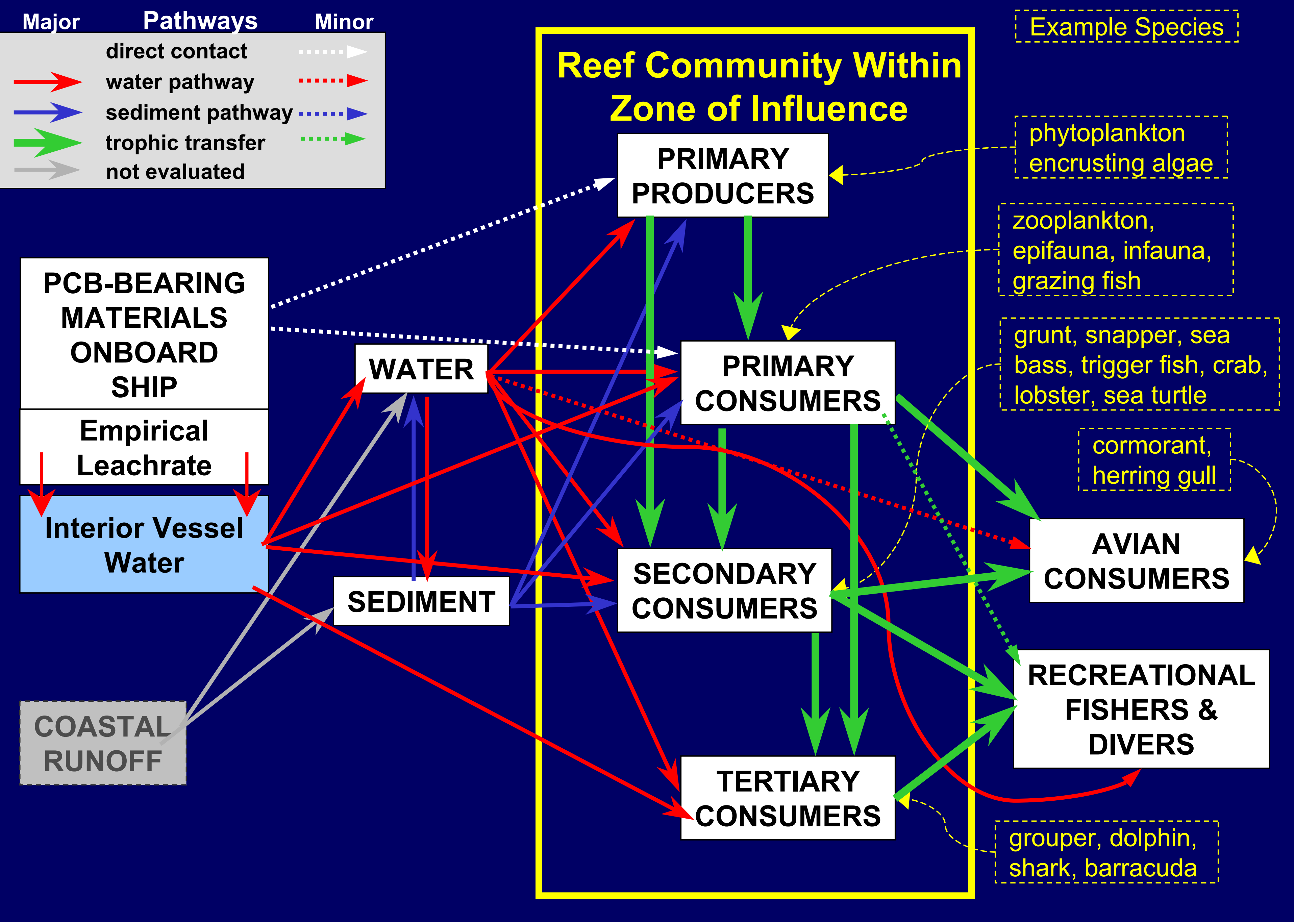


Fig. 10. The Conceptual Site Exposure Model showing the exposure pathways evaluated for the ecorisk assessment. Note that exposure to recreational fishers and divers was evaluated by the Human Health Risk Assessment.

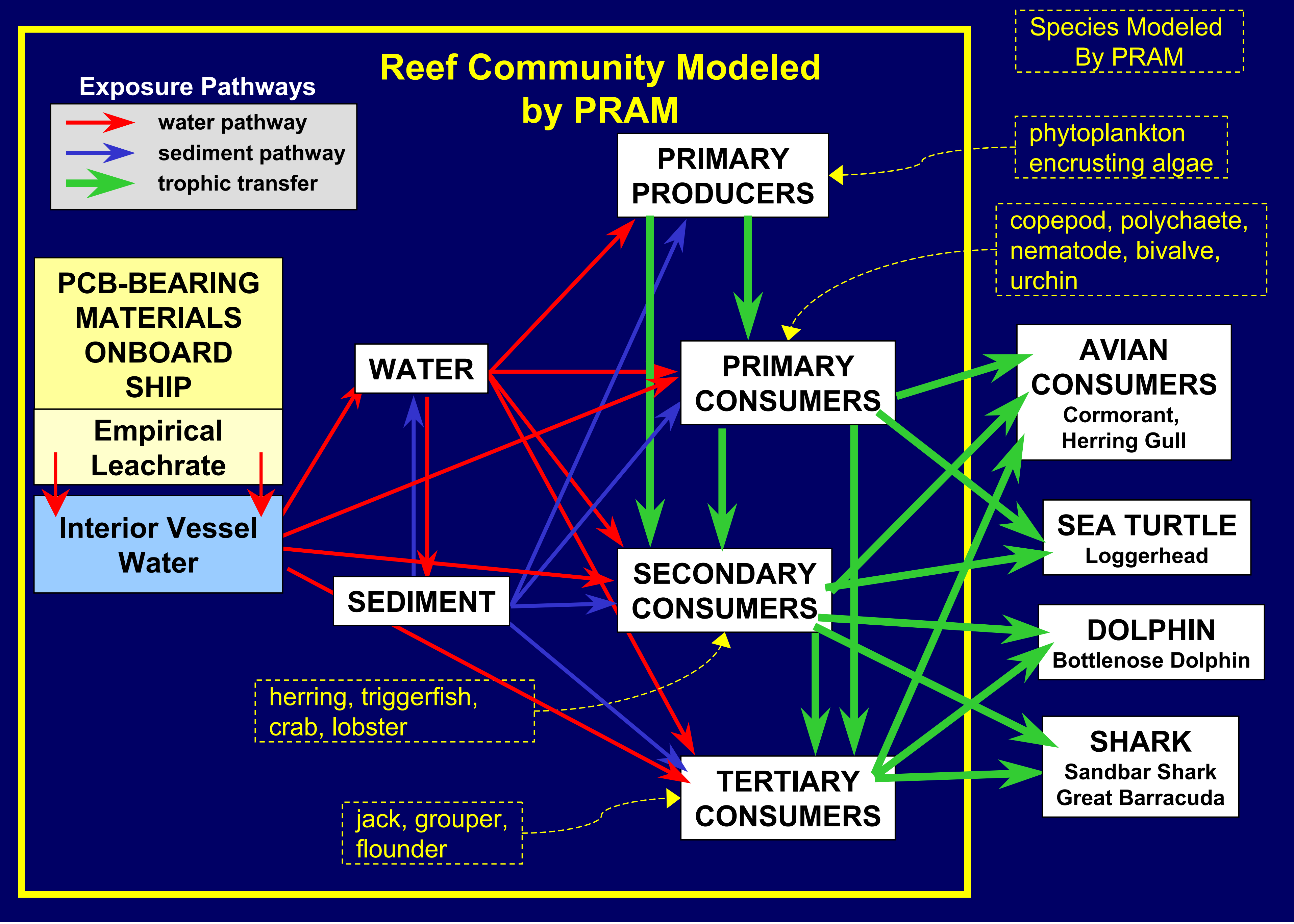


Fig. 11. The reef community modeled by PRAM and the exposure pathways (solid arrows) and receptor species (white boxes) evaluated for the ecorisk assessment.

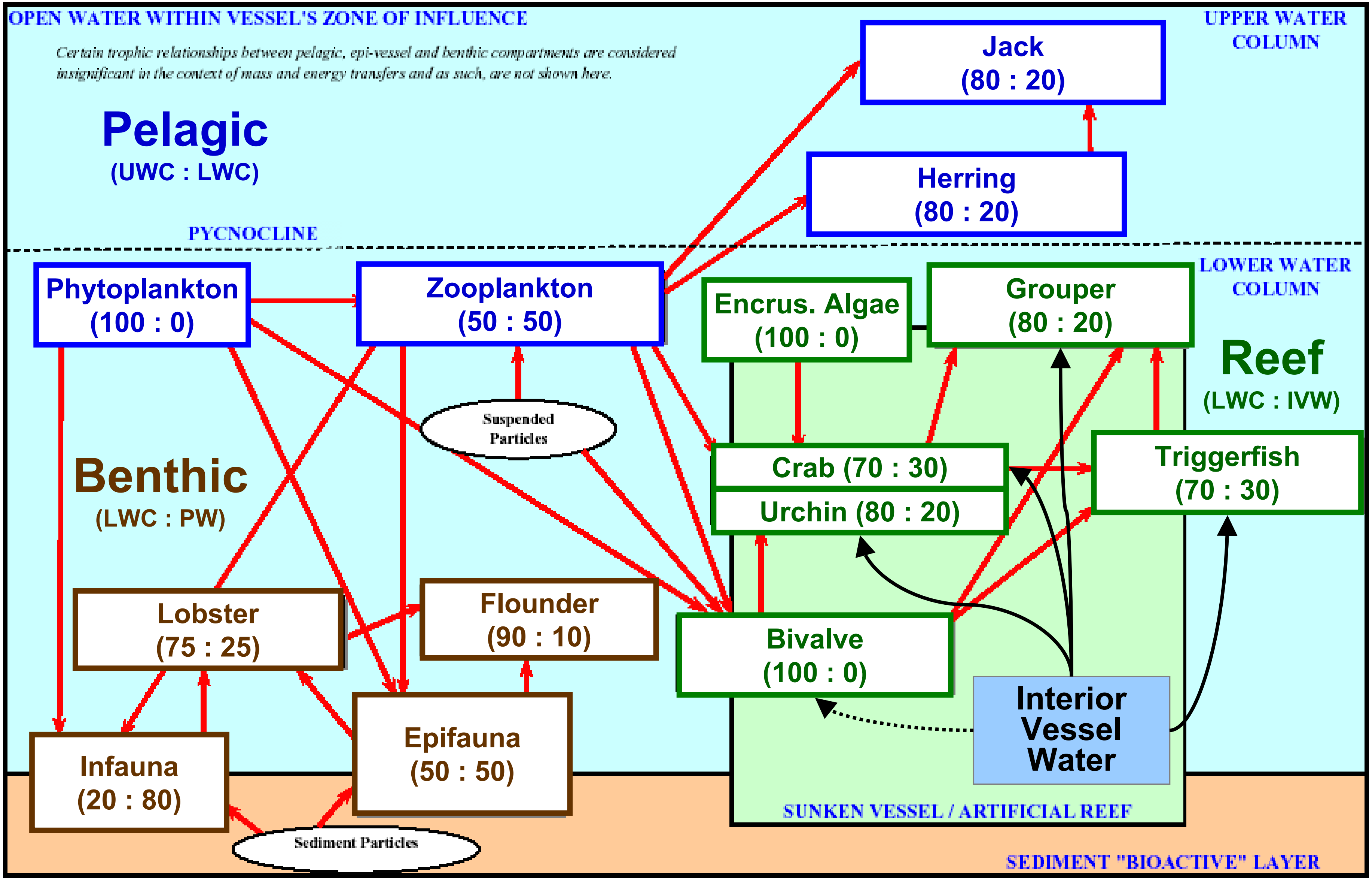


Fig. 12. Ecological communities modeled by PRAM (modified from Figure 8 in PRAM Documentation (NEHC/SSC-SD 2006a). The ratios in parenthesis show the percentage of exposure to upper water column (UWC) and lower water column (LWC) for the Pelagic Community, LWC and pore water (PW) for the Benthic Community, and LWC and interior vessel water (IVW) for the Reef Community.

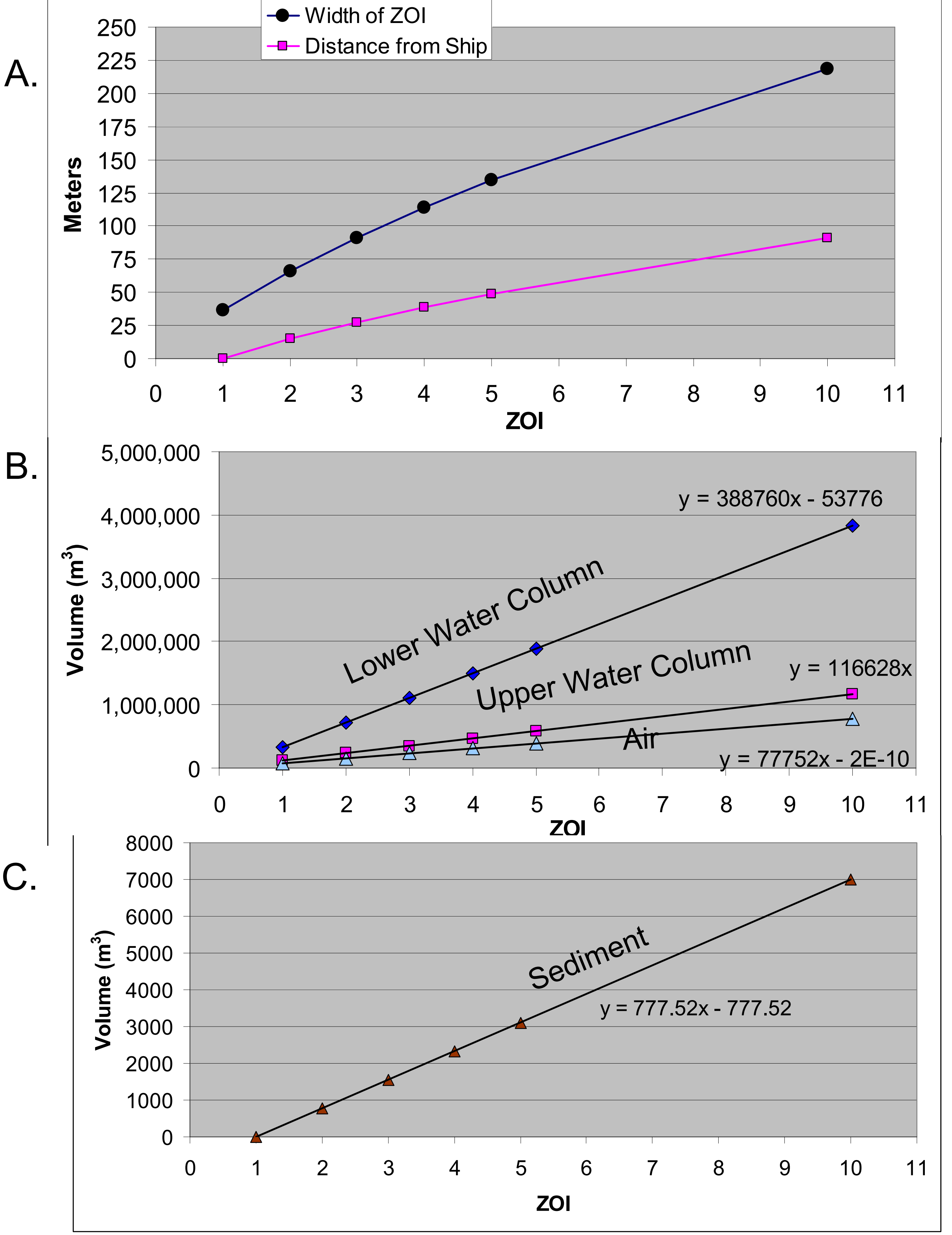


Fig. 13. The change in physical dimensions of PRAM as a function of ZOI for distance from ship (A), the volumes of the upper and lower water columns (B), and the sediment bed (C). The interior vessel volume remains constant at 5.38 x 10^4 m^3.

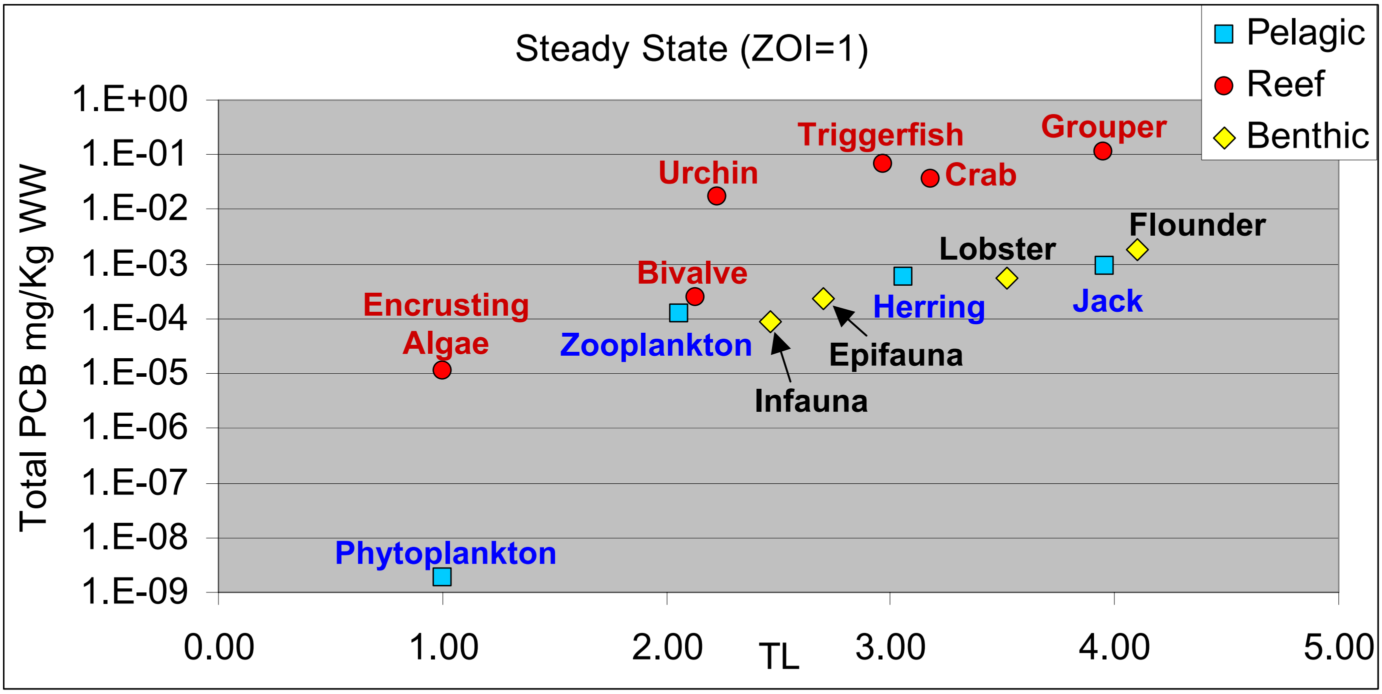


Fig. 14. The Total PCB mg/Kg WW concentrations modeled in the biological compartments of PRAM using default inputs and ZOI=1.

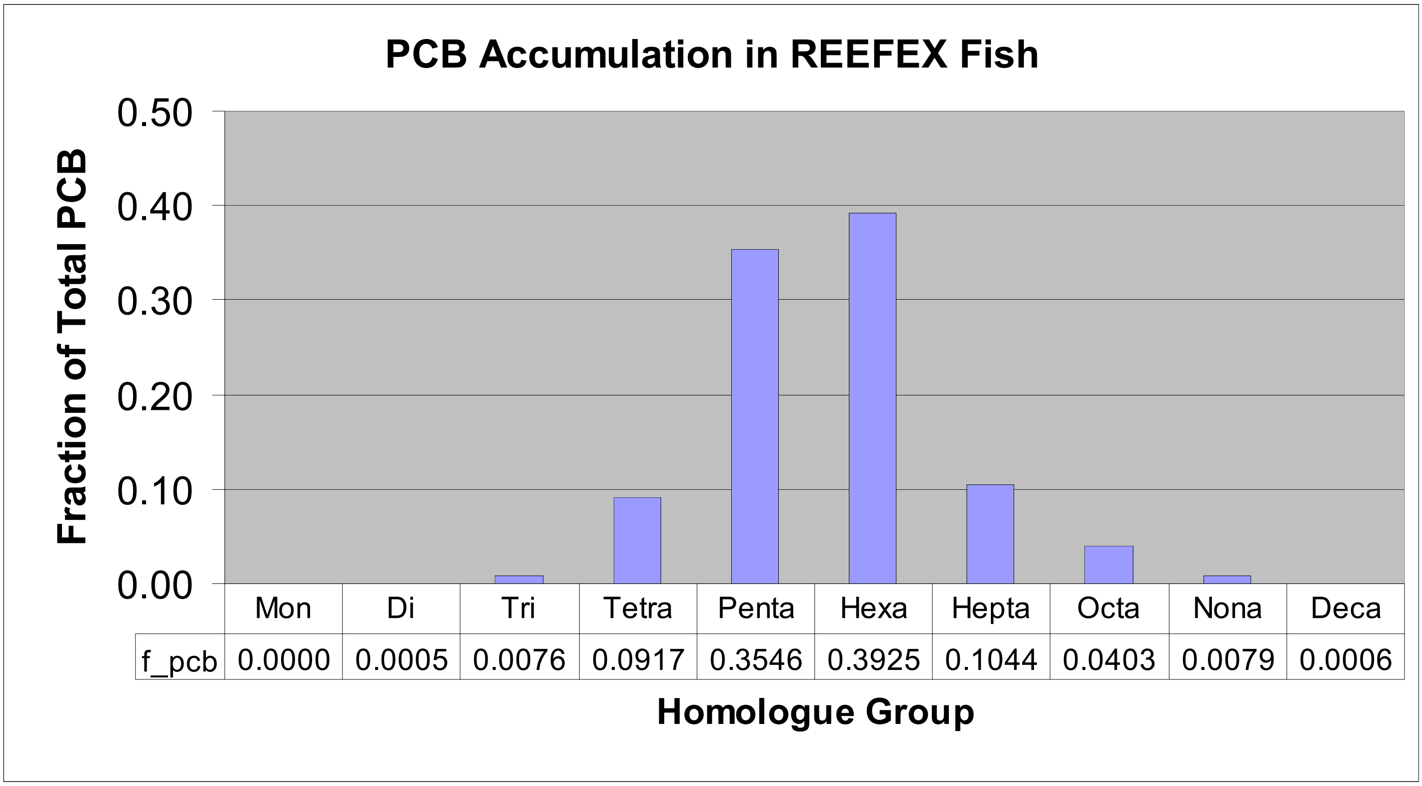


Fig. 15. Fraction of total PCB measured in each homolog group in fish collected from the ex-VERMILLION and reference reef during the REEFEX study (see Table 13).

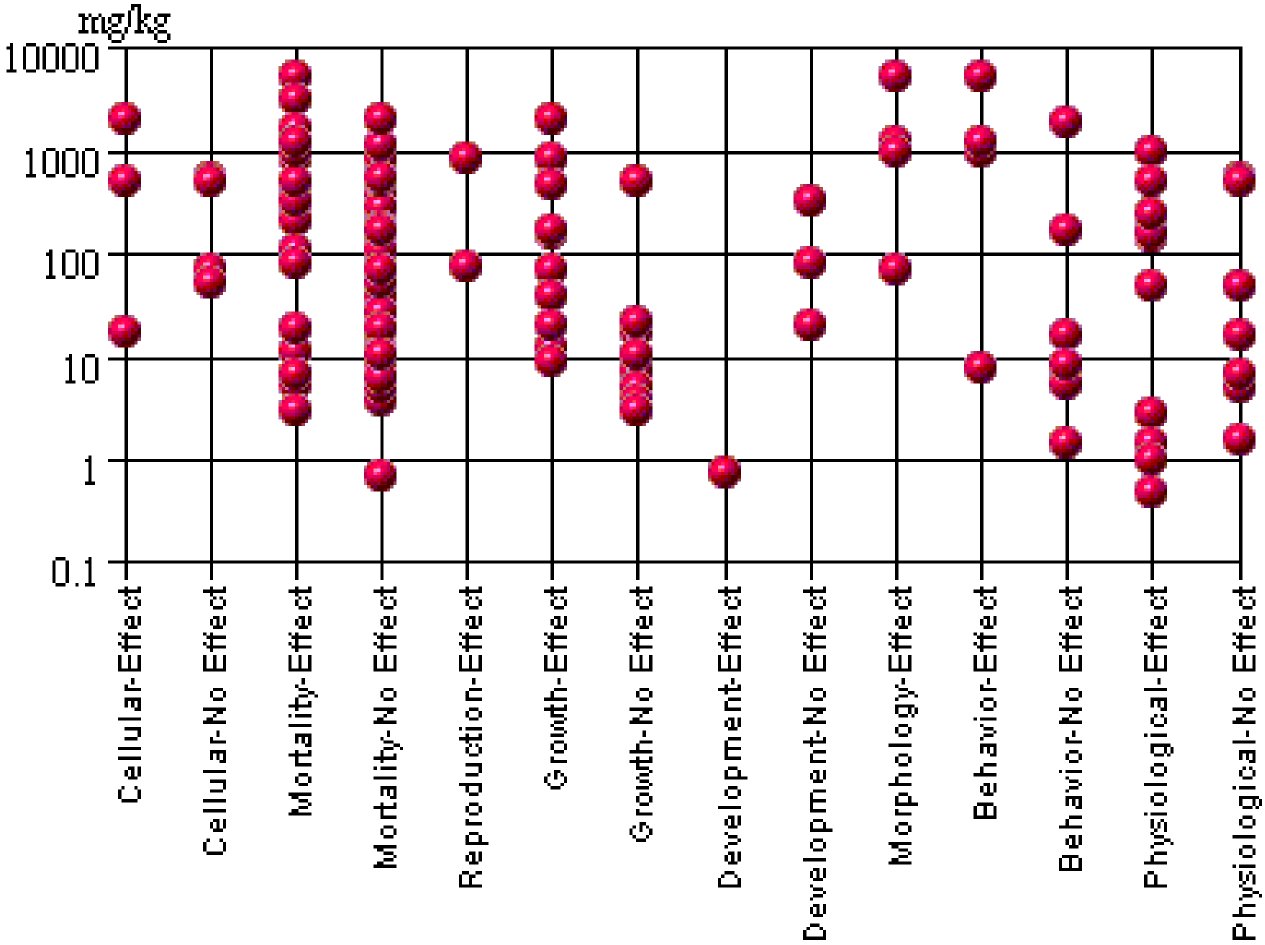


Fig. 16. Example of tissue residue effects data for PCB obtained from the ERED database. If available, benchmarks were selected for any fish species and marine invertebrates

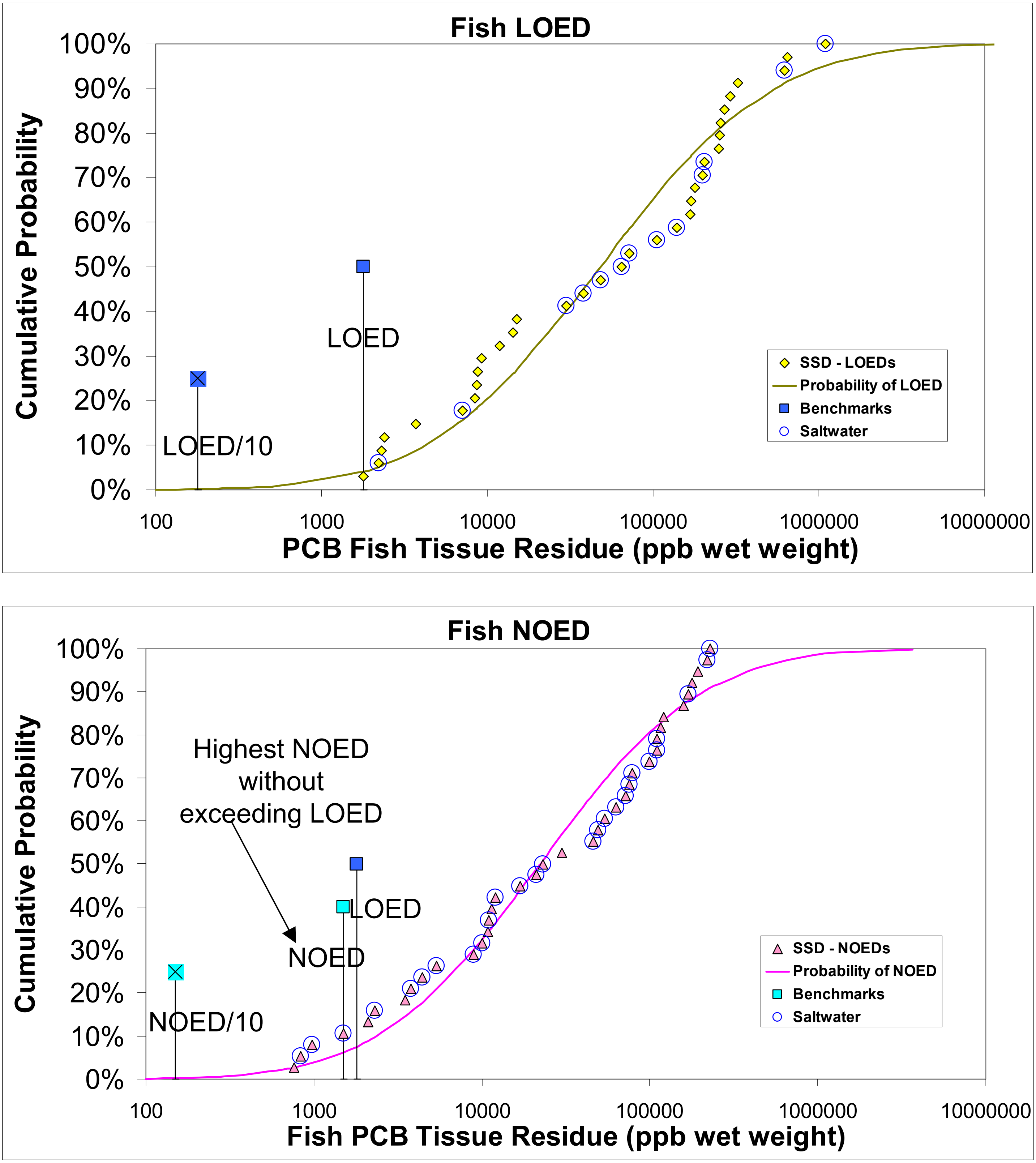
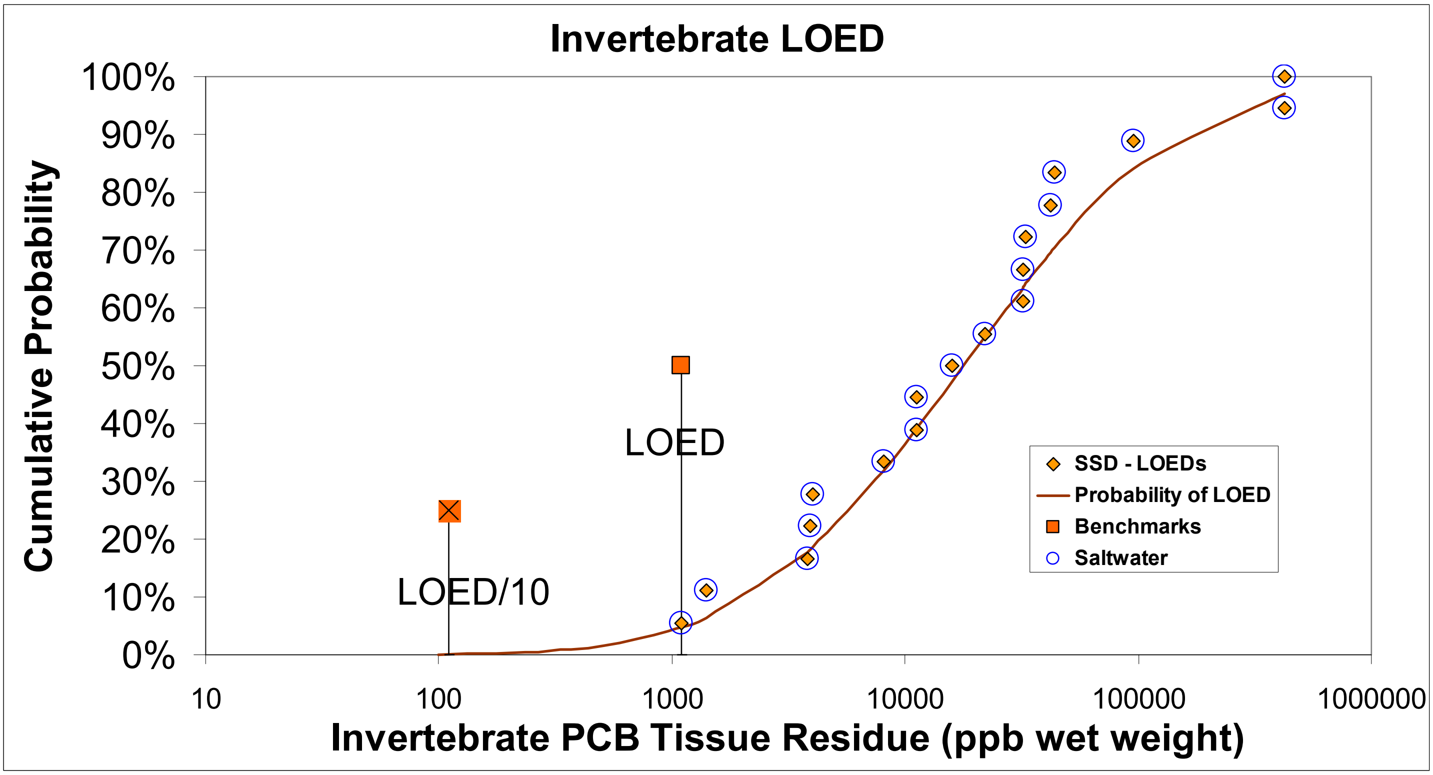


Fig. 17. Development of “Low Effects” (LOED) and “No Effects” (NOED) levels for fish tissue residues data obtained from ERED database.



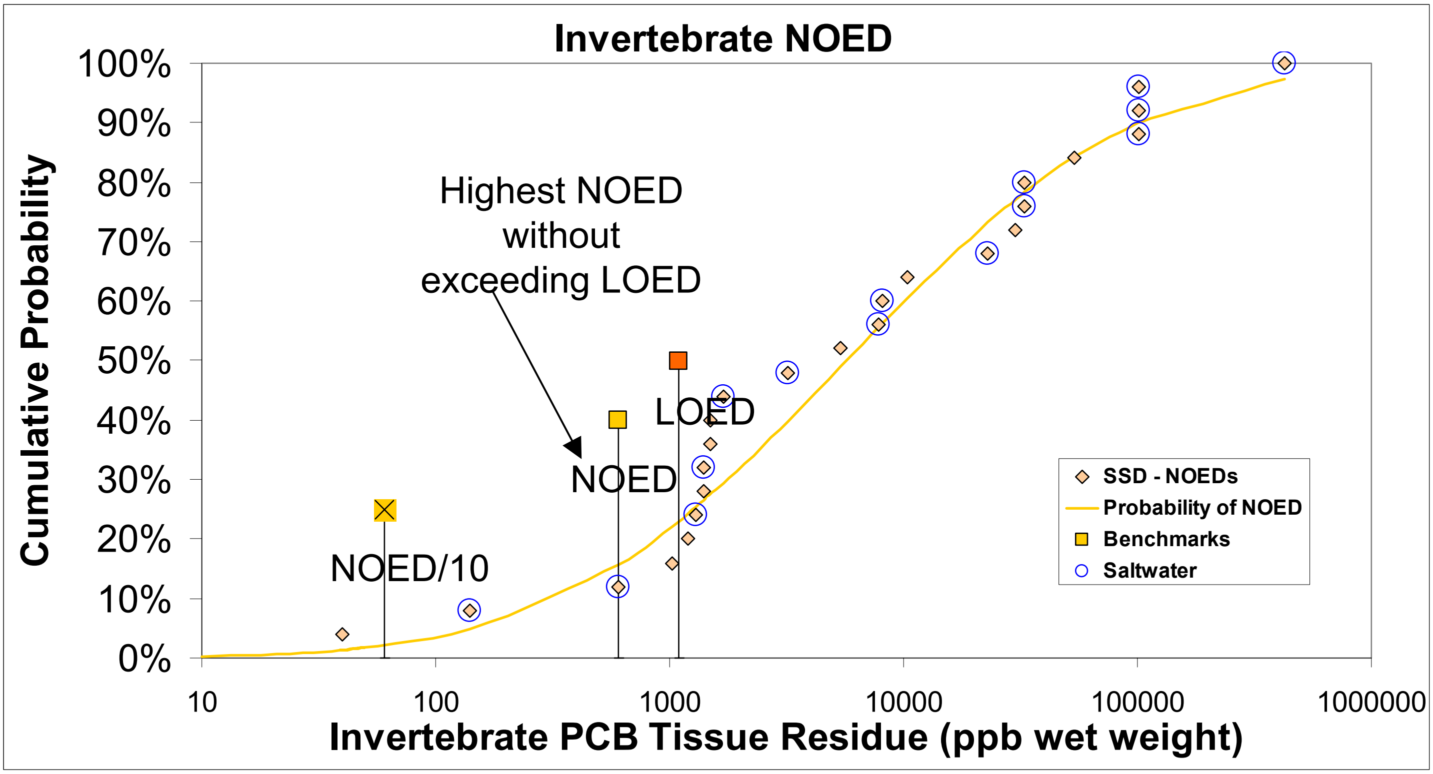


Fig. 18. Development of “Low Effects” (LOED) and “No Effects” (NOED) levels for invertebrate tissue residue data obtained from the ERED database.

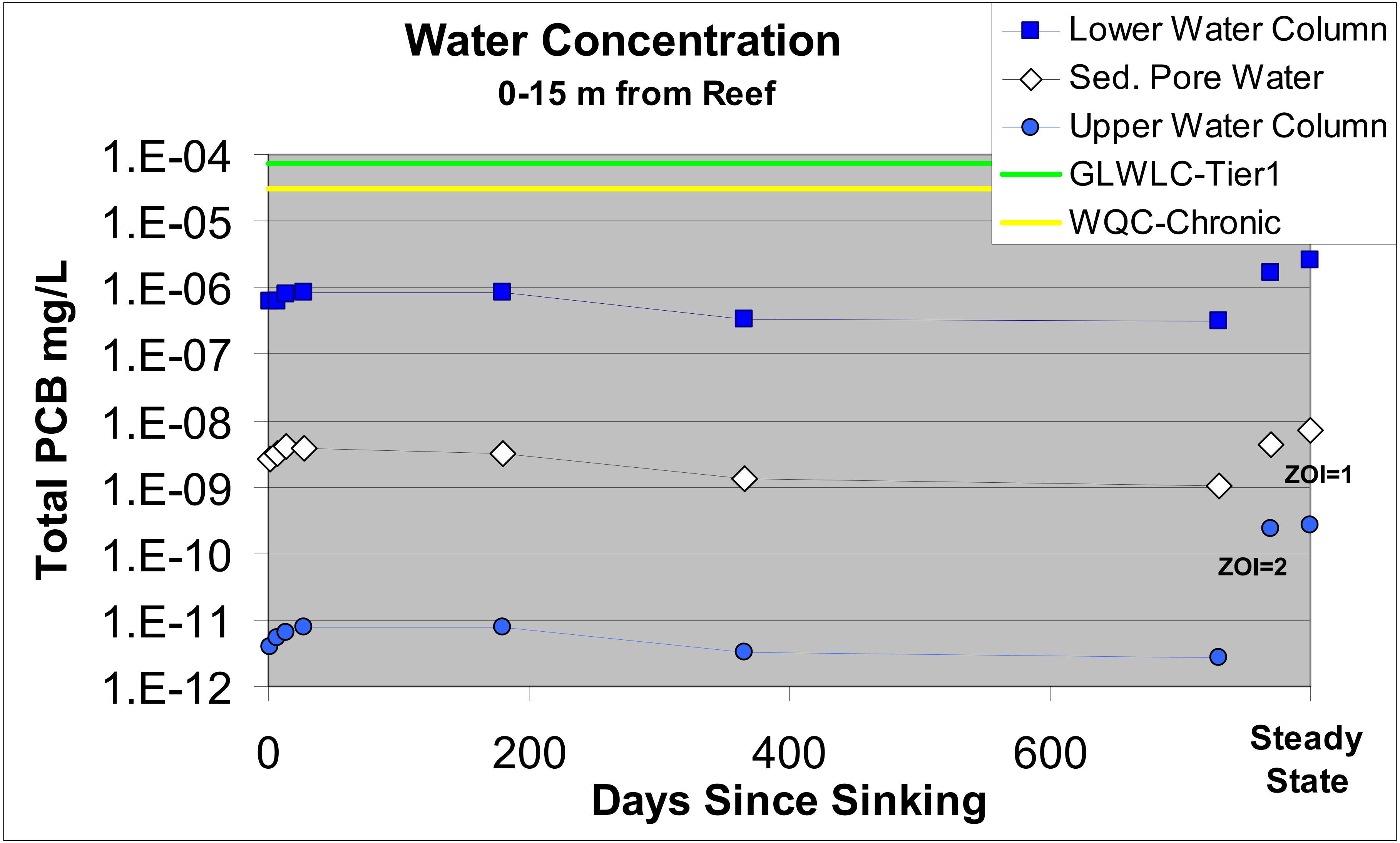


Fig. 19. Time series of Total PCB concentrations predicted by the TDM for the upper water column, lower water column, and sediment pore water within 0-15 m of the ship for the first two years following sinking and the steady state concentrations predicted by PRAM with ZOI=2 and ZOI=1. The water quality benchmarks are also shown.

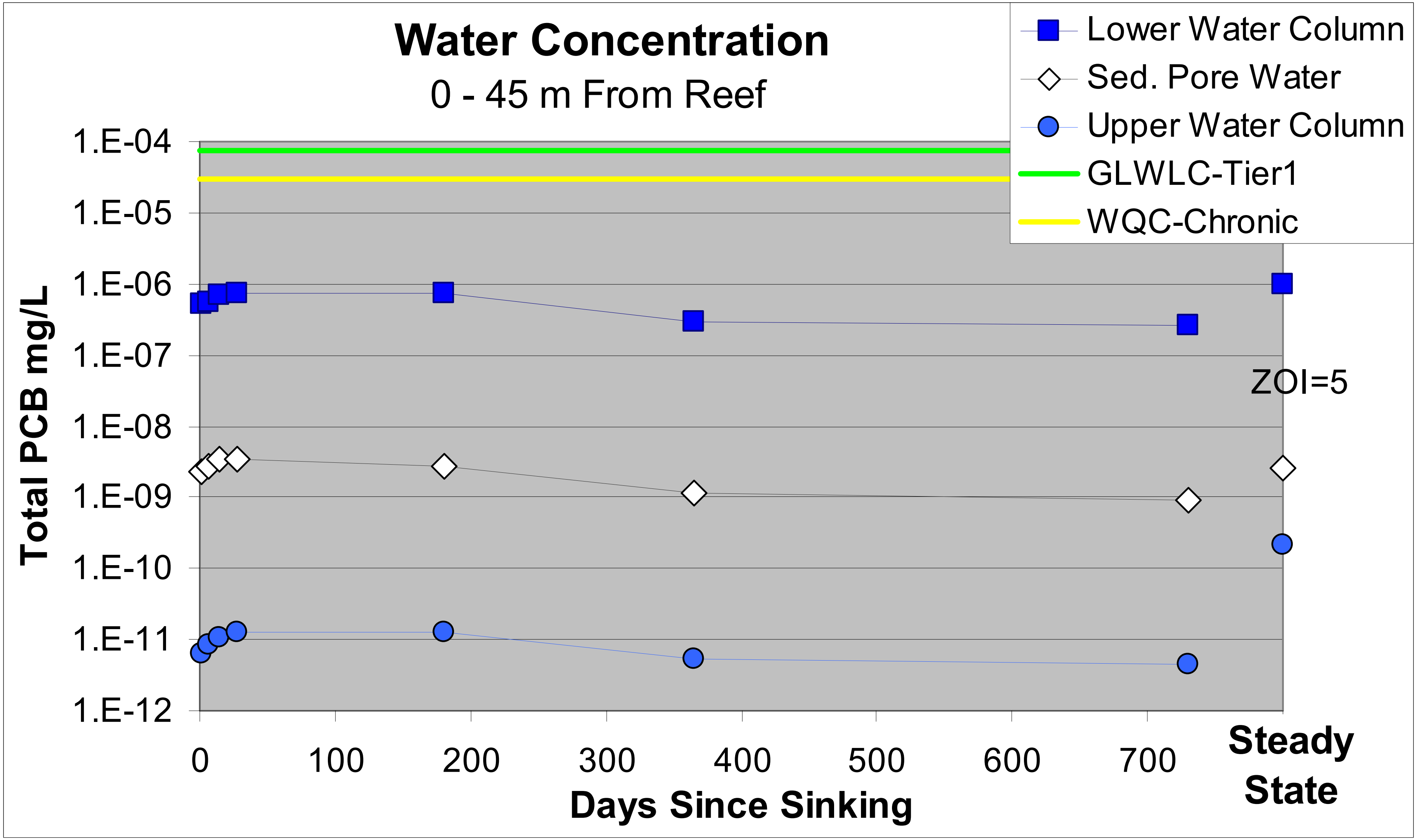


Fig. 20. Concentrations of Total PCB predicted in the water column 0-45 m from the reef by TDM and the steady state water concentrations predicted by PRAM for ZOI=5. The water quality benchmarks are also shown.

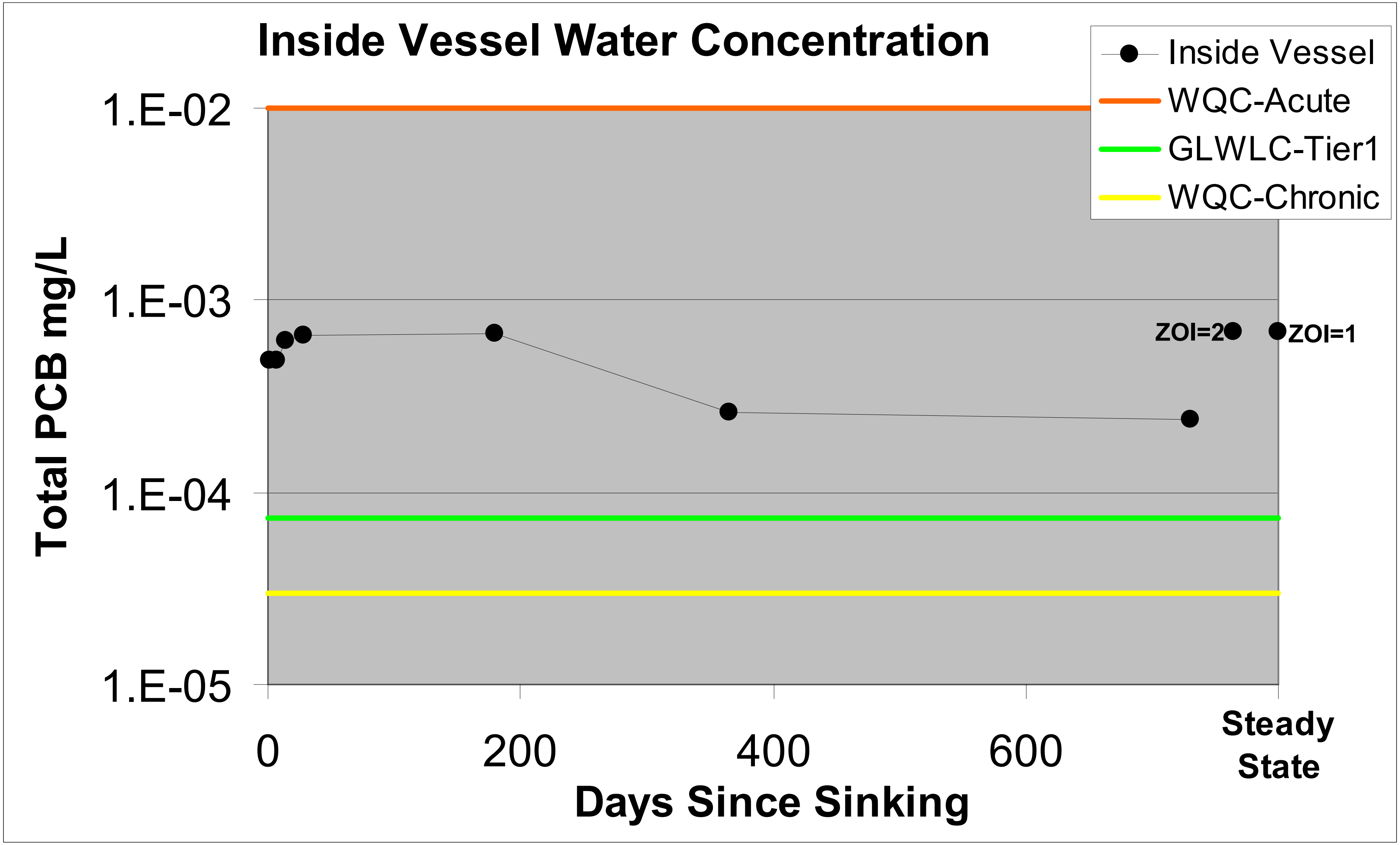


Fig. 21. Time series of Total PCB concentrations predicted by the TDM for the interior vessel water for the first two years following sinking and the steady state concentrations predicted by PRAM with a ZOI=2 and ZOI=1. The water quality benchmarks are also shown.

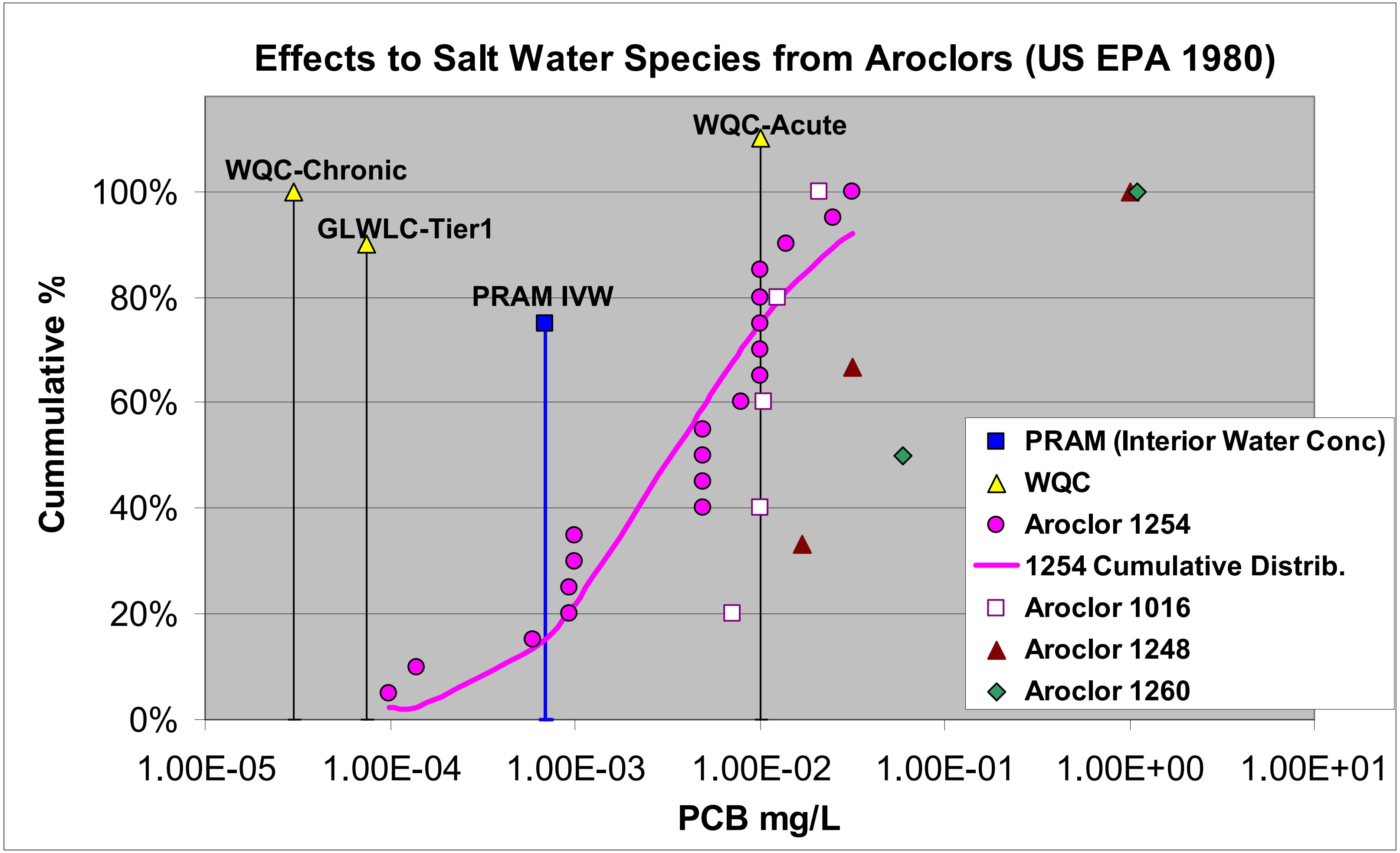


Fig. 22. Effects data for salt-water species exposed to technical Aroclors (U.S. EPA 1980), the WQC benchmarks, and the interior vessel water (IVW) concentration predicted by PRAM.

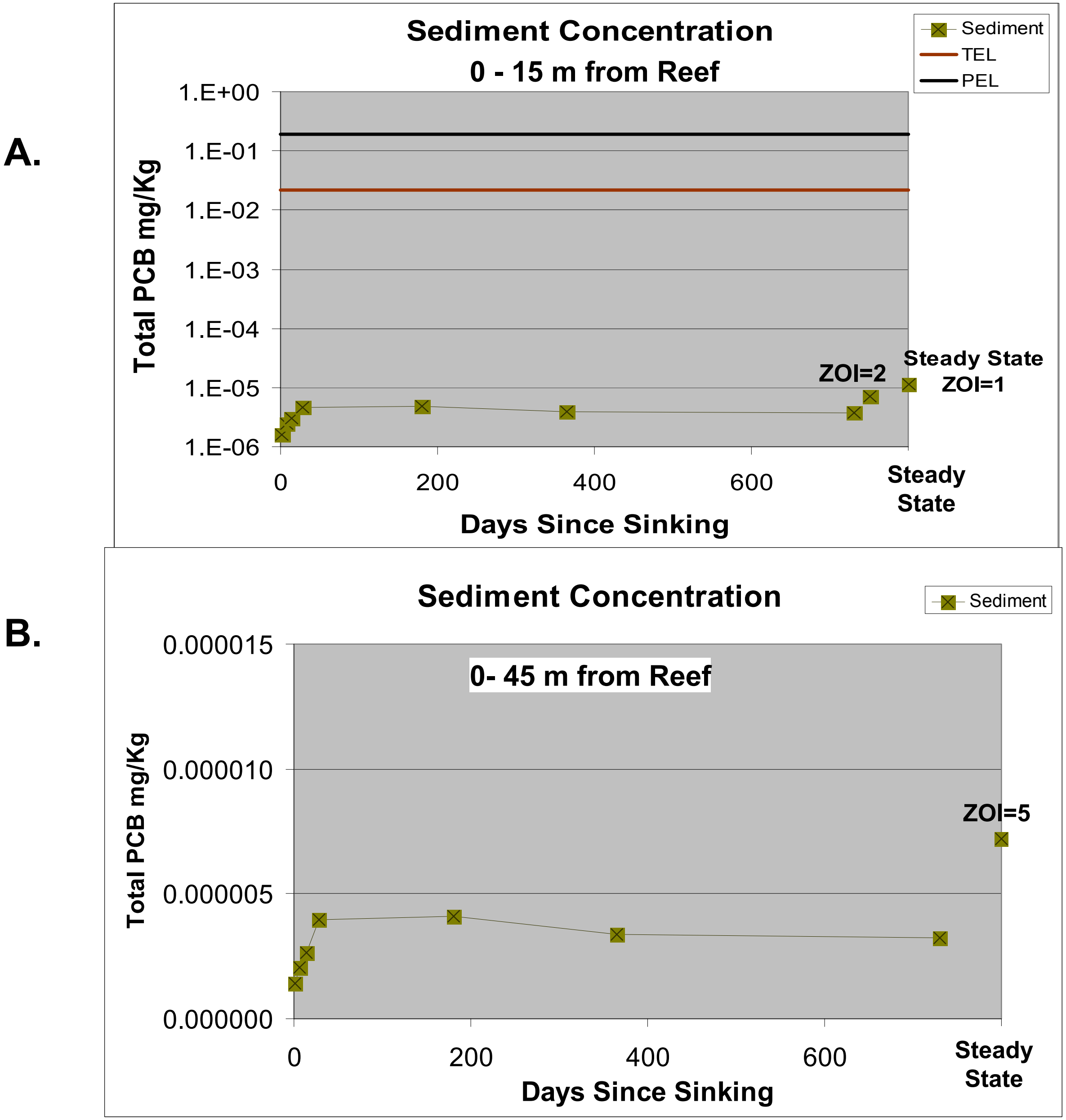


Fig. 23. Time series of Total PCB concentrations predicted by the TDM for sediment within 0-15 m, ZOI=2, and ZOI=1 (A) and 0-45 m, ZOI=5 (B) of the ship for the first two years following sinking and the steady state concentrations predicted by PRAM. The sediment quality benchmarks are also shown for 0 – 15 m concentrations (A).

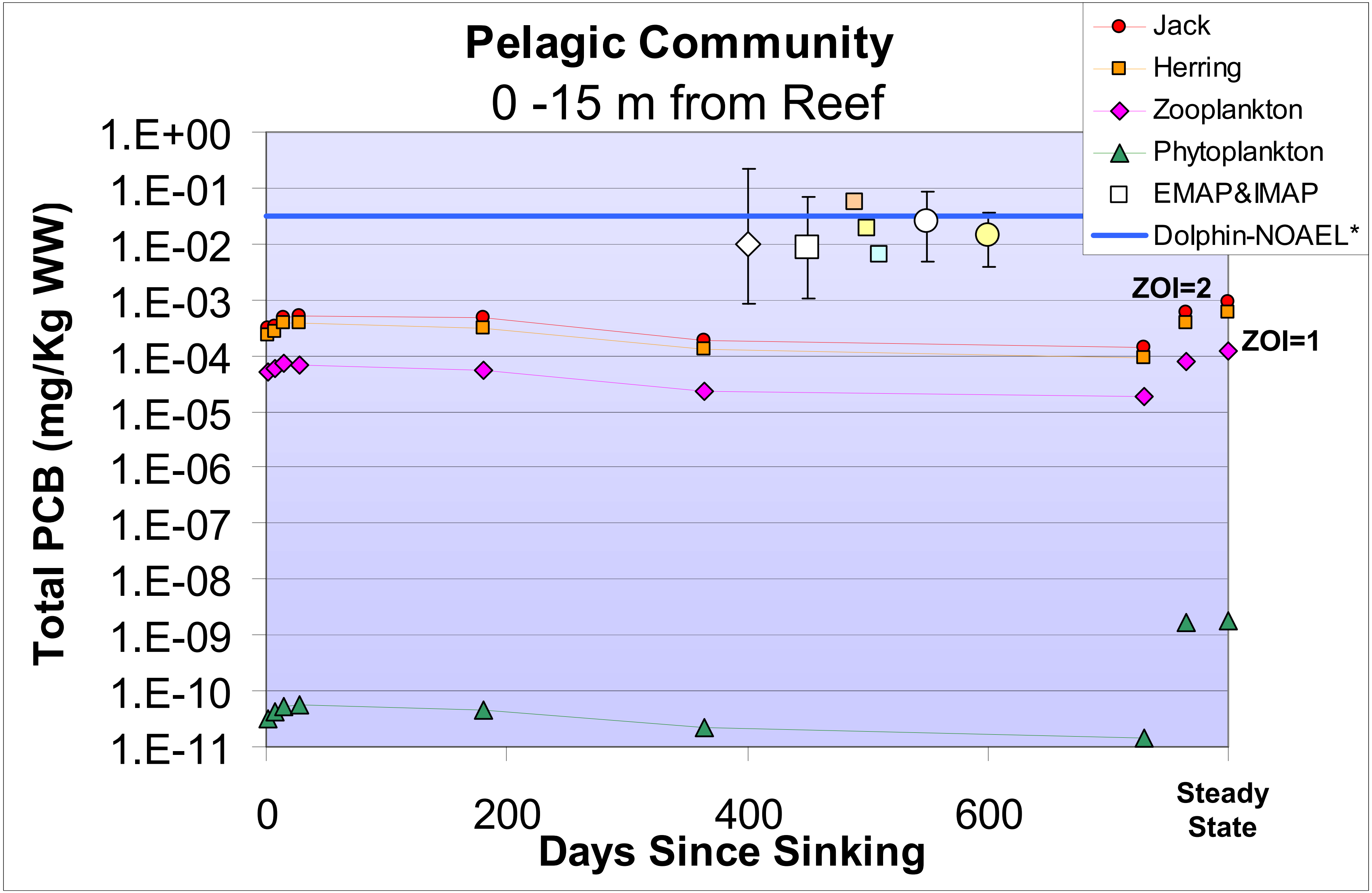


Fig. 24. Time series of Total PCB concentrations predicted by PRAM for the Pelagic Community within 0-15 m of the reef for the first two years following sinking and the steady state concentrations with ZOI=2 and ZOI=1. EMAP data for Atlantic croaker (white symbols) and spot (yellow symbols) are average (min and max) for all data from the Louisianan Province (diamond), Gulf Coast of Florida (large square), and Carolinian Province (circles). IMAP data are for three samples of sea trout, spot, and sea pig collected offshore of Pensacola (small squares).

*The AF-adjusted dolphin benchmark (Dolphin$_{\mathrm{NOAEL}}$/AF) for consumption of prey is also shown.

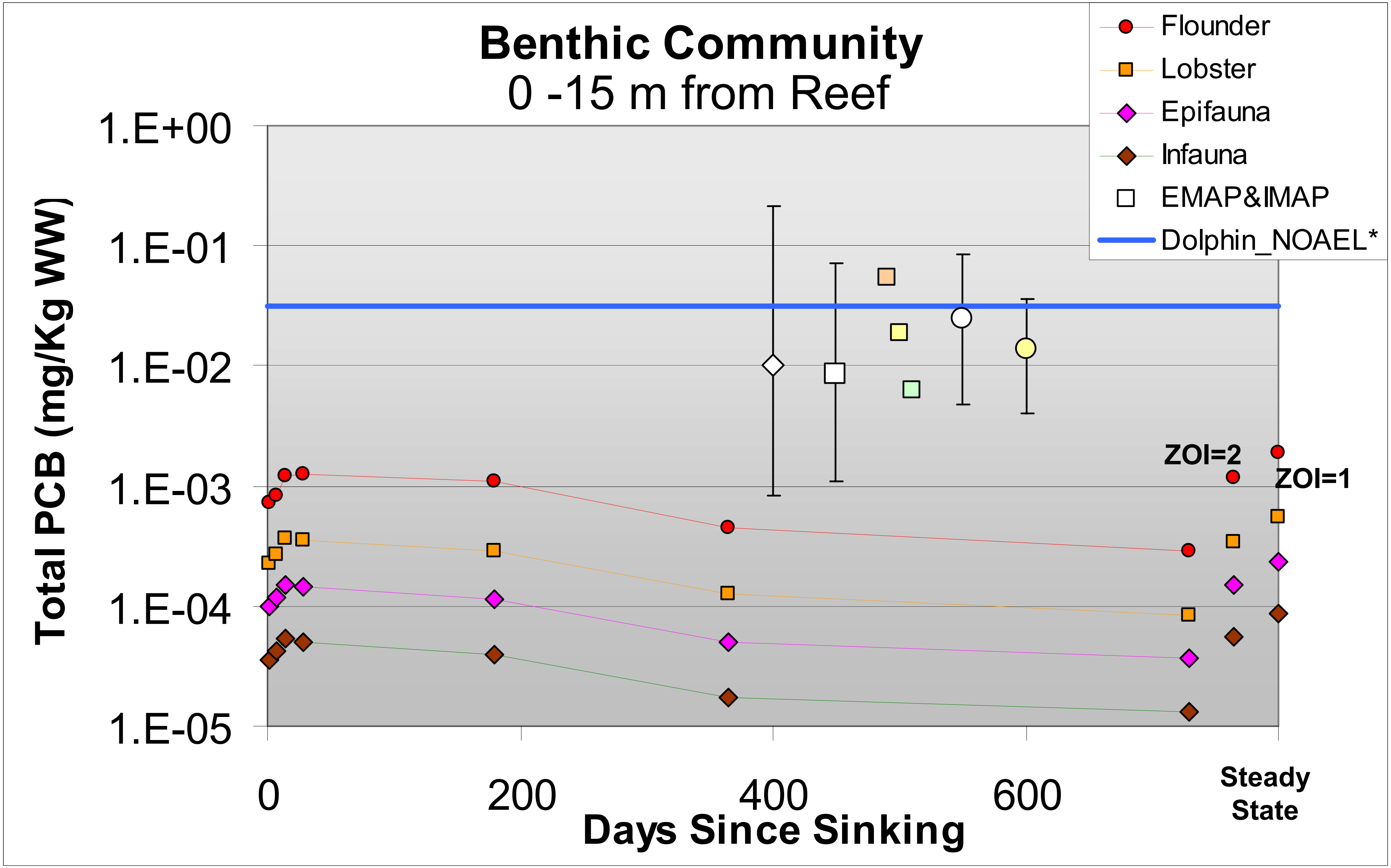


Fig. 25. Time series of Total PCB concentrations predicted by PRAM for the Benthic Community within 0-15 m of the reef for the first two years following sinking and the steady state concentrations with a ZOI=2 and ZOI=1. EMAP data for Atlantic croaker (white symbols) and spot (yellow symbols) are average (min and max) for all data from the Louisianan Province (diamond), Gulf Coast of Florida (large square), and Carolinian Province (circles). IMAP data are for three samples of sea trout, spot, and sea pig collected offshore of Pensacola (small squares).

*The AF-adjusted dolphin benchmark (Dolphin$_{NOAEL}$/AF) for consumption of prey is also shown.

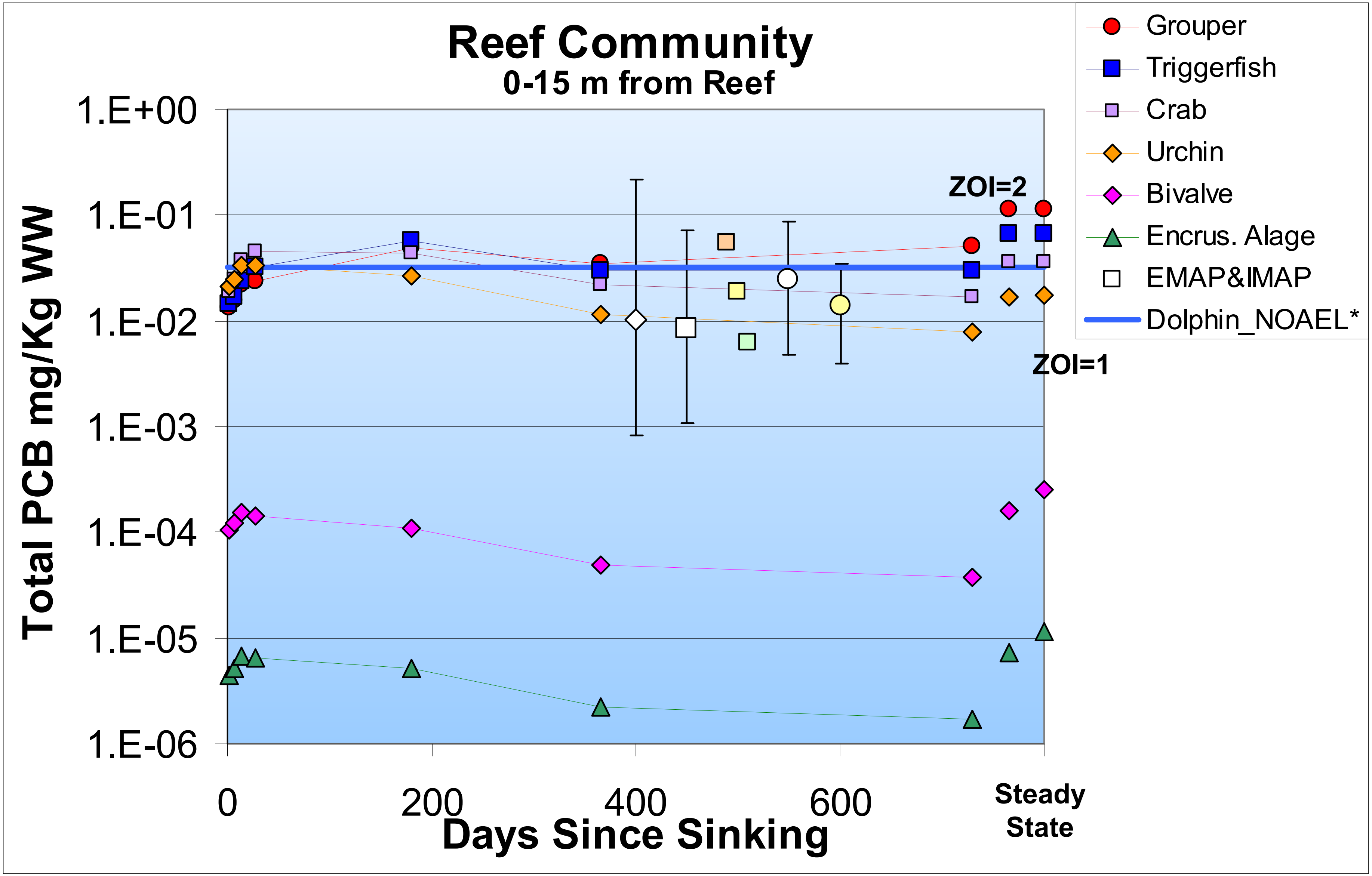


Fig. 26. Time series of Total PCB concentrations predicted by PRAM for the Reef Community within 0-15 m of the reef for the first two years following sinking and the steady state concentrations with ZOI=2 and ZOI=1. EMAP data for Atlantic croaker (white symbols) and spot (yellow symbols) are average (min and max) for all data from the Louisianan Province (diamond), Gulf Coast of Florida (large square), and Carolinian Province (circles). IMAP data are for three samples of sea trout, spot, and sea pig collected offshore of Pensacola (small squares).

*The AF-adjusted dolphin benchmark (Dolphin$_{NOAEL}$/AF) for consumption of prey is also shown.

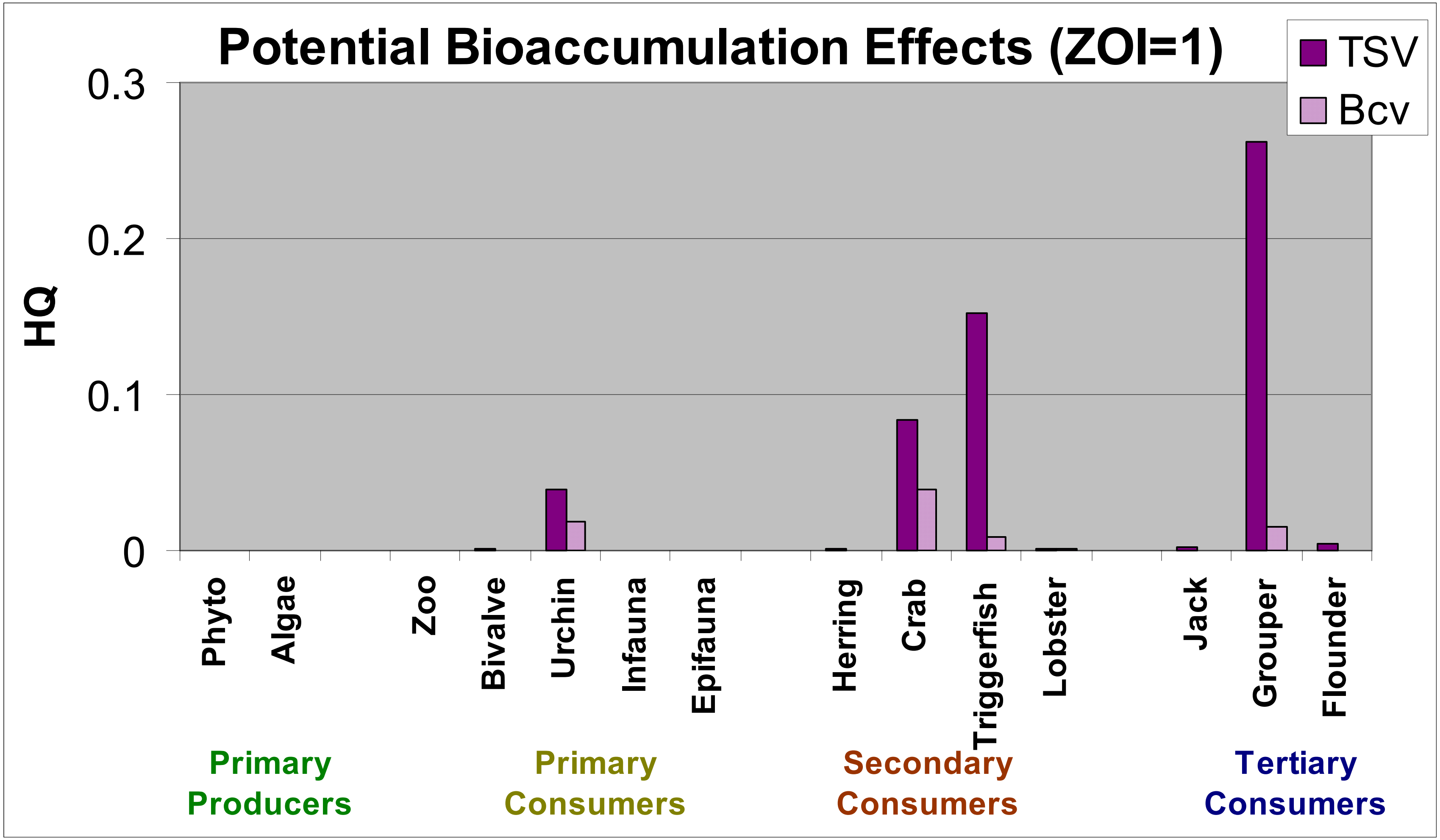


Fig. 27. Potential effects from bioaccumulation suggested by the HQs of tissue residues predicted by PRAM with a ZOI=1 for the tissue screening value (TSV) and bioaccumulation critical value (Bcv).

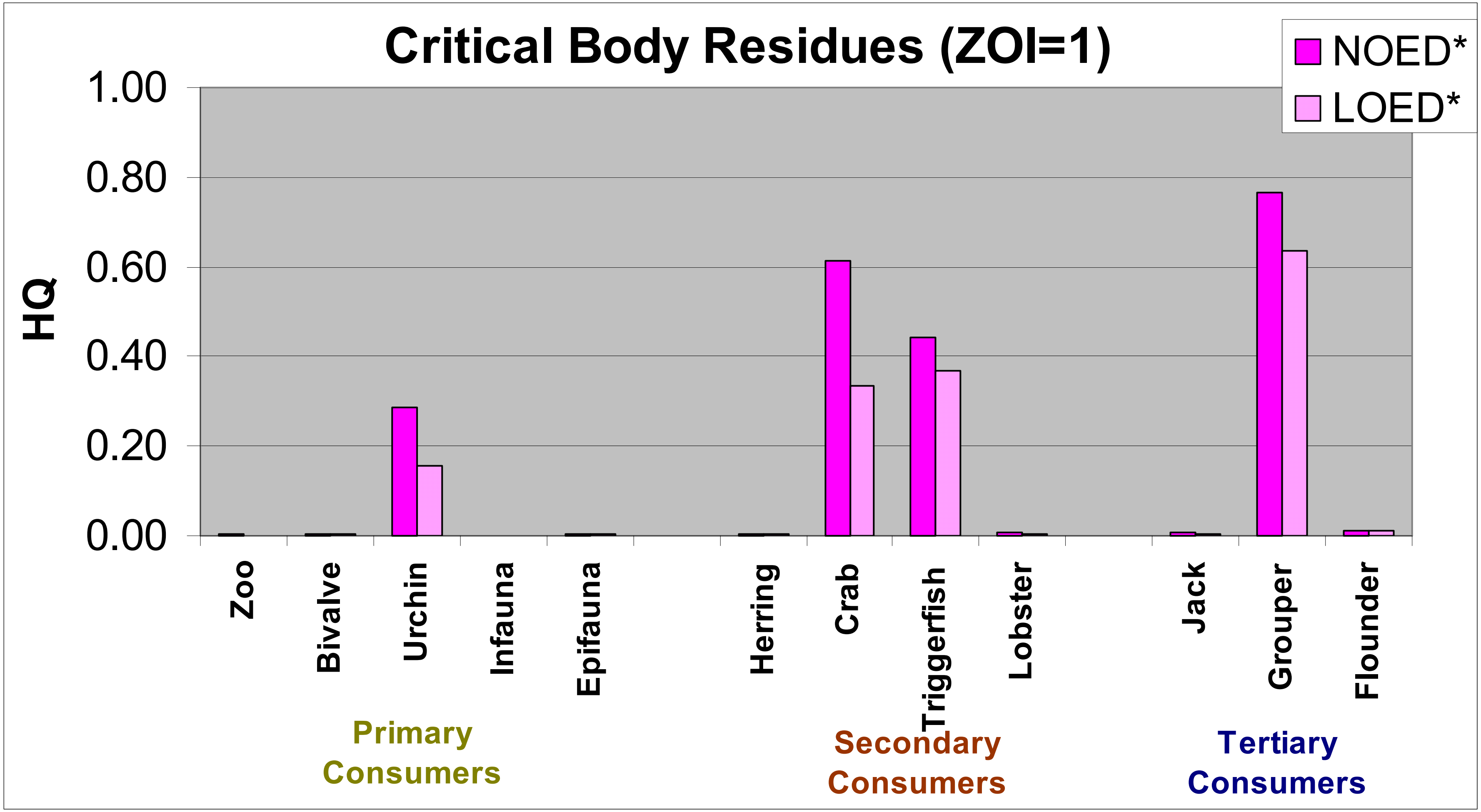


Fig. 28. Potential effects from critical body residues exceeding no effect and low effect levels for invertebrates and fish suggested by the HQs of tissue residues predicted by PRAM with a ZOI=1.

*Benchmarks are for the AF-adjusted no observed effects dose (NOED/AF) and the lowest observed effects dose (LOED/AF).

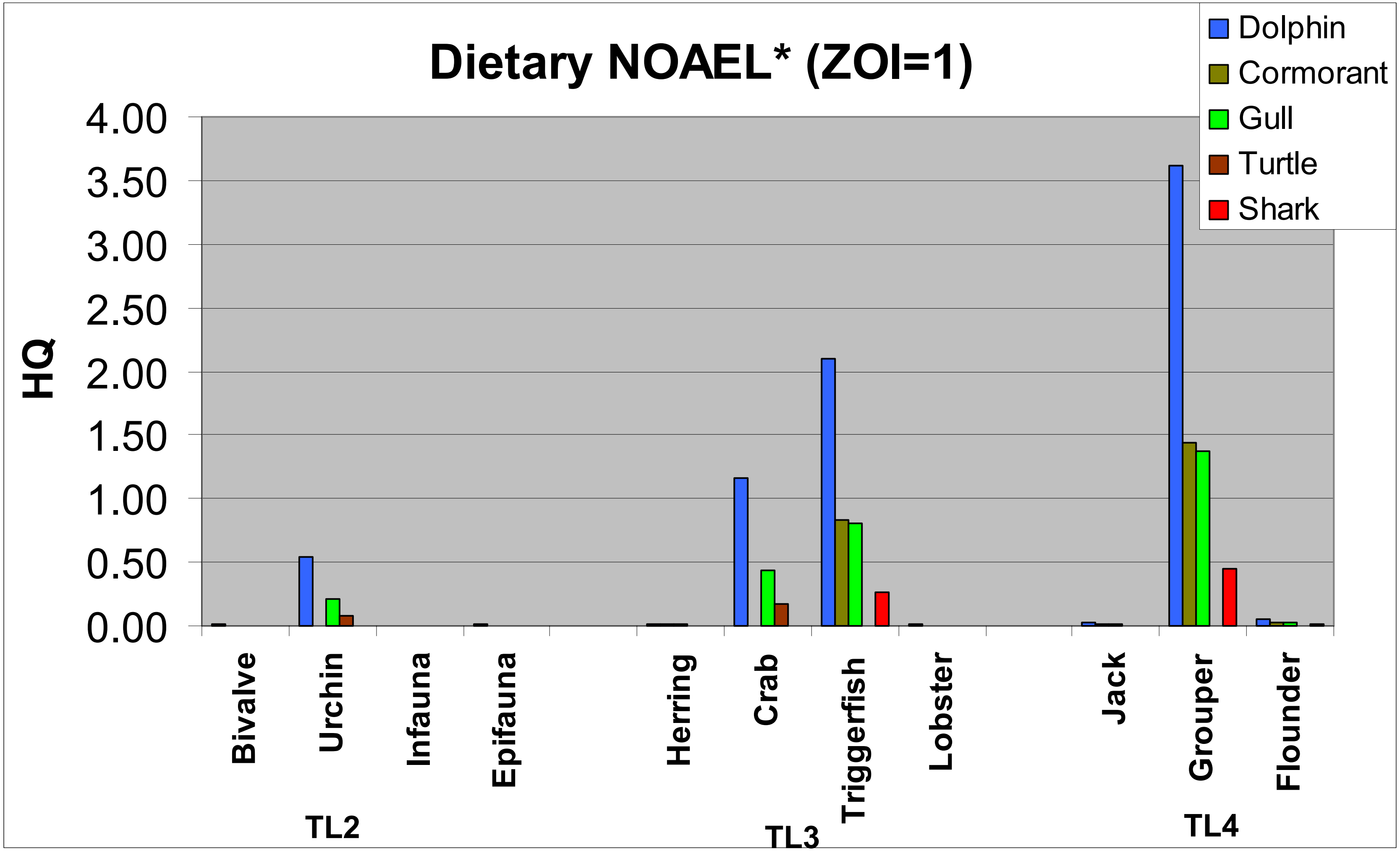


Fig. 29. Potential effects from dietary exposure to reef consumers exceeding no effect levels suggested by the HQs of tissue residues predicted by PRAM with a ZOI=1.
*Benchmarks are for the AF-adjusted dietary no observed adverse effect levels (NOAEL/AF).

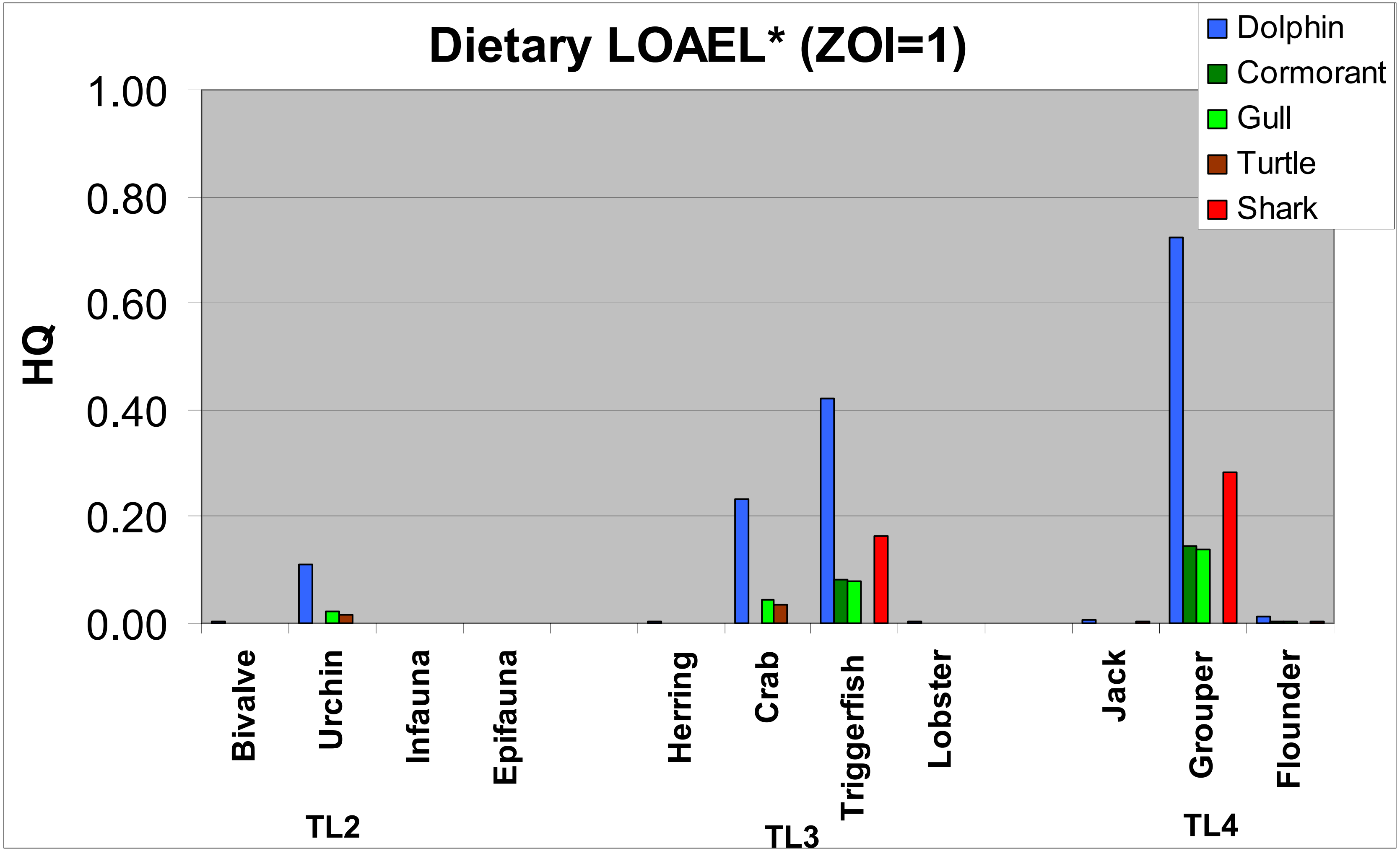


Fig. 30. Potential effects from dietary exposure to reef consumers exceeding low effect levels suggested by the HQs of tissue residues predicted by PRAM with a ZOI=1.

*Benchmarks are for the AF-adjusted dietary lowest observed adverse effect levels (LOAEL/AF).

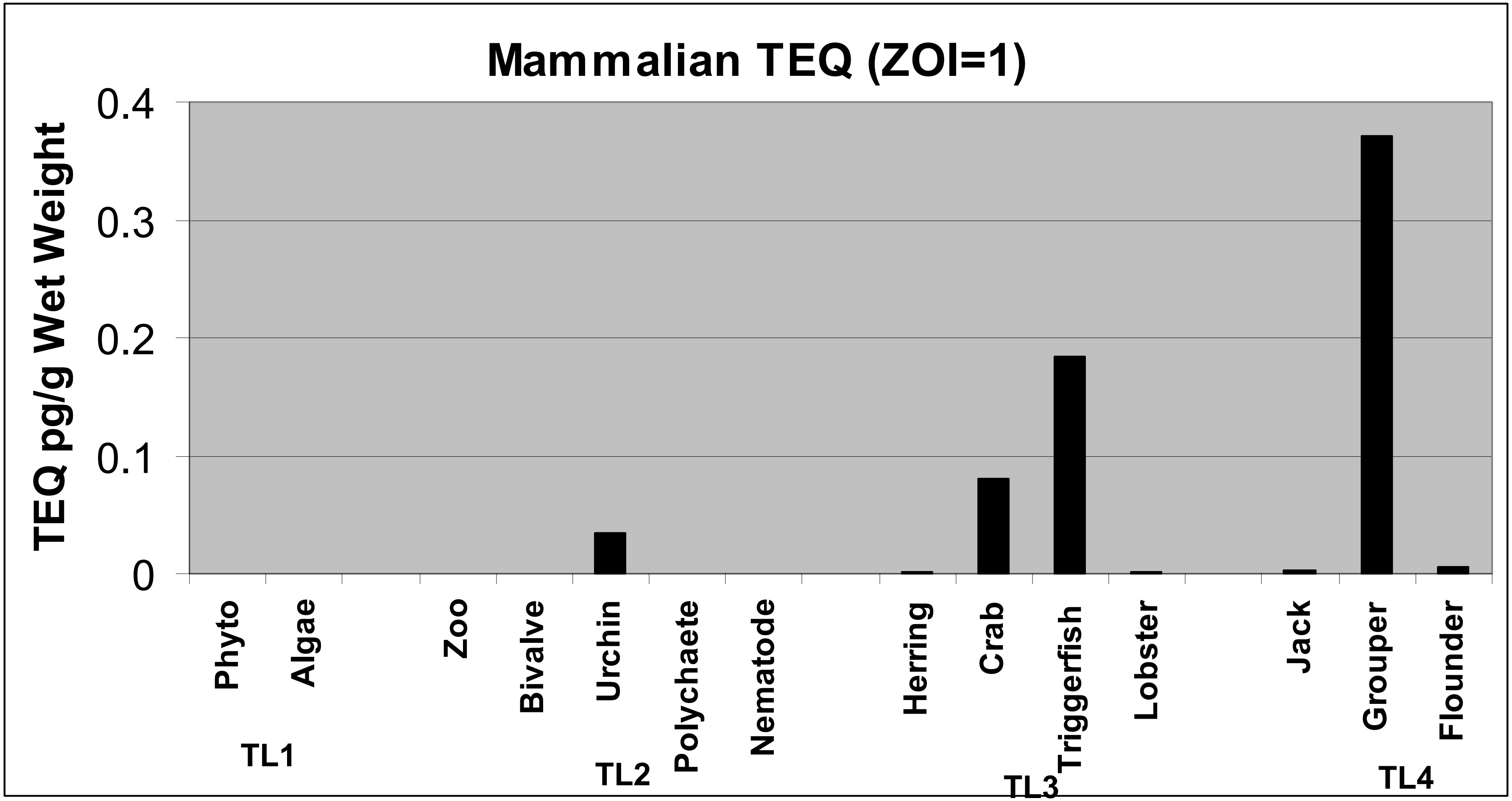


Fig. 31. Dioxin-like mammalian TEQs for food chain residues predicted by PRAM with a ZOI=1.

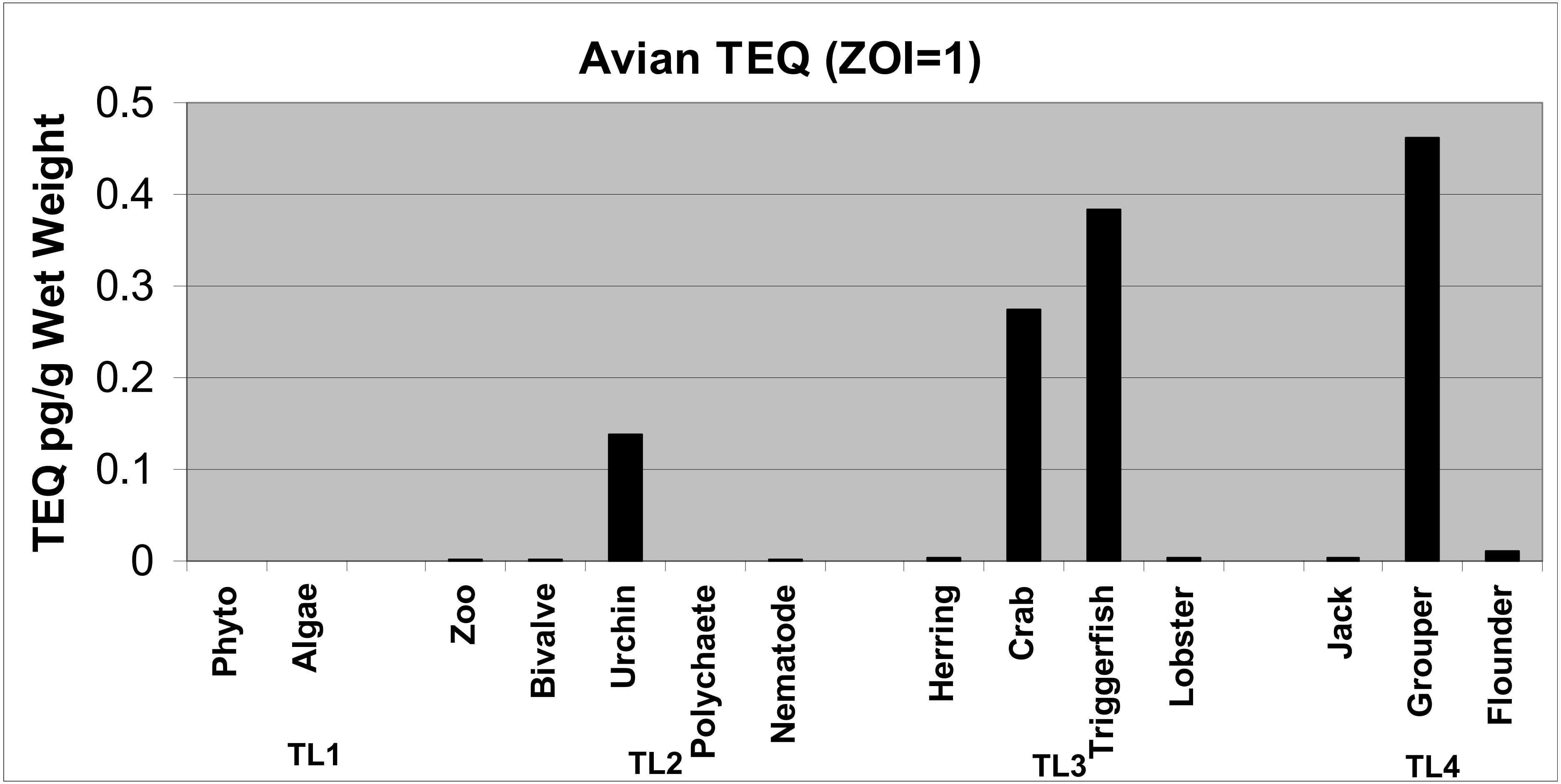


Fig. 32. Dioxin-like avian TEQs for food chain residues predicted by PRAM with a ZOI=1.

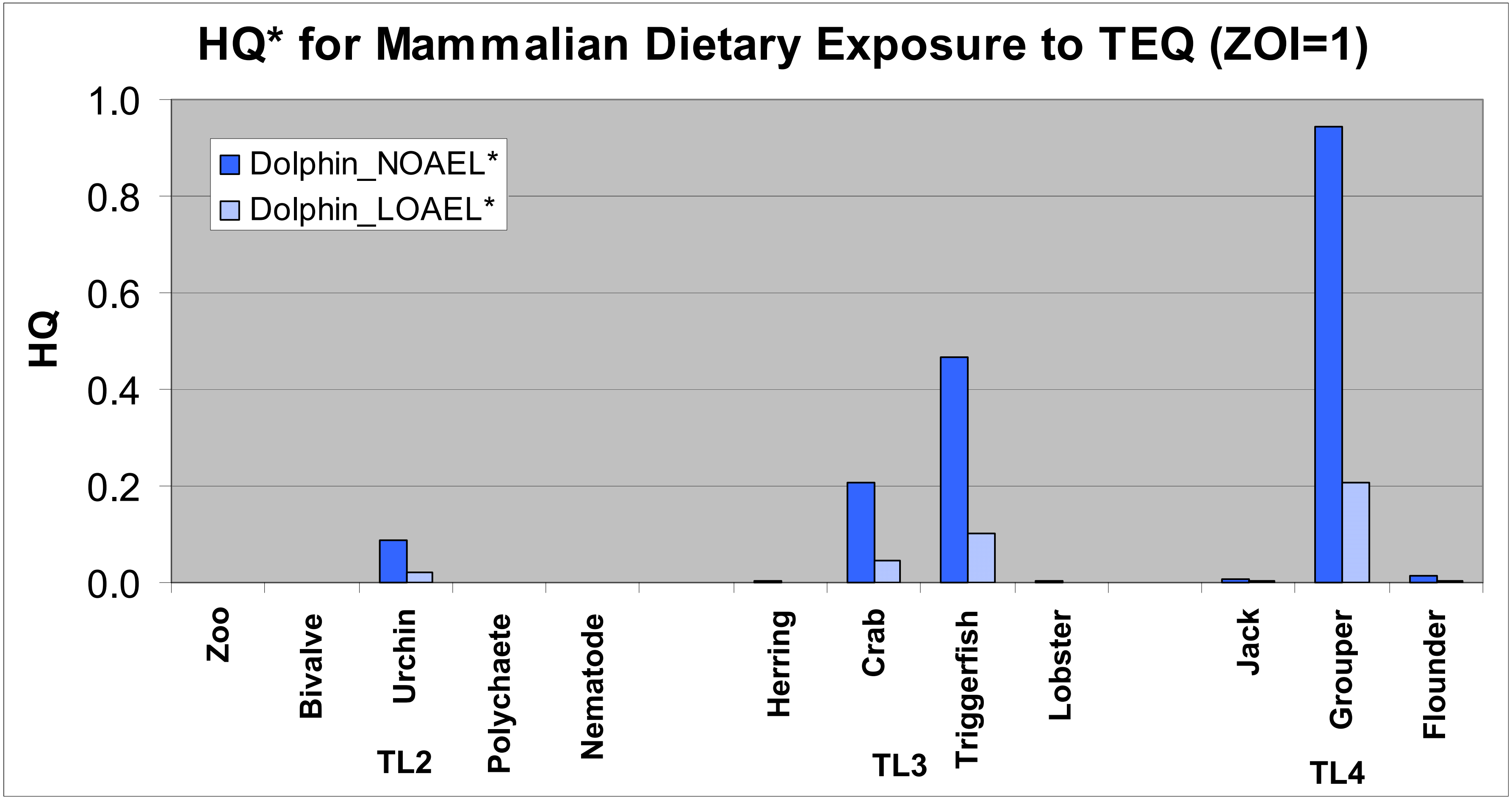


Fig. 33. Potential effects from dietary exposure of TEQ to dolphins suggested by the HQs of tissue residues predicted by PRAM with a ZOI=1.

*Benchmarks are for the AF-adjusted TEQ benchmarks (NOAEL/AF and LOAEL/AF) for dietary exposure to dolphins.

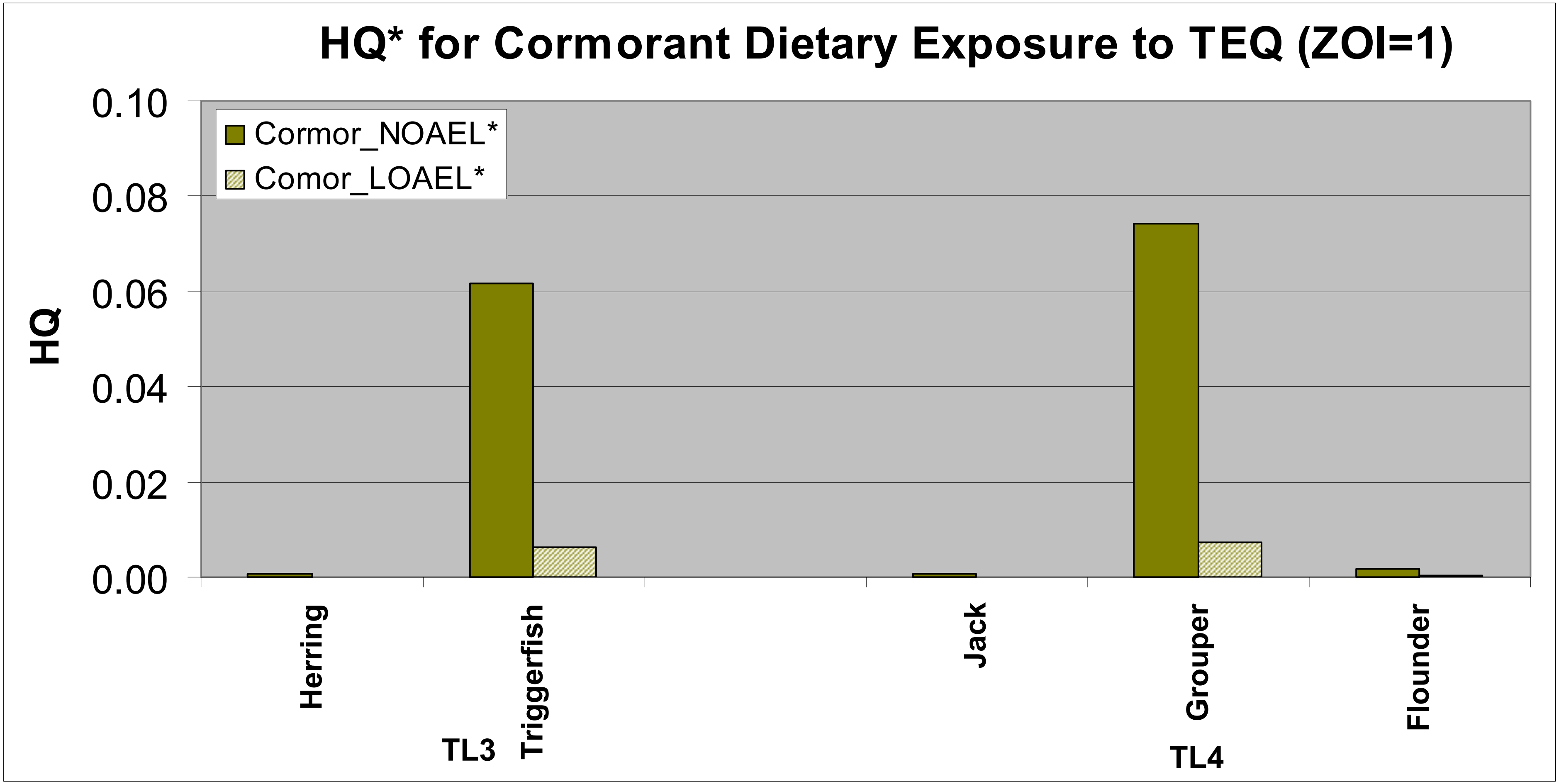


Fig. 34. Potential effects from dietary exposure of TEQ to cormorants suggested by the HQs of tissue residues predicted by PRAM with a ZOI=1.

*Benchmarks are for the AF-adjusted TEQ benchmarks (NOAEL/AF and LOAEL/AF) for dietary exposure to cormorants.

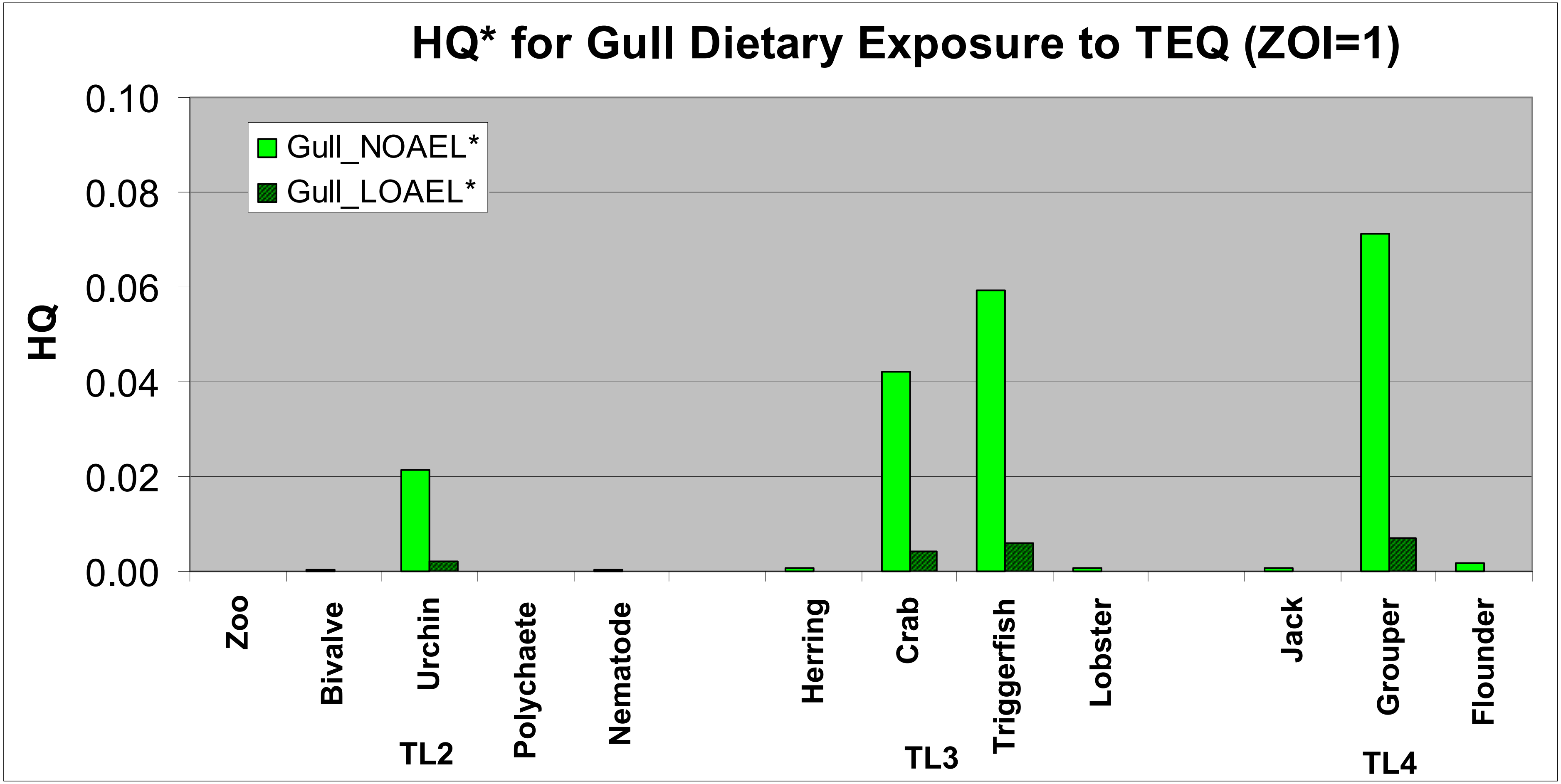


Fig. 35. Potential effects from dietary exposure of TEQ to herring gulls suggested by the HQs of tissue residues predicted by PRAM with a ZOI=1.

*Benchmarks are for the AF-adjusted TEQ benchmarks (NOAEL/AF and LOAEL/AF) for dietary exposure to gulls.

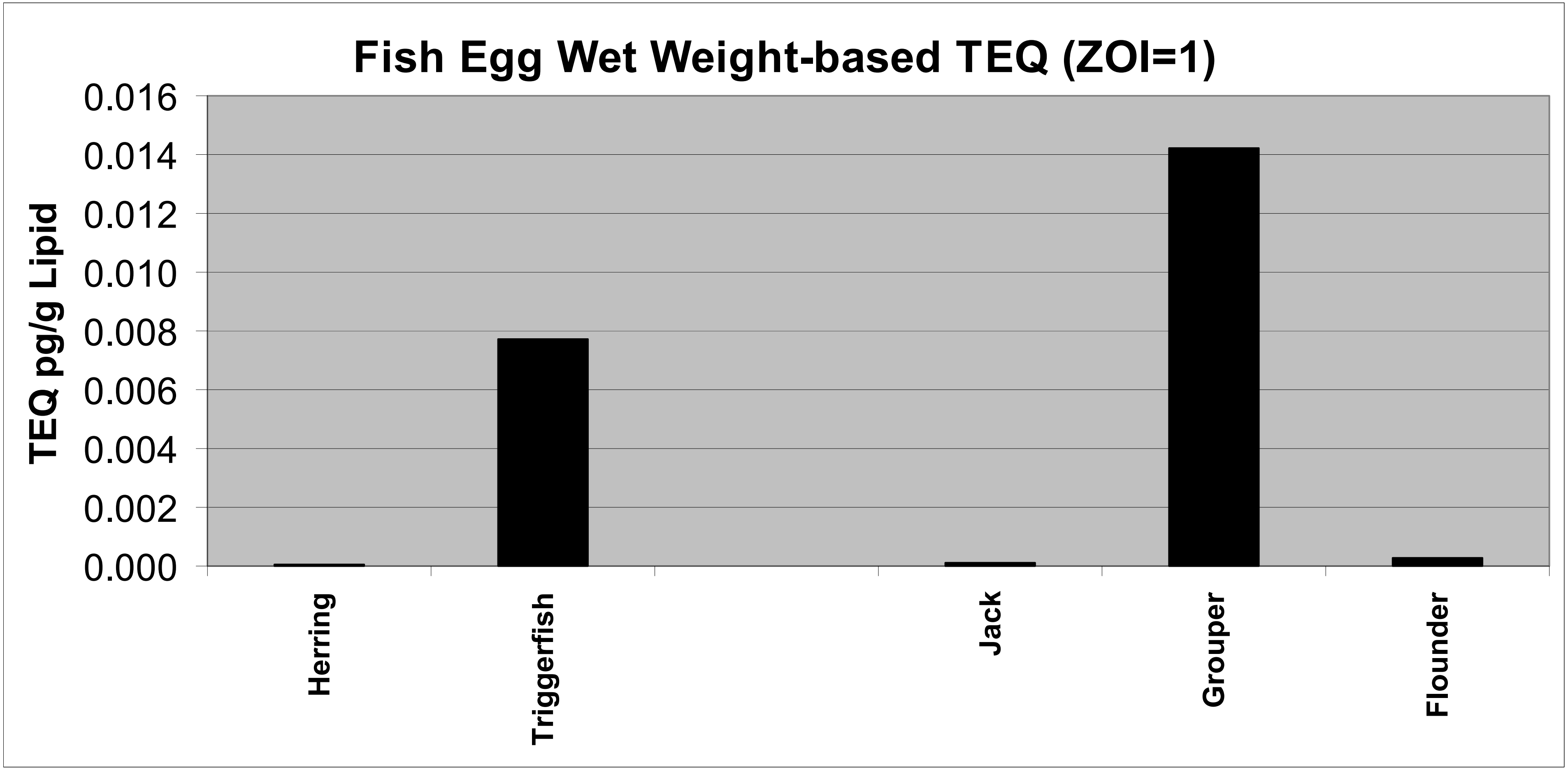


Fig. 36. Dioxin-like TEQs in fish eggs (wet weight) based on food chain residues predicted by PRAM with a ZOI=1.

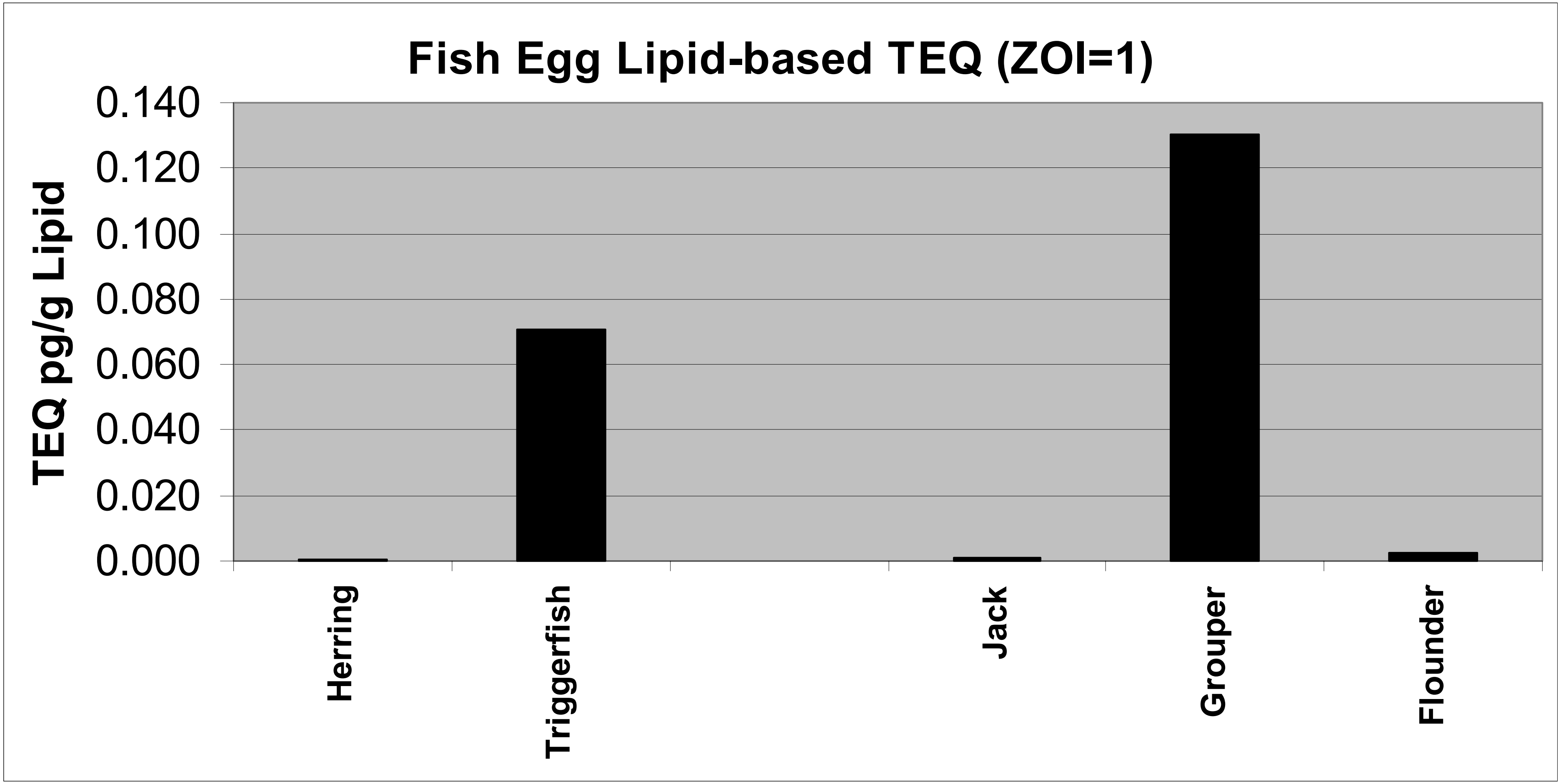


Fig. 37. Dioxin-like TEQs in fish eggs (lipid weight) based on food chain residues predicted by PRAM with a ZOI=1.

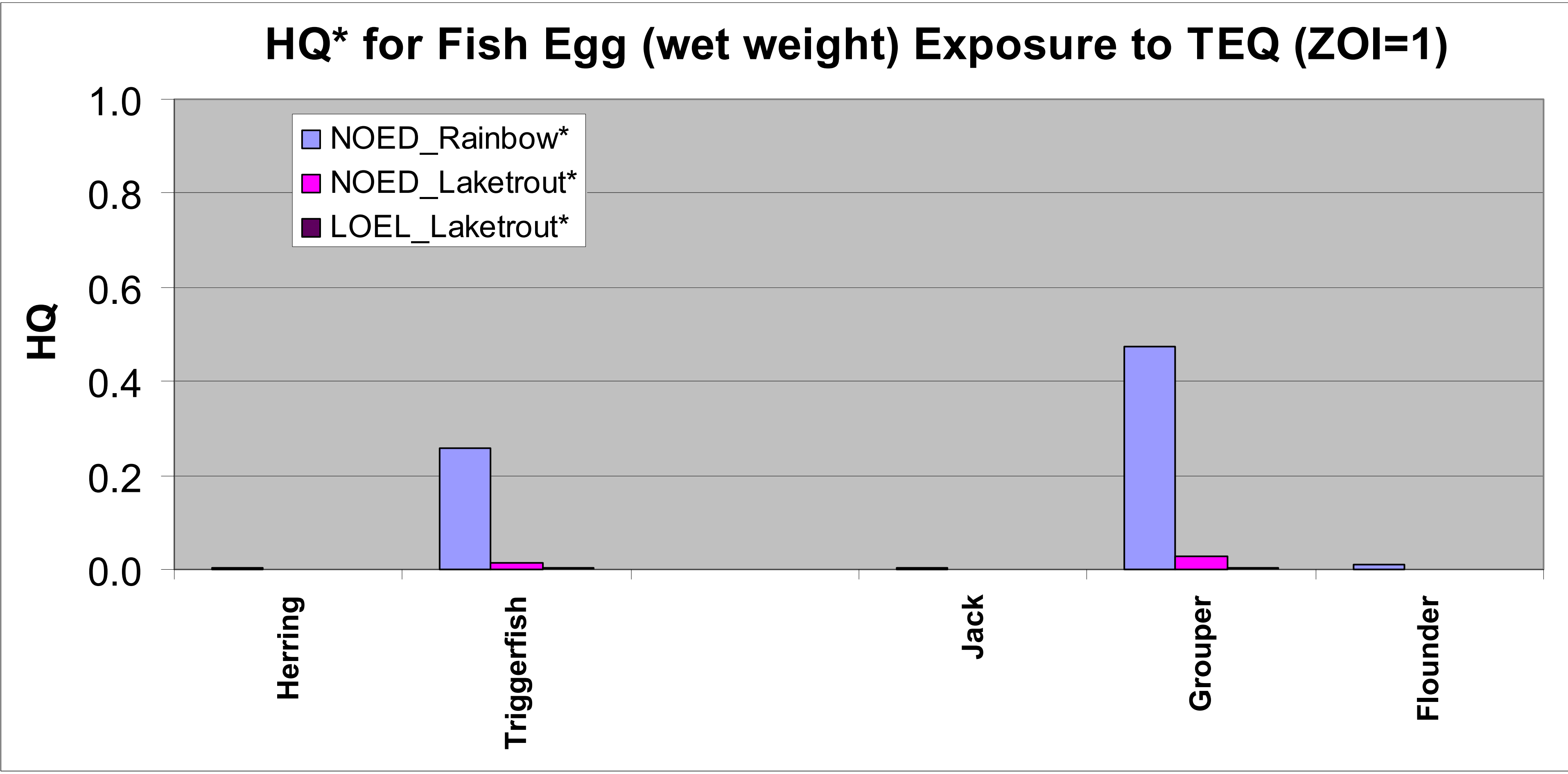


Fig. 38. Potential effects from TEQ exposure of fish eggs (wet weight) suggested by the HQs of fish egg tissue residues based on predictions by PRAM with a ZOI=1.

*Benchmarks are for the AF-adjusted TEQ benchmarks (NOAEL/AF and LOAEL/AF) for maternal transfer to fish eggs.

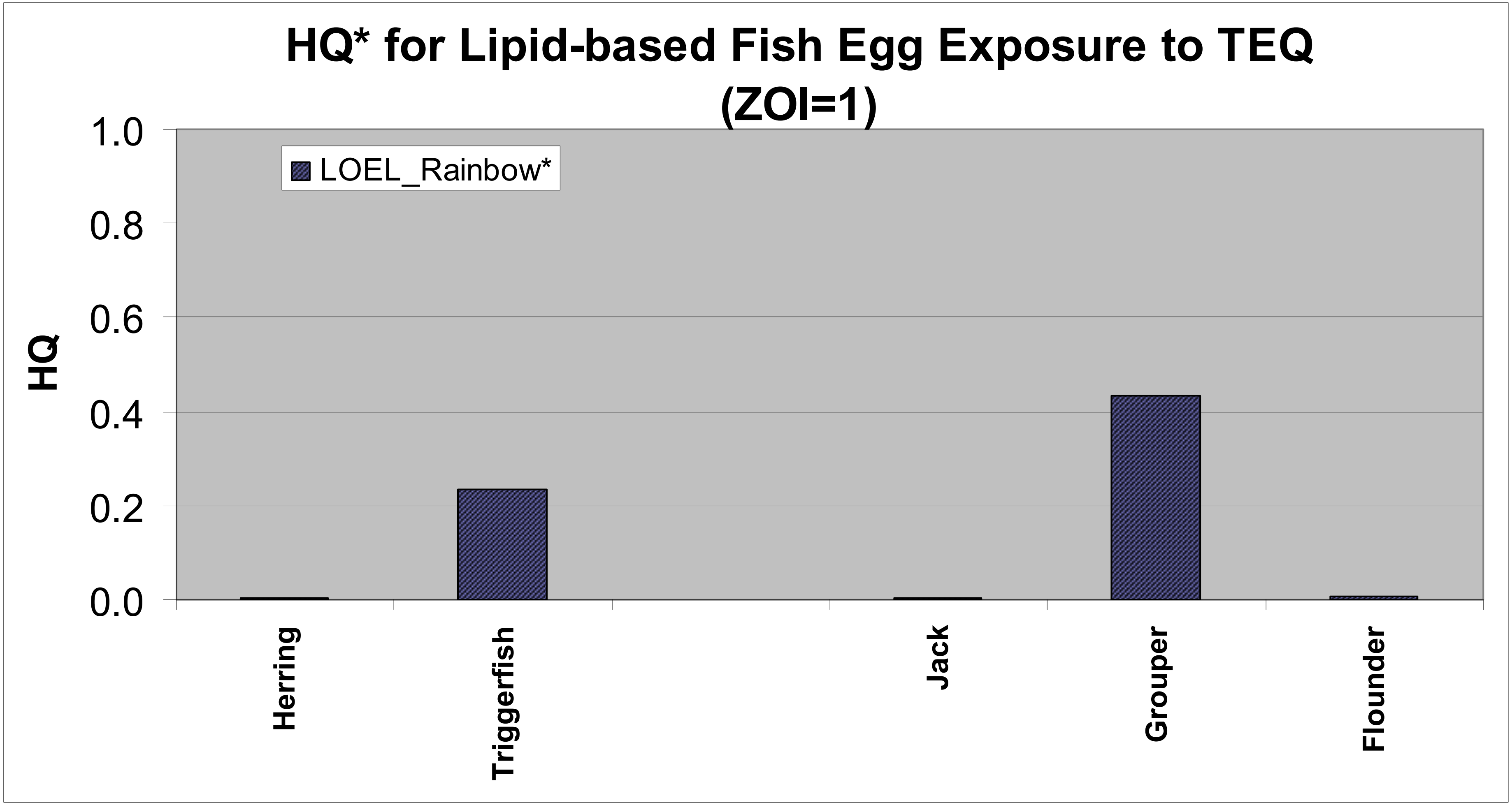


Fig. 39. Potential effects from TEQ exposure of fish eggs (lipid weight) suggested by the HQs of fish egg tissue residues based on predictions by PRAM with a ZOI=1.
*Benchmarks are for the AF-adjusted TEQ benchmark (LOAEL/AF) for maternal transfer to fish eggs.

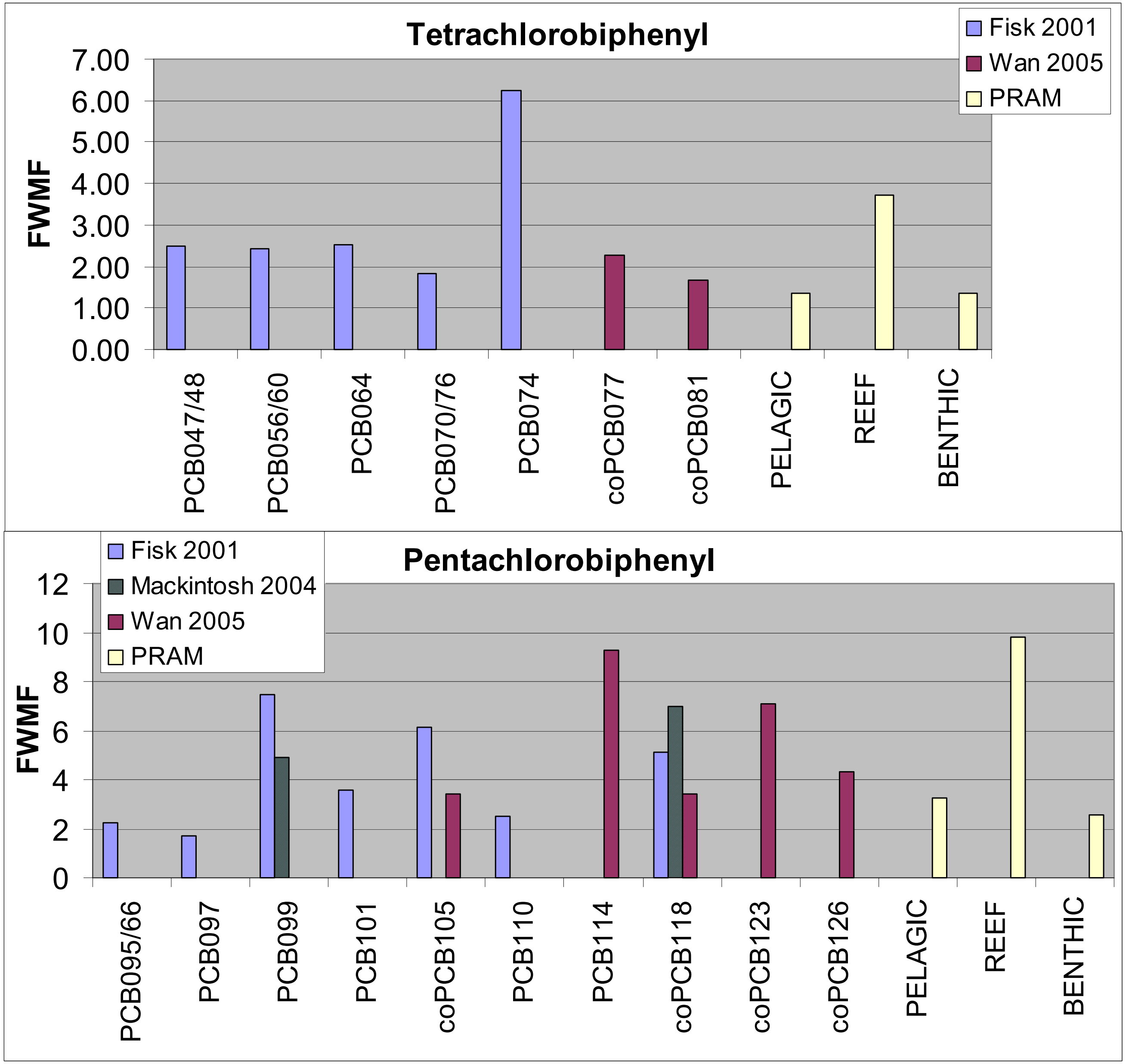


Fig. 40. The food web magnification factors (FWMF) for coplanar (co) and non-coplanar PCBs reported in the literature and simulated by PRAM for tetra- and pentachlorobiphenyls.

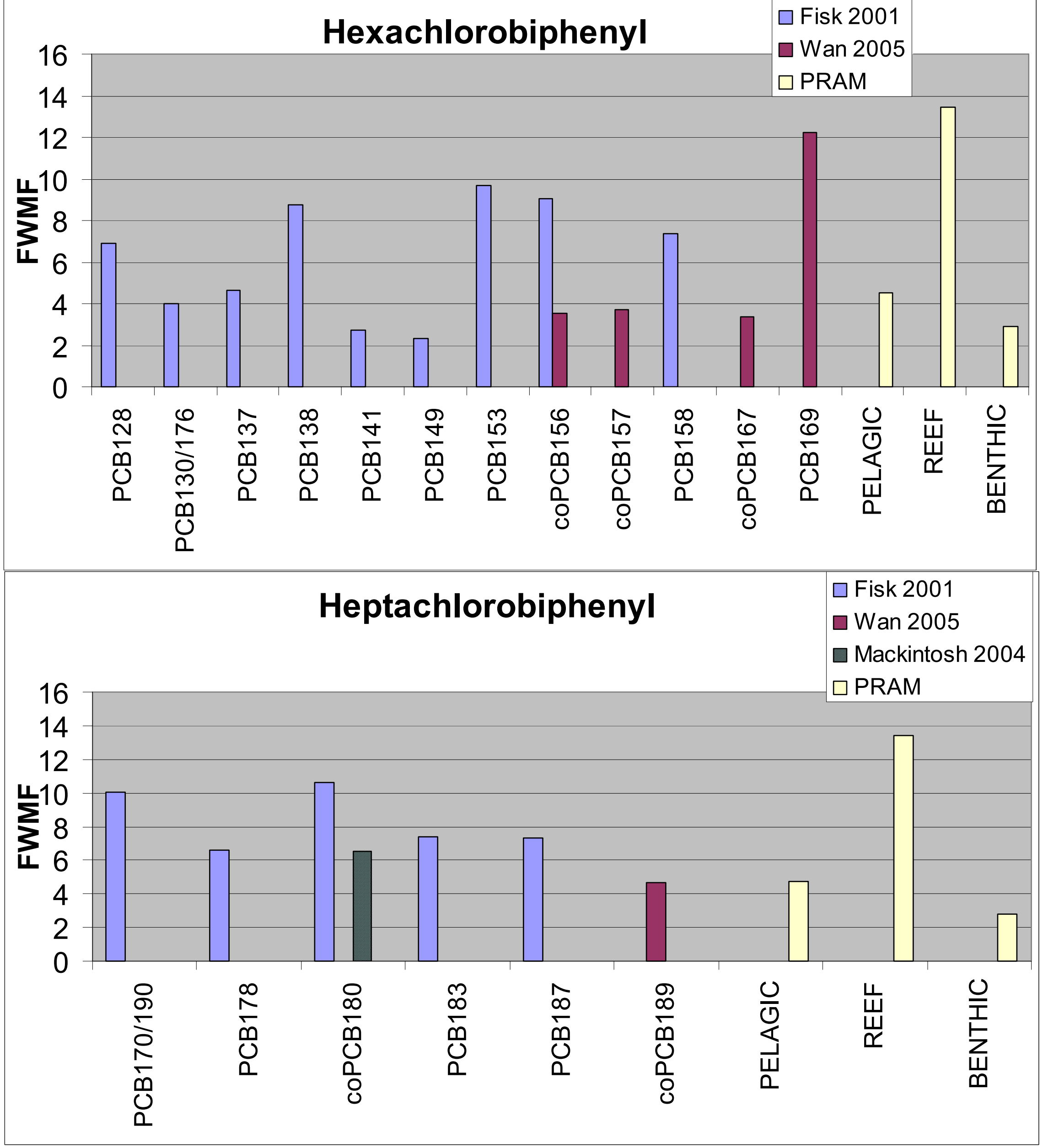
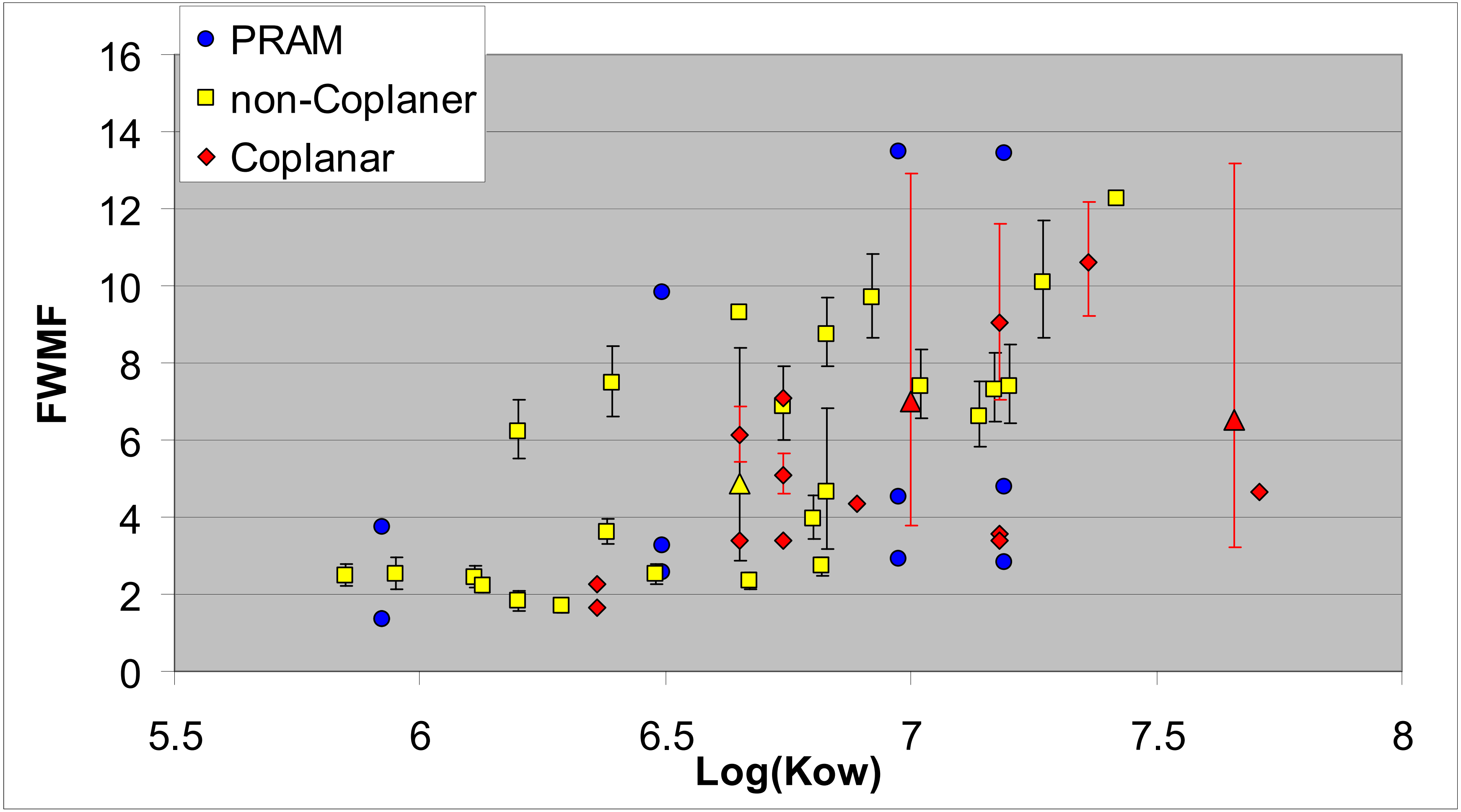


Fig. 41. The food web magnification factors (FWMF) for coplanar (co) and non-coplanar PCBs reported in the literature and simulated by PRAM for hexa- and heptachlorobiphenyls.



error bars on Mackintosh 2004 (triangles) are 95th% CL
error bars on Fisk 2001 (squares) are +/- 1 Std error

Fig. 42. The range of food web magnification factors (FWMF) for coplanar (red) and non-coplanar (yellow) PCBs reported in the literature and simulated by PRAM (blue) for tetra-, penta-, hexa-, and heptachlorobiphenyls. Literature values are from Fisk et al. 2001, Mackintosh et al. 2004, and Wan et al. 2005.

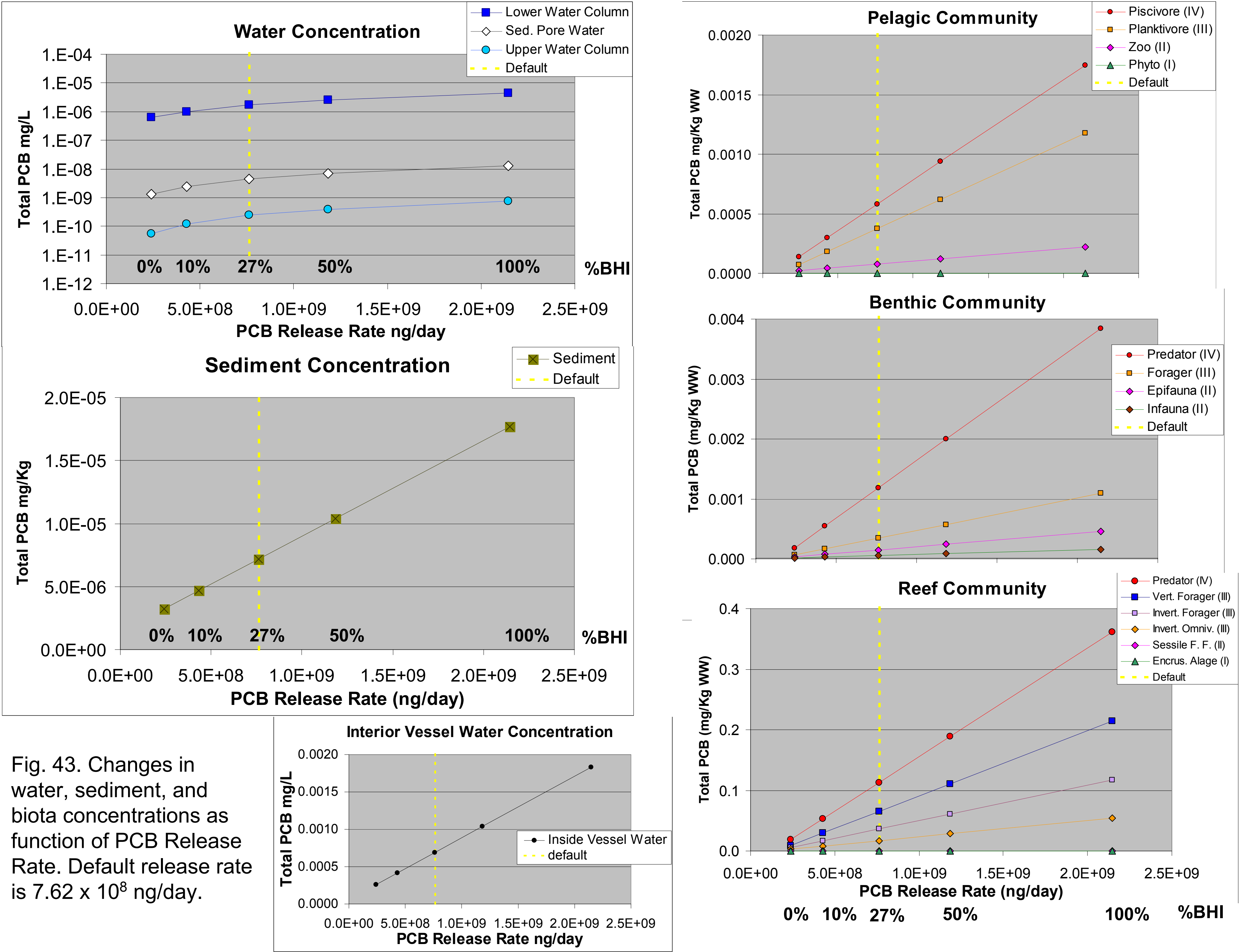


Fig. 43. Changes in water, sediment, and biota concentrations as function of PCB Release Rate. Default release rate is 7.62 x 10^8 ng/day.

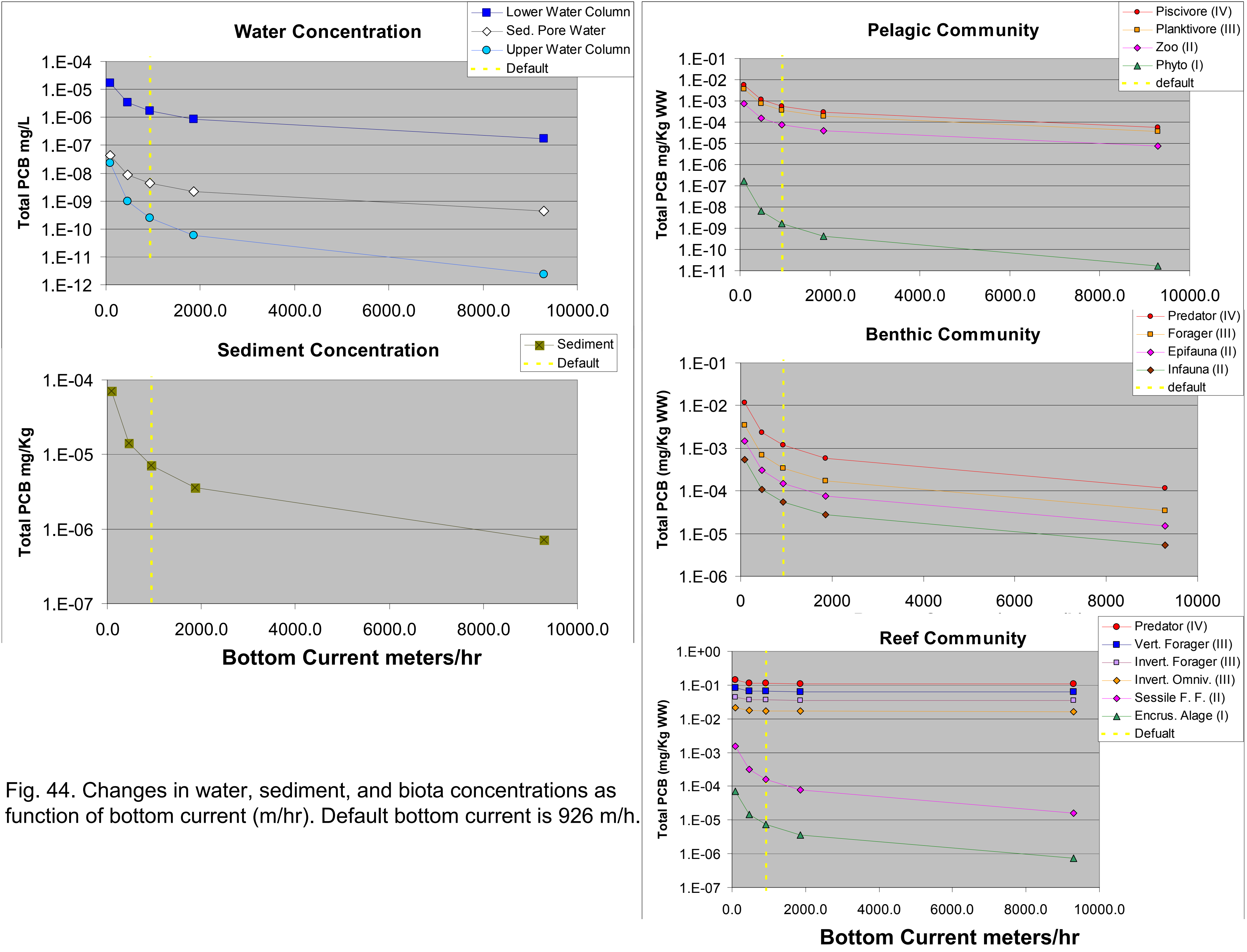


Fig. 44. Changes in water, sediment, and biota concentrations as function of bottom current (m/hr). Default bottom current is 926 m/h.

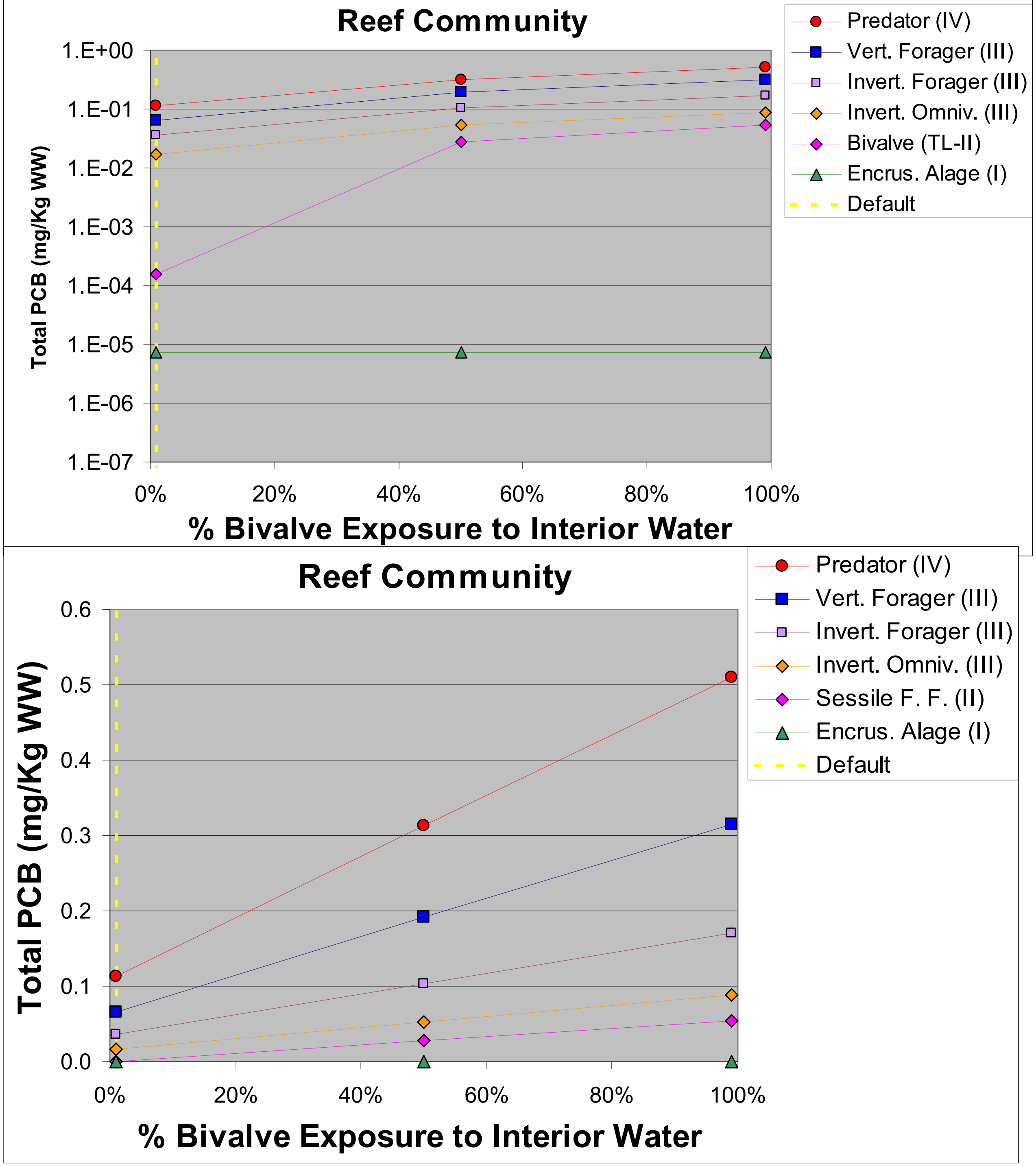


Fig. 45. Changes in concentrations of PCBs in the reef community as function of increasing bivalve exposure to interior vessel water. Default exposure is 0%. The same data are presented in both figures, upper figure present data on a log scale.

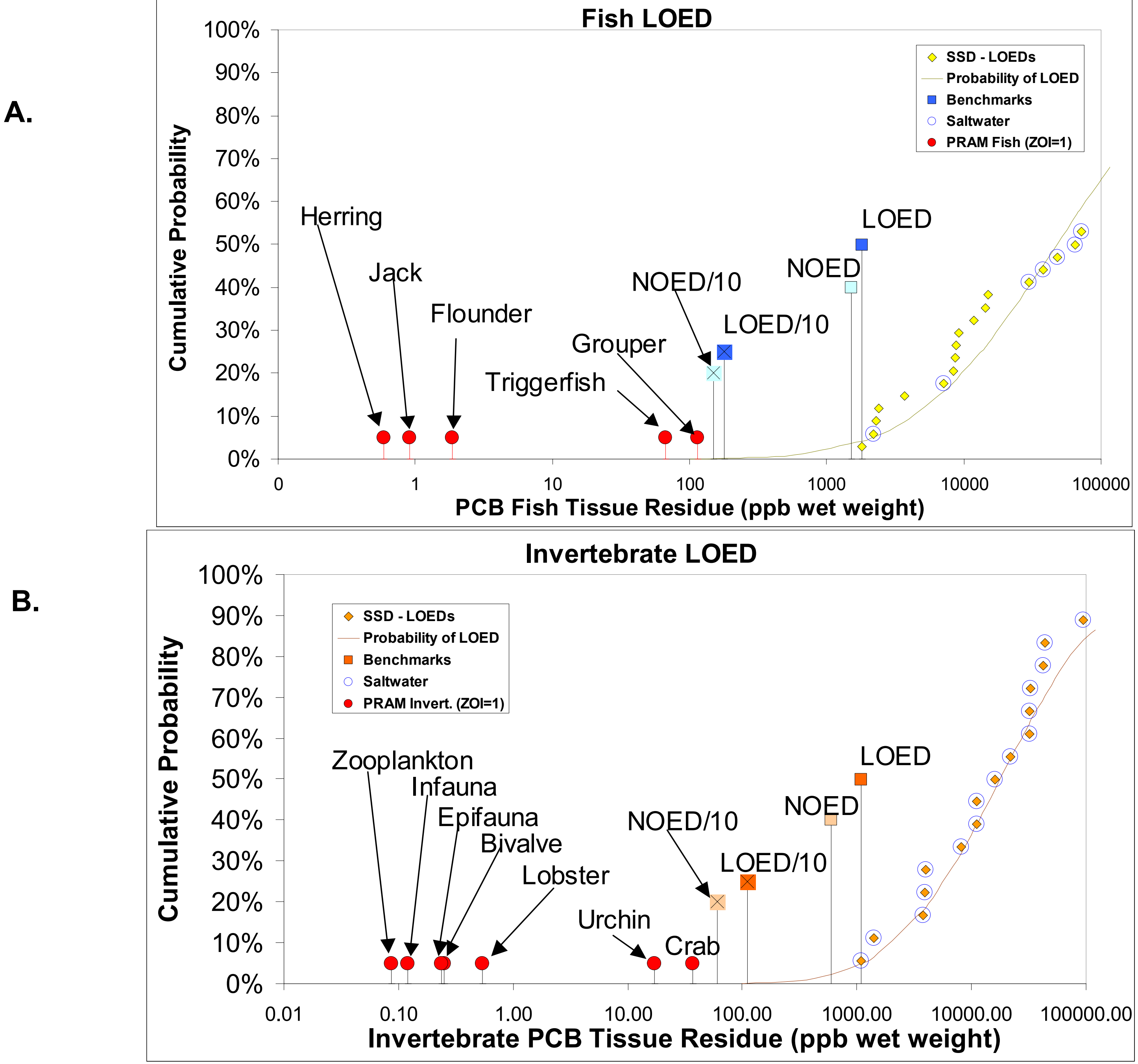


Fig. 46. The SSD and benchmarks for low effects from tissue residues and predicted biota concentrations from PRAM (ZOI=1) for fish (A) and invertebrates (B).

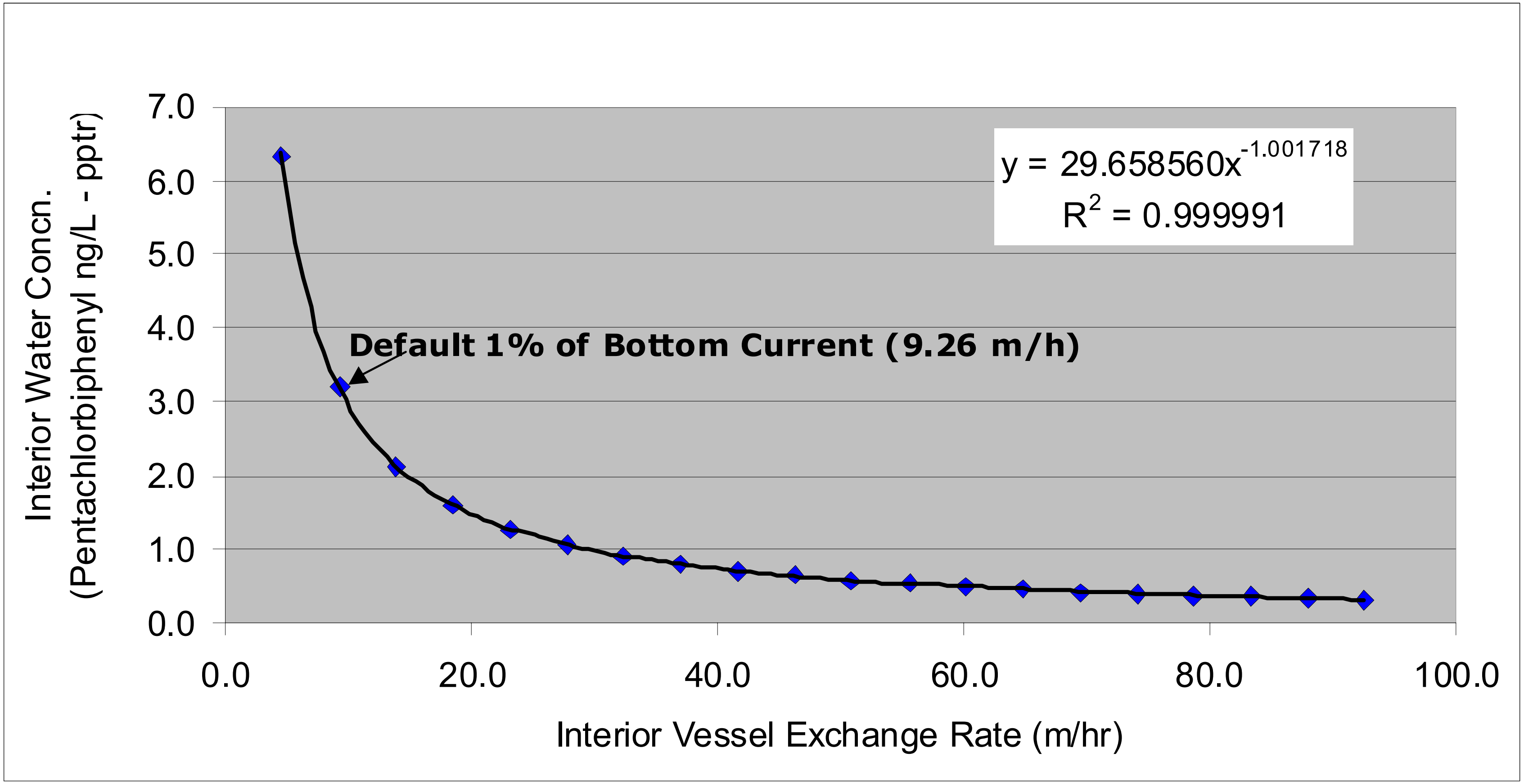


Fig. 47 The concentration of pentachlorobiphenyl in the interior of the ship modeled by TDM as function of fraction of bottom current which was held constant at 926 m/h (0.5 nautical miles per hour).

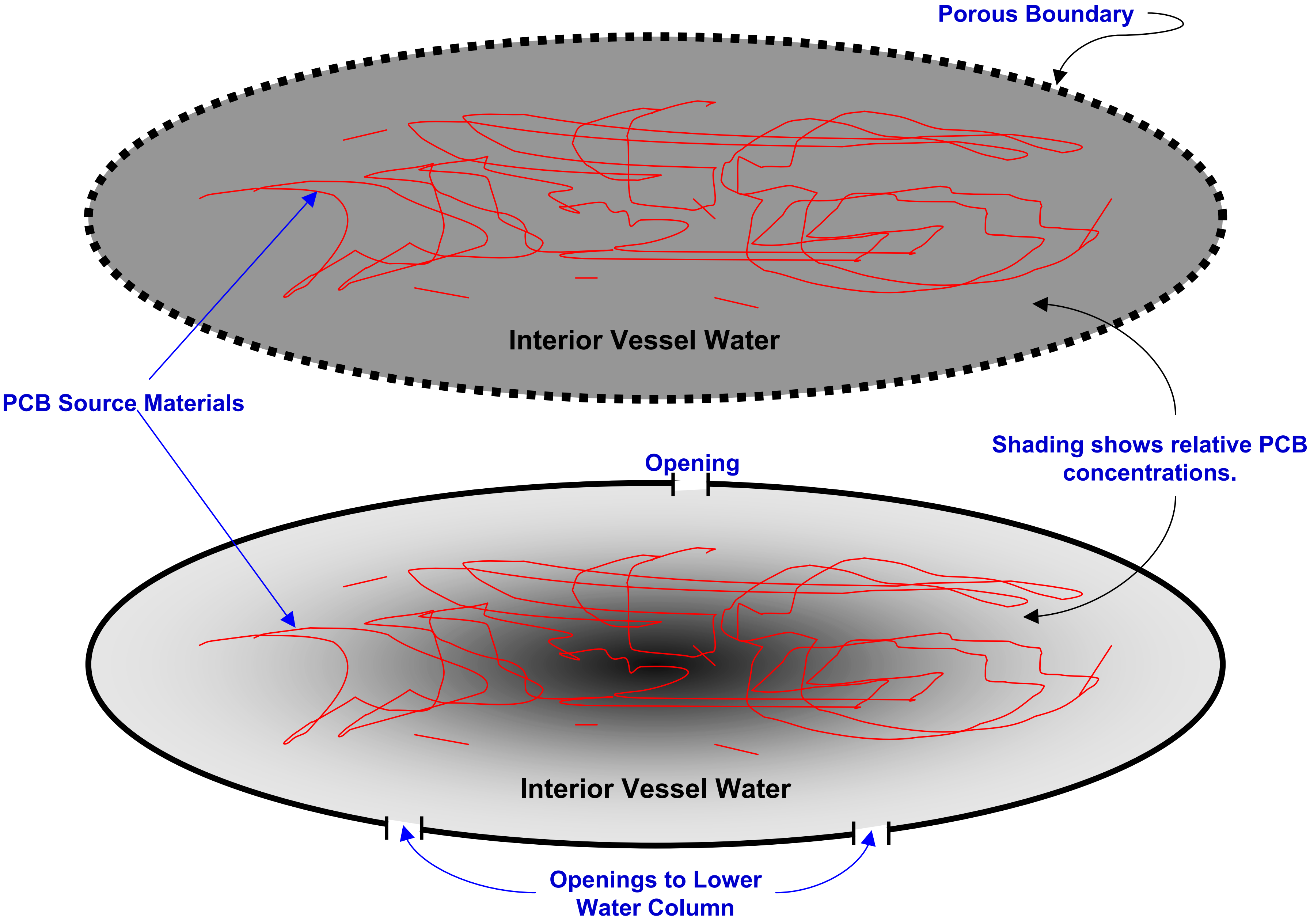


Fig. 48. The interior vessel water is modeled as a homogenous mixture of PCBs with a porous boundary (upper diagram), but in reality a gradient will exist (lower diagram) with lower PCB concentrations near the limited openings where foraging fish and invertebrates are more apt to occur.

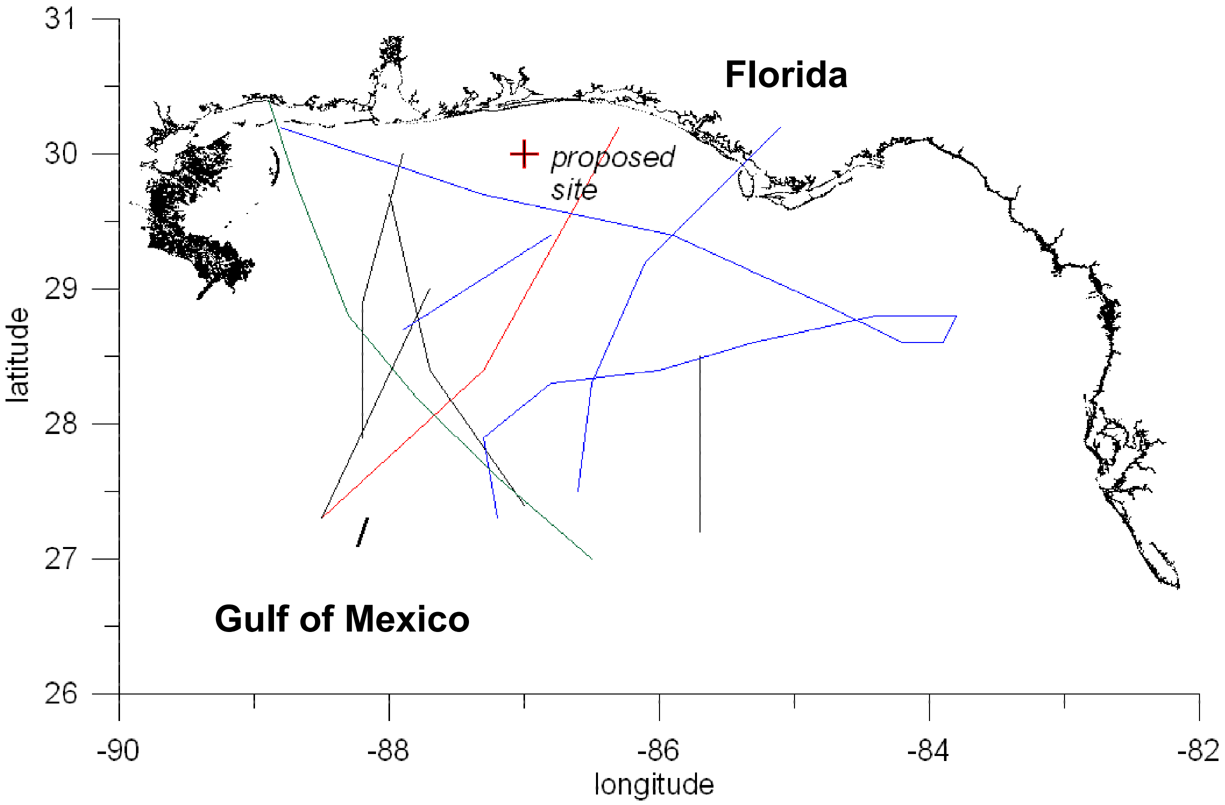


Fig. 49. Tracks of eleven named hurricanes in the vicinity of the ex-ORISKANY reef site from 1970 to 2004. Data from NOAA 2005.

12. APPENDICES

Appendix A. Responses to Comments on the Draft Final Report

Johnston, R.K., R. George, K.E. Richter, P.F. Wang, and W.J. Wild, 2005. EX-ORISKANY Artificial Reef Project: Ecological Risk Assessment. Draft Final Report, June 14, 2005, Prepared for: Program Executive Office Ships (PMS333) Naval Sea Systems Command by Space and Naval Warfare Systems Center, San Diego, CA, 268pp. http://www.epa.gov/Region4/air/lead/documents/ex-OriskanyArtificialReefProjectEcologicalRiskAssessment6-05-drftfinal.pdf

A.1 Response to Comments from U.S. EPA Round 1

A.2 Response to Comments from SAB

A.3 Response to Comments from U.S. EPA Round 2

A.1 Response to Comments from U.S. EPA Round 1 (Comments Received Fri, Oct. 14, 2005)

Below are the consolidated review comments prepared by the U.S. Environmental Protection Agency's Office of Research and Development (ORD), Office of Prevention, Pesticides, and Toxic Substances (OPPTS), and Region 4.

	GENERAL COMMENTS	
#	COMMENT	RESPONSE
1	EPA reviewed this document with the expectation that it would be a stand-alone report, self-contained with respect to descriptions of all steps of an ecological risk assessment, and organized and communicated in a manner that would facilitate understanding of assessment design, analyses, findings and interpretation. Unfortunately, this expectation was not met. The primary audience for this document is EPA. EPA has developed and adopted a general framework for ecological risk assessment, as communicated in US EPA (1992, 1998) and other documentation. Communication of the ecological risk assessment approach, analyses and findings would be better served if this document was reorganized to map more directly onto that framework. Specifically, the materials currently presented in Sections 3-8 should be restructured into sections of problem formulation, analysis (with major subsections for characterizations of exposure and ecological effect) and risk characterization. Alternatively, if the Navy used some other credible framework as a model for organizing their assessment, that model should be cited early in the document. This general issue is revisited in specific comments -below.	Thank you for your helpful comments. The final report will be revised to more clearly communicate the assessment design, analyses, findings, and interpretation. The final report will be restructured to more closely follow the US EPA risk assessment framework as recommended.
2	The informational content of any given section of the document is internally diverse and often inconsistent with subsection headings. As one illustration of this, Section 4.2.1.1, which should describe primary producers and their attributes as assessment endpoints (the title of Section 4.2 being "Assessment Endpoints and Receptor Species"), devotes nearly half of its (brief) text to a description of how risk to this group of species was evaluated (in a fashion redundant with Section 5). Yet, by title anyway, Section 5 of the document purports to describe the "ecological risk methodology." To enhance the transparency of the assessment, a more linear approach should be adopted to communicate salient information, with cross references supplied to other sections as needed (or desired). For the example described, this would translate into removing material from Section 4.2.1.1 that does not directly describe primary producer entities and their attributes as assessment endpoints, receptor species chosen as surrogates for the assessment endpoint, and the rationale for these choices.	The final report will be revised to incorporate the suggested changes.

3	The unexpectedly low editorial quality of the document does a disservice to the assessment. The document would benefit from a thorough editorial review for grammar, syntax and clarity, and to reduce redundancy.	Editorial and grammatical errors will be corrected throughout the report.
	SPECIFIC COMMENTS	
1	List of Equations, pp. xv-xvi: Without indication of what each equation describes, this list has little value. EPA recommends identifying each equation by name (e.g., “calculation of Total PCB”), or striking the listing. List of Equations, pp. xv-xvi: Without indication of what each equation describes, this list has little value. EPA recommends identifying each equation by name (e.g., “calculation of Total PCB”), or striking the listing.	The list of equations will be deleted.
2	Glossary of Terms, pp. xvii-xxv: A Glossary is potentially valuable to ensuring understanding of the meaning and usage by the Navy of technical terms, acronyms, and so on. However, several of the definitions provided are nonstandard, incomplete, or by their construction, misleading or incorrect. For example, “algae” is defined as “microscopic plants...[that] live floating or suspended in water...” (emphasis added), thereby excluding macroscopic forms of algae, such as kelp and Ulva, as well as encrusting forms. As another example, “assessment endpoint” is given a meaning that differs from its generally accepted, more formal definition of “an explicit expression of the environmental value that is to be protected, operationally defined by an ecological entity and its attributes” (US EPA 1998), Suter’s original definition notwithstanding. [As an aside, imprecise use of the term “assessment endpoint” in the earlier document A Screening Level Ecological risk Assessment for Using Former Navy Vessels to Construct Artificial Reefs, Final Report (dated July 17, 2003), confounded interpretation of screening-level assessment activities and findings, as noted in the review of that document.] Continuing, the definitions provided for “bioaccumulation,” “bioconcentration” and “biomagnification” imply that these terms are in some regards interchangeable, when in fact, standard usage differentiates among them (bioaccummulation is the net accumulation of a chemical via all routes of exposure, bioconcentration is net accumulation directly from water, and biomagnification is a phenomenon in which certain chemicals accumulate at higher concentrations in higher levels of a food chain through dietary routes). Some entries, such as “SWMU” (solid waste management unit) are not even used in the body of the document (although they suggest the origins of the glossary), and other seemly important terms, like TRV (toxicity reference value) are missing. Other examples abound. The concern here is more than pedantic. Improper or loose definition of standard terms in a Glossary can mislead the reader about assessment approaches, analyses and findings. Further, improper use of these terms	The glossary of terms will be updated and corrected.

	within the body of the report itself can confound the Navy's own understanding and interpretation of what they've done. EPA recommends that the Navy review the Glossary, and use here and throughout the document definitions that are more generally accepted by the scientific community. In doing so, they should rely upon such documents as US EPA (1998), and standard aquatic toxicology and ecological risk assessment texts. If their (unstated) objective is to facilitate understanding by a lay audience, formal definitions can be augmented with their plain-English interpretations. However, this document is a technical one by its very nature; EPA does not support efforts to render it less technical that result in imprecise communication of its objectives, analyses and findings.	
3	Section 3, pp. 3-1–3-9: Following General Comment 1, all of the material in this section should be considered part of problem formulation.	The revised final report will be reorganized as suggested.
4	Section 3.2, p. 3-3: The Background section of this document cites a report by Hynes et al. (2004). That report is a Documented Briefing that was prepared by the RAND Corporation for the Navy. That RAND document contains important background information on the precedent setting nature of the pending EPA decision that should be reflected in a revision to the Navy's Draft Final ERA.	As is documented in the Minutes of the SAB Polychlorinated Biphenyl - Artificial Reef Risk Assessment (PCB-ARRA) Consultative Panel Meeting, August 1-2, 2005, it is anticipated that only 12 ex-Navy warships are being considered for use in creating artificial reefs: "This assessment is precedent setting and will be important to future decisions regarding 12 other ships that have been identified for possible deployment as artificial reefs." http://www.epa.gov/sab/05minutes/pcb_artificial_reef_08_01_05_minutes.pdf This information will be provided in the revised final report. The implications of the potential cumulative impact of these ships will be addressed as part of the national permitting process.
5	Section 3.3.1, pp. 3-4–3-6: This subsection excerpts text from the State of Florida's application for the ex-Oriskany, describing among other things the results of model-based stability analyses for the ex-Oriskany under different scenarios of sinking site depth and storm intensity. The conclusion drawn in this excerpt, and by implication in the risk assessment, is that the ship would remain reasonably "stable" (by some unstated definition) during 50 and 100-year storm events with certain assumptions made regarding orientation, etc. Given the recent events of the Spiegel Grove and Hurricane Dennis, in which the ship was righted, EPA concludes that further analysis is warranted of the ramifications of storm-induced catastrophic disturbance of the ship and its environs. Would local resuspension of sediments expose biota to higher levels of PCBs than currently modeled by the exposure models? Would storm-induced weakening or deterioration of the hull or island affect rates of PCB release from interior compartments? Because hurricanes are a regular feature of coastal Florida, risk scenarios involving major storm events should be considered more rigorously in the overall assessment.	Further qualitative discussion of extreme events and their impact on the risk assessment will be included in the uncertainty section of the revised final report. This will include an evaluation of the frequency of catastrophic (category 4 or 5) hurricane strikes in the Pensacola area (there is about 0.5% chance per-year of catastrophic hurricane strikes during "hyperactive" interglacial periods, Liu and Fearn 2000), data on hurricane paths over the last thirty years (NOAA 2005), the expected current velocities for such events (Ohlmann and Niiler 2001), and expected impact on exposure to PCBs. The passage of a hurricane could potentially damage the reef, alter rates of release of PCBs from the ship's interior, and increase releases of PCBs from the vessel. However, in general a hurricane would also have the net effect of diluting PCB concentrations by dissipating PCBs away from the immediate site. A hurricane or tropical storm will greatly increase the current velocity in the vicinity of the reef. Increasing bottom currents (see Figure 58 of OERA) resulted in a large decrease of the steady-state PCB concentrations in the pelagic and benthic communities but little change in the PCB concentrations in the upper trophic levels of the reef community.

		It is unlikely that extreme storm events will cause significant structural damage to the hull in the next 100 – 200 years. Studies of other sunken vessels by the US Parks Service, including the ex-MASSACHUCETTS sunk in Pensacola Pass in 1921 in 30 ft of water – much shallower than the ex-ORISKANY's proposed depth and therefore more exposed to wave action – has shown relatively little structural damage from extreme events. "Even though the [ex-MASSACHUCETTS'] hull was stripped for scrap metal during the 1940s, the wreck is in relatively good condition for being submerged for 80 years and has reached a state of equilibrium with the environment. In fact, the Massachusetts was completely undamaged by the violent hurricanes of the summer of 1995." (U.S. Park Service 2005) http://www.cr.nps.gov/nr/travel/flshipwrecks/mas.htm The movement of the Spiegel Grove was unique. Because of a mishap during her sinking, the Spiegel Grove turned-over as she went down, landing on her side. This caused down-current sediment to be eroded away, until, during Hurricane Dennis, she "righted" herself. Very little, if any, damage to the hull's structure occurred. (Jon Dodrill, FFWC, personal communication) Additional evaluations of extreme event scenarios is under consideration for development of the national permit Additional references: Liu K. and Fearn M.L. 2000. Reconstruction of Prehistoric Landfall Frequencies of Catastrophic Hurricanes in Northwestern Florida from Lake Sediment Records. Quaternary Research, Volume 54, Number 2, September 2000, pp. 238-245(8). Ohlmann, J.C. and Niiler P.P., 2001. A two-dimensional response to a tropical storm on the Gulf of Mexico shelf. Journal of Marine Systems, Volume 29, Number 1, May 2001, pp. 87-99(13). NOAA 2005. National Hurricane Center Forecast Verification. http://www.nhc.noaa.gov/verification/verify7.shtml. U.S. Park Service 2005. Florida's Shipwrecks: 500 Years of History. National Park Service, National Register of Historic Places, Archeology Program. http://www.cr.nps.gov/nr/travel/flshipwrecks/index.htm
6	Section 3.3.3, p. 3-8: In the third paragraph, the first line should read "... evaluated to assess..."	Text will be corrected.
7	Section 3.3.3, p. 3-8, and elsewhere: The multiple ways that aggregate PCB concentrations into a single variable, in combination with the multiple ways that variables describing total PCB concentration are referenced (e.g., "tPCB" in the Glossary; "Total PCB," "total PCB," "sumPCB" and "tPCB" on p. 3-8; "TotalPCB" on p. 5-8 and in the captions to Figures 14 and 23; "Total	The revised report will be corrected to correctly identify the variables and standardize their use in the report. Total PCB will be used throughout (instead of TotalPCB, total PCB, or tPCB)

	PCBs" in Table 5), potentially make for confusion and uncertainty about what is being referenced. Some of these variables apparently mean the same thing (like "tPCB" and "Total PCB"), whereas some variables are different (like "Total PCB" and "sumPCB"). And, the same term can be given different meanings (compare "tPCB" as defined in the Glossary with how it is used in Table 14). To correct this, EPA recommends standardization of variable names throughout the document, and inclusion of an expanded explanation of those terms somewhere in the text (perhaps in a revised problem formulation section).	
8	Section 4, pp. 4-1–5-5 [sic]: Logically, a description of assessment endpoints selected for the assessment should appear before presentation of exposure pathways and the conceptual model, as they both are the focus of the assessment and help to define it. Else, the discussion of exposure pathways is without context.	The report will be revised to incorporate the suggestion
9	Section 4.1, p. 4-1: The Navy should provide a more in-depth written description of the conceptual model. For example, what are the relevant exposure pathways for each of the assessment endpoints? What are the likely direct and indirect effects hypothesized to result from these exposures? What factors likely influence the manifestation of those effects? Answers to these and similar questions are critical to understanding risk hypotheses (which, by the way, are not articulated), and to ensuring that the conceptual model is a reasonable representation of the risk problem.	A more in depth discussion of the conceptual model will be provided. The risk-hypothesis will be explicitly stated: "Will PCBs that are expected to leach from the ex-ORISKANY cause adverse toxicological effects to ecological receptors that could reside, feed, and/or forage at the artificial reef through water-borne and food chain exposure pathways?"
10	Section 4.1: No defense is offered for assigning minor importance in the conceptual model to the direct exposure route. The Navy should reconcile its decision to use this approach with what EPA would expect actual physical conditions to be where the vessel is to be placed, including addressing the reasonableness of PCB fate and transport assumptions.	A more detailed description of the conceptual model will be provided in the revised final report including discussion of why direct contact is considered to be a minor pathway, a discussion of the physical habitat provided by the ship, and the importance and uncertainty about exposure to the internal vessel water. Data and information from Weaver et al. 2002, will be very helpful in this respect. http://cars.er.usgs.gov/coastaleco/Tech-Rept-Pinnacles-2002/title_page/title_page.html With respect to the direct exposure pathway the report will be revised as follows: Another potential pathway is direct contact by marine organisms to the PCB-bearing materials onboard the ship. Encrusting organisms or other epibenthic organisms could come into direct contact with PCBs held within the solid matrices of the materials. Direct exposure was assumed to be a

		relatively minor exposure pathway compared to aqueous-phase releases of PCBs and no attempt was made to model bioaccumulation from direct exposure in PRAM. On the ex-ORISKANY the vast majority of PCB-containing materials will be in electrical cable (97.6% of the PCBs by mass, see Table 4). The PCBs are contained within the insulation of the cable, which is found inside the outer braided-metal shielding. The electrical cable and other PCB-containing materials – bulkhead insulation (0.94%), black rubber (0.06%), and ventilation gaskets (0.01%) – would most likely be located within the interior of ship where they would not be easily colonized by epibenthic organisms that need a constant source of food from the outside of the vessel. Additionally, most all exposed surfaces on the ship were painted many times during the life of vessel, further isolating the solid matrices containing PCBs from direct contact with encrusting organisms. Yet, there is a small portion of the PCBs that are associated with aluminized paint (1.4%) that could be on the exterior of the ship and there is uncertainty about whether the PCB-bearing materials were manufactured with PCBs or if their surfaces became contaminated with PCBs during the life of the ship or both. A further consideration is that the formation of concretions by encrusting organisms (barnacles, tubeworms, tunicates, bryzoans, sponges, and other fouling organisms) would serve to further isolate the PCB-bearing materials and inhibit the release. The dramatic decrease in the release of toxic substances from antifouling paint on ship hulls within days of cleaning due to the build-up of biofilms and recolonization by fouling organisms (Schiff et al. 2003) is an example of this process. Studies on the release of contaminants from artificial reefs made of scrap tires showed that the release rate of contaminants decreased over time probably because of the depletion of contaminants from the surface of the tires (Collins et al. 1995) and the build-up colonizing organisms (Collins 1999, Collins et al. 2002). While the build-up of encrusting organisms on surfaces may impede the release of PCBs, fish and other invertebrates can prey on encrusting organisms and extreme events, such as hurricanes, could also cause fouling organisms to be broken off exposing new surfaces to aqueous-phase leaching. It is also unlikely that marine organisms would actually “eat” the materials containing PCBs. Most of the materials are covered with metal or plastic shielding (electrical cables), bolted between flanges (rubber gaskets), and enclosed by paneling or painted surfaces (bulkhead insulation) which means that the main route of release would be from the surfaces being wetted and dissolution of PCBs into the aqueous phase. Although some organisms could incidentally consume the solid material (e.g. a snail grazing on a contaminated surface, or a crab feeding on fouling organisms), it was assumed that this pathway

		was very minor in comparison to aqueous releases. For the purposes of this risk assessment it was assumed that the predominant route of exposure from any PCBs contained in solid materials on the ship was from aqueous-phase leaching that could occur during or after the process of sinking. Collins, K. J., Jensen, A. C., and Albert, S. 1995. A review of waste tyre utilisation in the marine environment. Chemistry and Ecology, 10: 205–216. Collins, Ken 1999. Environmental impact assessment of a scrap tyre artificial reef. University of Southampton, UK. 7th International Conference on Artificial Reefs and Related Aquatic Habitats (7th CARAH) October 7-15, 1999, Sanremo, Italy Collins, K. J., Jensen, A. C., Mallinson, J. J., Roenelle, V., and Smith, I. P. 2002. Environmental impact assessment of a scrap tyre artificial reef. – ICES Journal of Marine Science, 59: S243–S249. Schiff Kenneth, Dario Diehl, Aldis Valkirs 2003. Copper Emissions From Antifouling Paint on Recreational Vessels. Technical Report #405, June 22, 2003. Southern California Coastal Water Research Project. Westminster, CA. www.sccwrp.org
11	Section 4.1: The conceptual model does not consider that sediments around the vessel may be continually resuspended and transported out of the conceptual ZOI. The Navy should consider the implications of such processes to exposure of biota to PCBs.	The following will be added to the description of the conceptual model: Resuspension and transport of suspended sediments is not included in PRAM or TDM. This is assumed to be conservative because including suspended sediments would increase the net transport of PCBs out of the system and reduce the exposure point concentrations.
12	Section 4.2, p. 4-2: Broadly speaking, the assessment endpoints are reasonable and receptor species appear to be representative of communities likely to be present near and use the reef. EPA recommends that the Navy expand the discussion of the selection of receptor species (Section 4.2) with appropriate descriptions of their representativeness, susceptibility to exposure and availability of relevant effects data.	Additional descriptions of the appropriateness of the receptor species will be provided
13.	Section 4.2, p. 4-2: The 2nd paragraph of this section states that “The assessment endpoints were developed to assess the potential effects to survival, growth, and reproduction to the communities and organisms model by PRAM...”. The implication of this statement is that the transport, fate and exposure modeling drove, rather than supported, the risk assessment. This is not a fair representation of the planning and decisions of the Technical	The paragraph will be revised to read: “The PRAM and TDM models were specifically developed to model PCB releases from the ship and accumulation of PCBs in abiotic media and the food chains of the pelagic, benthic, and reef communities (Table 2, Figure 10). Output data from the PRAM and TDM were used as exposure point concentrations to assess the potential effects on survival, growth, and reproduction of the receptors (Table

	Work Group. Further, but less critical, survival, growth and reproduction as used in this assessment are attributes of organisms, not communities. This misstatement appears to be a result of imprecise definition (or understanding) by the Navy of "assessment endpoint."	3)." Note that Table 3 will also be updated with the correct terminology.
14	Section 4.2, p. 4-2 (and elsewhere): Continuing on in that same paragraph, the text reads: "The assessment endpoints modeled by PRAM (Table 2) were concentrations of PCB homologs in water, sediment, primary consumers...". It is conventional and standard to refer to stressor concentrations in environmental media as "measures of exposure" or "exposure concentrations," but not as "assessment endpoints." This again reflects imprecise definition or the lack of understanding by the Navy of this critical concept. As a result, communication of assessment approach and findings is confounded. [This general problem occurs in several places in the document, and will not be noted hereafter.]	The report will be revised to assure that measures of exposure (PRAM output) and assessment endpoints are used correctly in the document.
15	Section 4.2, p. 4-2: The second-to-last sentence of the 2nd paragraph of this section refers to "the ecological risk screening." What screening is this? Is the Navy suggesting that this risk assessment is at a screening level? If so, this intention should be identified early in the document, and recommendations should be offered concerning the need to conduct higher-tier assessments or follow-up analyses.	Sentence will be revised to read: "Considerations for selection of receptor species for the ecological risk assessment included the availability of data and toxicological information." See also attachment 1 for discussion of revised evaluation criteria that will be used in the final report.
16	Section 4.2, pp. 4-2–4-3: The Navy is to be commended for articulating some of the boundaries of the assessment in the 3rd paragraph of this section.	Thank-you, comment noted.
17	Section 4.2.1, p. 4-3: The description of the reef community is weak and overly simplistic given that reef communities on hard bottoms and artificial reefs off the Florida Panhandle are well documented. EPA recommends that this description be expanded to include additional definition of biological community expected to occur at the site, together with descriptions of representative receptor species that will be used to evaluate risk (see Specific Comment 12).	Recent literature was reviewed to strengthen the discussion of the reef community. Specific information was obtained from studies of reefs and hard bottom areas in the northern Gulf of Mexico. This information will be included in the revised final report. See also response to specific comment 11.
18	Section 4.2.1, p. 4-4: It is not clear why some predatory animals (snappers and sea basses) are listed as "secondary consumers" and others "tertiary consumers." A more transparent definition is needed. If these groupings of animals are classified as such in the scientific literature, references should be provided.	This will be made clearer in the final report. By definition tertiary consumers feed primarily on secondary consumers and secondary consumers feed primarily on primary consumers. Representative species were used to model these trophic levels in PRAM. The tropic structure in PRAM is similar to the trophic structure identified for "Community Structure and Trophic Ecology of Fishes on the Pinnacles Reef Tract" Weaver et al. 2002, http://cars.er.usgs.gov/coastaleco/Tech-Rept-Pinnacles-2002/title_page/title_page.html

19	Sections 4 and 5: There are many statements made in Sections 4 and 5 of this document that give the distinct impression that a very conservative and protective approach was taken by the Navy with regard to their assessment of the potential ecological effects of sinking of the ex-Oriskany. Such statements are at odds with the criteria used to evaluate hazard quotients and overall risk (Section 5.4). EPA recommends that the Navy adjust its assumptions and statements to address this discrepancy to achieve a more consistent level of conservatism (see related Specific Comments 27 & 35-37).	Please see attachment 1 for discussion of revised evaluation criteria that will be used in the final report.
20	Section 5, p. 5-5 [sic]: Pagination needs to be amended, as the section currently begins on p. 5-5	Pagination will be corrected in the final report.
21	Section 5, pp. 5-5 [sic]–5-19: With reference to General Comment 1, this section is a combination of problem formulation and analysis (primarily of ecological effects). What is striking is the lack of description of exposure assessment methods (here or elsewhere in the document). With its current structure, this is the point of the document where a description of the use of PRAM, the TDM, and other exposure assessments should be given. This description should contain overviews of the modeling approaches and assumptions (heavily referencing the primary documentation of these models), and conditions of their use (e.g., mass loading and ZOI configurations). Depending upon the ultimate structure of the document, it would also present the results of exposure assessment activities.	As per response to General Comment 1, the text will be revised to be consistent with EPA guidance on ecological risk assessments. A section on Exposure Assessment will be added to the final report.
22	Section 5.2, pp. 5-5–5-17: By not referring back to the conceptual model in this section, the Navy has missed an opportunity to clarify aspects of its logic and assessment methodology. EPA recommends that each description of benchmarks identify clearly the salient exposure pathway(s) and assessment endpoint(s) for which the benchmark is intended to evaluate risk.	This recommendation will be implemented in the final report.
23	Section 5.2.1, p. 5-6: The last sentence of the 2nd paragraph of this section references to GL WLC criteria of 0.074 and 0.14 ug/L. Please state explicitly to what these values refer (e.g., chronic and acute criteria).	The Great Lakes Wildlife criterion recommends a chronic value of 0.074 ug/gL for the Tier 1 Criteria. The value of 0.14 ug/gL is not used (apparently this value was a typo in a document obtained from the internet, as 0.014 ug/L isthe freshwater chronic value). See http://frwebgate2.access.gpo.gov/cgi-bin/waisgate.cgi?WAISdocID=884826139633+1+0+0&WAISaction=retrieve for correct value. This error will be corrected in the final report.
24	Section 5.2.1, p. 5-6, 3rd paragraph: Why is this paragraph included? It appears to describe criteria for protection of human health. If the information	Paragraph is included to compare the ecological risk benchmarks to state standards. The paragraph will be revised to make clear that the state

	has bearing on the approach taken in the ecological risk assessment, the rationale and description of its use should be provided. Else, the paragraph should be deleted.	standards are based on human health and not applicable to the ecological risk assessment.
25	Section 5.2.1, p. 5-6: In EPA's Office of Pollution Prevention and Toxics (OPPT), a geometric mean of the LOED and NOED is used to calculate a chronic value. Our rationale for the use of the geometric mean is that both the NOED and LOED are derived from hypothesis testing. It is reasonable to assume that the true no effect concentration could be higher than the NOED, and the true lowest effect concentration could be lower than the statistically derived LOED. Thus, the geometric mean may be more representative of the maximum acceptable toxicant concentration. EPA recommends that calculate and use geometric means wherever possible to be consistent with OPPT practices.	This approach would only be valid if the LOED and NOED were calculated for the same organism from the same experiment. Since the literature values used to obtain the NOED and LOED were from different studies using different species, calculating the geometric mean between the NOED and LOED would not be defensible.
26	Section 5.2.3.1, p. 5-8, 1st paragraph: For clarity, EPA recommends replacing “differences in tissue concentrations that would cause adverse effects” with something like “to inherent differences in the sensitivities of freshwater and marine biota to toxic chemicals.”	The sentence will be revised to read: “This assumes that the differences between freshwater and saltwater criteria are due to differences in chemical uptake between freshwater and marine organisms rather than differences in tissue concentrations that would cause adverse effects.”
27	Section 5.2.3.1, p. 5-8, Footnote 7: Selecting a higher lipid content than the weighted average of 3% for “freshwater and marine organisms that are commonly consumed in the US” would have been more consistent with the intended conservative nature of the assessment. EPA recommends that the Navy provide a description of the effects of this assumption on resulting TSVs and the hazard quotients that use them. This description might include a comparison to the values resulting from a lipid concentration of 7.6%, as measured in fathead minnows.	The report documents what was used during the development of water quality criteria for PCBs. (U.S. EPA 1980, URS 1996). Using a value of 7.6% would increase the benchmark by a factor of about 2.5, and would be less conservative (e.g. increasing the lipid content increases the BCF which means that lower water concentrations would result in higher the tissue concentrations and the tissue residue benchmark resulting from exposure at WQC levels would be higher).
28	Section 5.2.3.2, p. 5-9: Is “tPCB” the same variable as “Total PCB” defined on p. 3-8? (See Specific Comment 7)	Total PCB will be used throughout the report.
29	Section 5.2.3.3, p. 5-9, Footnote 8: In explaining nomenclature, the Navy emphasizes selection of concentrations from the ERED database associated with no and lowest “observed adverse effect” (emphasis added). How was “adverse” defined? Also, the footnote is unclear whether the Navy is using NOED interchangeably with NOAED. While the term “adverse” is underlined, it does not appear in the acronym.	The following text will be added to the footnote: “where adverse was defined as a negative impact to growth, development, reproduction, or survival.” NOED and LOED were used to be consistent with the terminology used in the ERED database. The footnote indicates that the benchmarks selected were related to adverse effects.
30	Section 5.2.3.4, p. 5-10: Are NOEDs and NOAELs being used interchangeably?	That the NOED (and LOED) refer to tissue dose (or residue) while NOAEL (LOAEL) refer to concentration in prey (food) will be made clear in final report.

31	Section 5.2.3.4, p. 5-10: The Navy should use “PCBs” instead of “bioaccumulative contaminants”, since the assessment does not address other contaminants.	Sentence will be revised to read: “The potential for PCBs to affect higher trophic levels was evaluated by assessing contaminant concentrations in tissues of representative prey.”
32	Section 5.2.3.4, p. 5-10, 2nd paragraph: Is “TRV” the same as “TSV” from Section 5.2.3.1? If not, please provide a specific formal definition here and in the Glossary.	Toxicity Reference Value (TRV) is not the same as the Tissue Screening Value (TSV). The definition in the text (and glossary) will be revised to read “Toxicity Reference Values (TRVs), or point estimates of chemical concentrations causing ecological effects for a given receptor were used to determine potential adverse exposure to predators.”
33	Section 5.2.3.4, p. 5-10–5-15: The meaning of portions of this section is not clear. The jumbling of references to and descriptions of multiple receptor species, sources of toxicity information and thresholds, and extrapolation issues (as epitomized the 2nd paragraph) is difficult to parse and confusing at best. Specific questions include:	Section will be revised as suggested. Specific questions are answered below:
	a. When a NOEAL or NOED is used to calculate a TRV, shouldn’t the TRV represent the “concentration at or below which significant effects” (emphasized wording added) are not anticipated?	a. suggested revisions will be made
	b. When a LOEAL or LOED is used to calculate a TRV, shouldn’t the TRV represent “the lowest chemical concentration at which” effects could be expected (emphasized wording added)?	b. suggested revision will be made
	c. Why isn’t 4th paragraph in Section 4.2 instead of here?	c. suggested revision will be made
	d. If food chain benchmarks are the contaminant concentrations in the diet of receptor species that are expected either to be protective of adverse effects on the receptor, or the lowest concentrations at which effects could be expected, then how can “TRVs for...herring gull...and...double-crested cormorant...[be] used to develop benchmarks for dietary exposure from the consumption of prey tissues” (p. 5-11)? Aren’t those TRVs the benchmarks themselves? Or should that sentence end with something like “of avian consumers”?	d. Text will be revised to read: “The benchmarks for PCB exposure to omnivorous herring gulls (*Larus argentatus*) and piscivorous double-crested cormorant (*Phalacrocorax auritus*) were developed based on toxicological studies on ring-necked pheasants (*Phasianus colchicus*, Table 12, 13, Sample et al. 1996).”
	e. If TRVs are available for gull and cormorant, as implied in the sentence referenced immediately above, why are data from studies involving mallard duck being used to develop dietary benchmarks?	e. reference to mallard will be deleted
	f. If TRVs are available for gull and cormorant, as implied in the sentence referenced above, why would “the TRV...[for these species be] based on toxicological studies on ring-necked pheasants” (p. 5-11)?	f. see d above
	g. Which studies were used – mallard duck, ringed-necked pheasant, or both?	g. see d above
	h. Why isn’t the 7th paragraph in Section 4.2 instead of here?	h. suggested revision will be made
	i. If “scaling” means using an empirical relationship to translate	i. The report will be revised to clarify that the dose must be scaled to the

	effective dose from a test species to a receptor species based on the ratio of their body weights (p. 5-11), what is the logic for again scaling the TRV by a body weight-dependent dietary uptake factor when calculating a dietary consumption benchmark D (Eqs. 11-14)? j. If “scaling” is inappropriate for birds (p. 5-12), what is the logic for scaling the TRV by a body weight-dependent dietary uptake factor when calculating a dietary consumption benchmark D (Eqs. 11-14)? k. Why isn’t the paragraph beginning at the bottom of p. 5-12 in Section 4.2 instead of here? l. If loggerheads feed five time per week, consuming about 3% of their 113kg body weight per feeding, why wouldn’t the estimated daily intake rate be 2,421 g/day [= 113,000 g BW x 0.3%/feeding x 5 feedings/wk)/(7 d/wk)] instead of 1,450 g/day (p. 5-13)? How does this affect the estimate of risk to loggerheads? m. If “scaling” is inappropriate for birds (p. 5-12), how can the benchmark for loggerheads (not sea turtles in general, by the way) be “obtained by using the same scaling factors used for...avians [sic]” (p. 5-13)? n. Is “avians” a noun? o. Why isn’t the 1st full paragraph on p. 5-13 in Section 4.2 instead of here? p. What is the formal definition of “FCM” (p. 5-13)? q. What does the “w” before “FCMTotalPCB” in Eqs. 15-17 signify? r. Is the benchmark tissue concentration for shark calculated by setting the shark’s concentration to the tissue residue NOED and LOED of prey, and adjusting by FCM (Eqs. 16-17)? If so, to what was DShark compared to evaluate risk? s. Are shark/barracuda NOED and LOED available in the literature, as implied by the last paragraph of this section, or were the values that are reported calculated from Eqs. 16-17? If the latter, wouldn’t it be more appropriate to call these DShark, NOED and DShark, LOED? EPA recommends restructuring this section to begin with an overview of the various benchmarks and conceptual description of how they were used (related back to the conceptual model), followed by subsections for each of the assessment endpoints with descriptions of the data, calculations and nuances for each receptor species. If the document is reorganized along the lines recommended in General Comment 1, the actual benchmark values calculated would also be presented with this material.	exposure concentration that would cause an effect and the daily dietary intake of the receptor. j. The report will be revised to make clear that it is necessary to account for difference in daily dietary intake between test species (pheasant) and receptor species (cormorant, gull) k. suggested revision will be made l. 2421 g/day is the correct consumption rate. This is the value used in Table 15 to calculate the benchmark. The text will be corrected. m. The report will be revised to make clear that the benchmark was obtained by using the same scaling factor used for mammals (Equation [9]) and substituting the body weight and ingestion rate of loggerhead turtles into Equation [13]. n. “s” deleted o. suggested revision will be made p. Food-chain multiplier (FCM). The ratio of BAF to an appropriate BCF. The formal definition will be added to text and glossary. q. Report will be revised to make clear that w signifies “weighted” r. The report will be revised to make clear that the dietary benchmark for shark was obtained by dividing the NOED (or LOED) by the weighted FCM for Total PCB (weighted by the relative homolog concentration). The benchmark is compared to the concentration of PCB in the shark’s prey (Tertiary Consumer). s. $D_{Shark,NOED}$ and $D_{Shark,LOED}$ will be used This section of the report will be restructured as suggested.
34	Section 5.2.4, pp. 5-15–5-17: The Navy is to be commended for its proactive evaluation of risk associated with dioxin-like PCBs.	Thank-you comment noted.

35	Section 5.4, p. 5-18: The table at the bottom of this page is intended to communicate guidance for interpreting hazard quotients and concluding levels of risk. These interpretations are not consistent with existing OPPT practices, in which a quotient of 1 is sufficient to conclude a risk. The evaluation criteria in section 5.4 also seem to be inconsistent with the preceding paragraph where it is clearly stated that "When a hazard quotient of 1 the chemical is above potentially harmful exposure levels and the HQ represents the factor above harmful exposure." The use of the term "moderate" in the criteria 1.0 ≤HQ < 5 is not consistent with the aforementioned interpretation of risk. Further, many of the possible HQ outcomes seem to be mislabeled (e.g., the second entry should read "0.1 # HQ < 0.5," and so on). This table injects a great deal of subjectivity that detracts for the quantitative nature of the assessment. EPA recommends that such guidance not be offered and utilized, as it carries policy implications that have not been vetted through the Technical Working Group.	The evaluation criteria will be revised to be more consistent with OPPT practices. The evaluation of potential ecological effects using the HQ approach will be revised in the final document. Briefly, the most conservative benchmarks (eg. chronic water quality criteria, and no effect levels etc.) will be used as an initial screen, followed by comparison to less conservative benchmarks (acute water quality criteria, lowest effect levels, etc) and available toxicity data if the initial screen is exceeded. Please see Attachment 1.
36	OPPT applies uncertainty factors to take into account uncertainties due to species sensitivity, extrapolations from acute to chronic effects, and extrapolating from laboratory to field conditions. The use of uncertainty factors would not apply to the water quality criteria but there are sections where uncertainty factors are identified (e.g., page 5-12) and it is not clear what values are being used. It is also not apparent whether uncertainty factors were used in other extrapolations. EPA recommends that the Navy clarify its decisions regarding the use of uncertainty factors, and describe the impacts of those decisions on the levels of risk concluded.	The report will be revised to use "assessment factors" where appropriate. The benchmarks for critical body residues and dietary exposure to dolphins, birds, turtles, and sharks will be divided by an assessment factor of 10 to account for species-to-species differences in the effects levels. The application of uncertainty factors and assessment factors will be clearly documented in the final report.
37	Section 5.4, p. 5-19: The table at the top of this page is intended to communicate guidance for interpreting exposures relative to benchmark concentrations to determine "overall risk" to each assessment endpoint evaluated. Unfortunately, it injects a great deal of subjectivity that detracts for the quantitative nature of the assessment. EPA recommends that such guidance not be offered and utilized, as it carries policy implications that have not been vetted through the Technical Working Group.	The subjective evaluation will be revised, please see Attachment 1 for revised evaluation criteria.
38	Section 6.1, pp. 6-1–6-8: The inclusion of details concerning PRAM model evaluation in this document is curious for at least three reasons. First, the majority of this material seems more appropriate for the documentation supporting PRAM itself, as the model is the exposure underpinning for both ecological and human health risks assessments. Rather than presenting, for example, the results of model runs at ZOIs varying from 1-5 and 10 (p. 6-1), the ecological risk assessment should focus on reporting the exposures predicted for the ZOIs proposed by the Navy and viewed by the TWG as	This section will be moved to an appendix of the ecological risk and the PRAM documents.

	reasonably conservative and appropriate (see p. 3-10 of Prospective Risk Assessment Model (PRAM) Version 1.4c Documentation, May 2005 (Draft Final)), and simply summarize or refer to the ZOI sensitivity analyses presented in the PRAM documentation (Section 2.2.3 of that report). Second, the details of evaluation results are not balanced by similarly involved descriptions of the model earlier in the document, and therefore much of the material in Section 6.1 is without context. This imbalance creates other difficulties as well. For example, references to "PRAM 1.4" and "PRAM 1.4c" (both p. 6-1) are meaningless without description of model versions. And third, similar evaluations are not reported for the other exposure modeling component of the assessment – the TDM. That said, the evaluations presented here offer some valuable insights to PRAM performance that can augment documentation of the model (but see Specific Comments 47 - 50 below). EPA recommends removing these analyses from the ecological risk assessment and adding them to the documentation of PRAM.	
39	Section 6.1.2, p. 6-3: The definition for bioaccumulation factor (BAF) given here differs from that provided in the Glossary. In general usage, the BAF is defined as the ratio of a chemical in tissue to its concentration in water when both the organism and its food are exposed (cf, US EPA 1997. Federal Register 62(48)). As noted in the document, Eq. 29 describes a lipid-based (and organic carbon adjusted, thus the freely-dissolved concentration for water) BAF – it probably should be indexed as such (e.g., BAFLipid) to avoid confusion and to help distinguish it from a BCF. But, the final sentence of the first paragraph of this section ("Therefore, changing the ZOI should not appreciably [affect] the BAFs predicted by the model.") does not follow from the reasoning presented. The reason why BAFs are not expected to change with increasing ZOI is 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 definition of BAF will be corrected in text and glossary as "the ratio (in L/kg) of a substance's concentration in tissue of an aquatic organism to its concentration in the ambient water" (U.S. EPA 1995). The $\text{BAF}_{\text{Lipid}}$ will be used to denote the lipid-based bioaccumulation factor: Lipid-normalized BAF which is the ratio of a chemical in the lipid of an organism to its freely dissolved concentration in the water. Text will be revised to read: "Therefore, changing the ZOI should not appreciably affect the $\text{BAF}_{\text{Llipid}}$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."
40	Section 6.1.3, pp. 6-3–6-4: The stated purpose of this evaluation of PRAM is to determine whether it can mimic reported observations of: 1) the pattern of PCB bioaccumulation as a function of Kow of homologs, 2) the degree of biomagnification between trophic levels, and 3) the relative [to what?] magnitude of accumulation. The section concludes that "PRAM is providing reasonable estimates for this aspect of the model" (p. 6-4). Inspection of Figures 20-23 suggests that PRAM can replicate general patterns of PCB accumulation as a function of Kow, but not that it performs reasonably with regard to the other two aspects, particularly for pelagic food chains. Figure 20 indicates a systematic under-prediction of tissue concentrations for top predators in both pelagic and benthic food chains. [By the way, how can the	In section 6.1.3 the PRAM output for homologs and Total PCB (sum of homologs) are being compared to a statistical regression model for individual congeners and Total PCB reported by Jackson et al. 2001 for coho and Chinook salmon from the great lakes. The purpose of the comparison was to show that PRAM can model the pattern of PCBs bioaccumulated as a function of Kow, the degree of biomagnification between trophic levels, and the magnitude of the accumulation relative to the concentration in the prey. Note that figures 20 and 22 show that accumulation for individual congeners from Jackson (et al. 2001) and homologs from PRAM while figures 21 and 23 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

	Predator (IV) concentration predicted for the benthic food web be higher than that observed for coho salmon (Figure 21) when all (reported) predictions for homologs are lower?] Even when corrected for intercept, modeled Piscivore (IV) tissue concentrations are up to an order of magnitude lower than observed at Kows below roughly 6.5. What does this portend for predictions of tissue concentrations for biota associated with the ex-Oriskany, and the corresponding risks?	homologs) from PRAM, and different regressions were used for each (that is why the Predator (IV) concentration is higher than coho). Figure 22 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. 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 (Fig 30) 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. This information will be added to the model evaluation appendix.
41	Section 6.1.5, pp. 6-6–6-7: Similarly, PRAM systematically underestimated lipid-based BAFs in comparison to the data set reported by Burkhard et al. (2003) (Figure 26), although the general patterns across Kow agree reasonably well. EPA concurs with the Navy's suggestion that "some model tuning may be warranted" (p. 6-6) to add confidence in the accuracy of PRAM predictions.	Comment noted. Further development of PRAM is being considered in support of the national permit.
42	Section 6.1.5, p. 6-7: Why is this last paragraph included? It addresses sources of variability in field-collected data sets, offering nothing with respect to the efficacy of PRAM. EPA recommends that the paragraph be deleted.	The following text will be added to the beginning of the paragraph: "In comparing the results from PRAM to BAFs obtained from field data, it must be noted that there are many reasons for variability in BAFs obtained from field data." The report will be revised to state in advance that there is uncertainty in evaluating PRAM results with field data reported in the literature.
43	Section 6.2, p. 6-8: Section 6.2 states that "interior" water concentrations are predicted to remain well above chronic WQ benchmarks, but goes on to state that risks associated with exposure to interior water were evaluated via exposure to other media (lower and upper water columns, sediment, and biota). In fact, Figure 32, and Appendices HQ1day to HQ 800 day suggest that there would be substantial risks to organisms that might enter the interior part of the ship: hazard quotients using all three benchmarks (the chronic water quality criterion, GLWLC- Tier 1 and GLWLC) were greater than 1. The Navy's own evaluation criteria presented in Section 5-4, Page 10, state that hazard quotients of 10 indicate "very likely that exposure is harmful" and the risk conclusion is "Very High." At day 800 after sinking, the	Exposure to interior water by components of the reef community is included in PRAM and was evaluated in the ecological risk assessment. More discussion on interior water exposure will be provided in the final report. The HQ calculated for interior water exposure is only one line of evidence in the overall risk assessment. The "interior vessel water" is used in the PRAM and TDM to link emission from the solid materials containing PCBs to the reef community. The potential toxicity from contact with the interior water was evaluated as part of the ecological risk assessment. The ecological significance of the interior water exceeding water quality benchmarks will be discussed in the revised report. Because of the limited

	Hazard Quotients for the saltwater chronic criterion, GLWLC-Tier 1 and GLWLC were reported as 22.9796631, 9.3160796, 4.9242135, respectively (Appendix HQsstate - 22). These figures were nearly identical to Hazard Quotients for day 28 after sinking - 22. 0198129, 8.9269512, 4.7185313, respectively. As mentioned earlier, OPPT considers hazard quotients of 1 and greater sufficient to establish that a risk may exist. The Navy should clarify why risks of exposure to interior water was not addressed directly, and should discuss what that higher exposure concentration would portend for fish and invertebrates that will freely move around inside the vessel for some period of time.	exchange between the interior water and the lower water column surrounding the reef, the interior of the vessel is not expected to be readily colonized by epibenthic organisms that need a constant source of food from the outside of the vessel. Therefore, it was assumed that the predominant route of exposure from the interior water would be from bioaccumulation and trophic transfer in the food chain rather than toxic effects from direct exposure.
44	Section 6.2, Fig. 33: The titles and labeling in this figure are confusing. Although the accompanying text (p. 6-8) suggests data in the panels to be relevant to water column concentrations predicted using PRAM ZOIs of 2 and 3, the two lower panels show sediment concentrations (why?), and all panels have subtitles referencing distances "from Reef" of either 45m or 60m. Assuming these distances to be modeled output locations from the TDM (as described in Section 5.1, p. 5-5), why would they differ from the understood dimensions (15 and 27m, respectively) of the salient ZOIs? Further, why is the ZOI = 3 dimension shown as 29m, when elsewhere in the document (e.g., Section 5.1, p. 5-5) that dimension is given as 27m? EPA recommends that this confusion be addressed by amending the figure titles, labeling and content accordingly. But, these peculiarities suggest a more important question: What is the relationship between the TDM's estimates of exposure at points in space with PRAM's estimates of exposure within volumes? Assuming the TDM's predictions of concentration to fall off geometrically with distance from the ship, is it fair to compare (implicitly or explicitly) concentrations predicted at the edge of a ZOI envelop with PRAM's predictions throughout the ZOI envelope? Would some distance-averaged or mid-point TMD prediction be more representative?	Titles and labeling will be corrected as noted. The following information will be added to the report to clarify the exposure scenarios evaluated. The TDM estimates are based on exposure concentrations within defined volumes, just as the PRAM estimates are of exposure concentrations within defined volumes. The TDM volumes are defined in terms of 15-meter wide annuli. The height of these annuli are a fixed height, such that data presented on figures simple state the width of the annuli, rather than reiterating the height of each annulus. If the figure indicates that the data are for the "0-15 m bin", it means that the concentrations indicated were calculated for the annulus that is 15 m wide, and which begins at the exterior of the ship and extends laterally away from the ship to a distance of 15 m. For the lower water column, the height of the annulus is from the sediment up to the pycnocline; for the upper water column, the height of the annulus is from the top of the pycnocline to the surface of the water. A distance-averaged concentration was used for the TDM/PRAM model (i.e., both PRAM and TDM predict PCB concentrations averaged across a distance from the ship, not at discreet points). The TDM provided exposure concentrations for bins 0-15m, 15-30m, 30-45m, 45–60m, etc. away from the ship, while PRAM provided an estimate of the steady state concentration for the whole volume as a function of ZOI. A ZOI=2 (14.7m) is roughly equivalent to the TDM bin of 0-15m and ZOI=5 (48.8m) falls at the boundary of the 30-45m and 45-60m TDM bins. For the TDM/PRAM model the abiotic exposure concentrations were obtained from the TDM model. The TDM output was input into PRAM, for each time interval, by calculating the PCB concentration provided for the 0-15m bin, 0-45m interval (average of 0-15m, 15-30m, and 30-45m bins), and 0-60m interval (average of 0-15m, 15-30m, 30-45m, and 45-60m bins). The concentration for each bin was averaged over the appropriate time interval (eg. 1d (average for day 1), 7d (average from day 2 to 7), 14d (average from day 8 – 14), 28d (average from day 15 –

		28), etc). TDM/PRAM then calculated the resulting steady concentrations for the biological compartments. This explanation will be provided in the revised report. The TDM/PRAM results plotted in Figs 31, 32, 34-37 should be labeled as “0 – 15 m from Reef”, likewise Figs 33, 38-39 should be labeled “0 – 45 m” and “0 – 60 m” from the Reef. This will be made clear in the revised report. Of concern was whether a short-term pulse could cause transient exposure higher than the two-year steady state estimate. The purpose was not necessarily to compare PRAM and TDM/PRAM, but rather assure that the full range of potential risks were evaluated.
45	Section 6.4.1.1, p. 6-10: Replace “Figure 36” with “Figure 35.”	Correction will be made
46	Section 6.4.1.3, pp. 6-11–6-12: This discussion of uncertainties associated with characterization of ecological risk from total PCB exposure is very cursory. EPA recommends that the Navy enhance this discussion by addressing questions such as: What are the primary sources of uncertainty as they affect the values of hazard quotients? What are the sensitivities of risk estimates to changes in underlying assumptions of exposure and effect? Where are the biggest information gaps, and should any of these be filled to support a more complete or definitive understanding of risks? Additionally, discussion of the effect that encrusting organisms may have on leaching and transport of PCBs should be added.	More details on the uncertainty were provided in the uncertainty section, which will be updated to address the questions raised. Please see Attachment 2 for discussion on direct exposure to encrusting organisms.
47	Section 6.5, pp. 6-14 & 6-15 and Section 8.1, p 8-1: The Summary of Findings portions of the Results and Discussion section and the Conclusions and Recommendation section both make explicit, exclusive, and extensive use of the qualitative and subjective terminology that has already been mentioned as problematic in Specific Comments 35 and 37, above. As was also noted above, the basis for using these subjective terms needs to be provided and suitably supported.	Comment noted. Summary will be revised to reflect the findings from the risk assessment (see Attachment 1 for revised evaluation criteria).
48	Sections 7.1 (p. 7-1), 7.6 (p. 7-3–7-4) and 7.7 (pp. 7-4–7-5): In sharp contrast to Section 6.4.1.3, these discussions of uncertainties are valuable and informative. The Navy is to be commended for exploring quantitatively the ramifications of changes in assumptions about source strength, bottom current and exposure to the food web on the predictions of risk. It would have been more informative to interpret the outcomes of different scenarios of source strength and bottom current in terms of risks to assessment endpoints, as was done for exposure to the food web. EPA also notes the disclosure about the discrepancy between PRAM documentation and actual model performance provided in Footnote 11 (p. 7-4).	Comment noted. Where applicable, ecological risk benchmarks will be included on the uncertainty analysis figures. The discrepancy between PRAM and model documentation will be corrected for future releases of PRAM.
49	Section 7, p. 7-1, Fig. 57 and Appendix D.2: It would be helpful to provide	The figure will be annotated to show 0 – 100% of bulkhead insulation

	the translation between bulkhead insulation remaining on board and the PCB release rate estimates.	removal.

A.2 Response to Comments from SAB

Below are comment received from the U.S. EPA Science Advisory Board Polychlorinated Biphenyl--Artificial Reef Risk Assessment (PCB-ARRA) Consultative Panel. Comments received on Oct. 14, 2005.

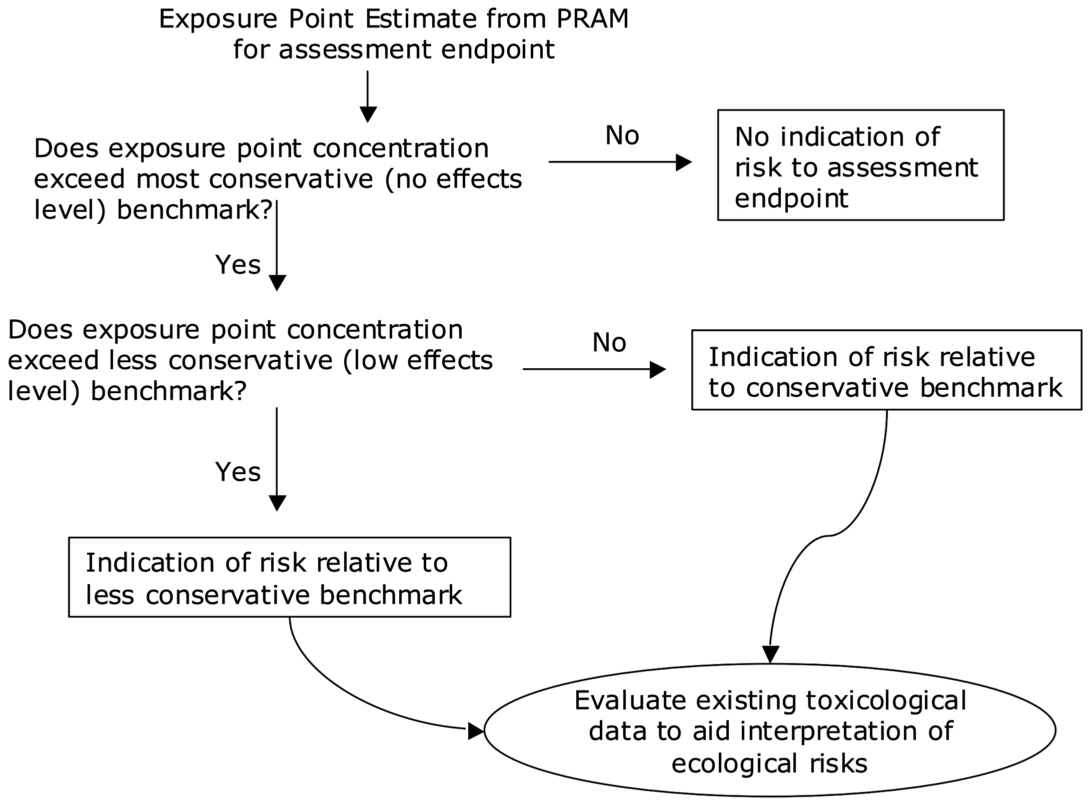
#	COMMENT	RESPONSE
1	A general emphasis is on “ecological receptors that could reside, feed, and/or forage at the artificial reef.” The models focused on predicting bioaccumulation in the “food chain of the pelagic, benthic, and reef communities.” Assessment endpoints were “effects to survival, growth, and reproduction to the communities and organisms modeled by PRAM as well as ecological consumers that could also feed and forage at the reef. ” Primary producers (Trophic Level 1 or TL1) … algae Primary consumers (TL2) … copepods, bivalve, urchin, polychaete, nematode Secondary consumers (TL3) …herring, triggerfish, lobster, crab Tertiary consumers (TL4) … jack, grouper, flounder.	Comment noted.
2	Grouping these trophically defined species by habitat allowed focus also on benthic, pelagic, reef communities and seems appropriate. Additional endpoints were cormorants, herring gulls, sea turtles, dolphins, sharks and barracuda. Have enough attention was being paid to keystone species? It is quite plausible that ecological engineers are important in reefs, e.g., specific hard coral or other encrusting species. Certainly, relevant information can be obtained from sources such as: http://cars.er.usgs.gov/coastaleco/Tech-Rept-Pinnacles-2002/executive_summary/executive_summary.html	The tissue residue concentrations modeled by PRAM and the ecological risk benchmarks used in the ecological risk assessment are for representative species that are expected to be present at the reef. The tissue concentrations and potential ecological effects inferred from the model results would also be applicable to tissue residues and exposure concentrations experienced by any keystone species present at the reef. This will be noted in the revised report. The ecological risk assessment only addressed potential toxicological risks from PCBs, the ecological consequence of reef development was outside the bounds of the ecological risk assessment. More discussion on the reef community will be added to the revised document (see response to EPA comment 20) including the reference provided. Weaver et al. 2002, Biological Sciences ReportUSGS BSR 2001- 0008OCS Study MMS 2002- 034 Northeastern Gulf of Mexico Coastal and Marine Ecosystem Program Community Structure and Trophic Ecology of Fishes on the Pinnacles Reef Tract
3	This is a Screening level risk assessment. And need to be careful of how far you can go in the interpretation. The evaluation of the hazard quotient (eg. HQ 10) and the individual benchmarks for this application of the interpretation of risk may be problematic. This is based on one person’s professional judgment and is not scientifically supported. No effect level versus some effects. More conventionally for PCBs to use below 1 is assumed to be no risk and above there is a risk. The use of NOEL, LOEL.	The evaluation of potential ecological effects using the HQ approach will be revised in the final document. Briefly, the most conservative benchmarks (eg. chronic water quality criteria, and no effect levels etc.) will be used as an initial screen, followed by comparison to less conservative benchmarks (acute water quality criteria, lowest effect levels, etc), and available toxicological data, if the initial screen is exceeded. Please see Attachment 1. The ecological risk benchmarks were derived to be conservative thresholds of

		potential effects. Both the “no effect” and “low effect” benchmarks were used to better characterize potential ecological risks.
4	The scientific justification for choosing the end-points and those that were deemed to be most sensitive should be addressed.	The report will be revised to improve the discussion of the reef community (see SAB comment 2) and provide additional supporting documentation on the validity of the ecological risk benchmarks used in the assessment.
5	Given the many uncertainties and unknowns for the biological systems, this RA could not likely be applied to other places with confidence. A protocol needs to be developed which is tied to a monitoring program that focuses on transferability, data gaps, both from laboratory and field studies. Post-decision monitoring program that helps to inform the next version of the risk assessment.	Further studies are being considered in support of the national permit. An important piece of the ex-Oriskany post reef deployment is the post reef monitoring. As is identified in both the transfer agreement between Navy and the State of Florida and the Risk Based Disposal Approval, monitoring will be a responsibility, of the State of Florida. Both pre- and post- sinking monitoring objectives are being considered. The pre reef monitoring will establish the existing background conditions against which post reef conditions will be assessed. The post reef-monitoring program will be specific to species, which are listed in the Predictive Risk Assessment Model (PRAM), and the data from the sampling performed under the post reef monitoring will be input to PRAM to assist in post reef validation of the predicted risks.
6	As a related issue, the same species can vary in its trophic position. Here is an example of lake trout from eight Canadian Shield lakes (Figure from Newman & Unger (2003), Fundamentals of Ecotoxicology, CRC/Lewis Publishers,; Modification of Fig. 2 & 3 of Cabana & Rasmussen. 1994. Nature 372: 255-257.) Thus the model needs to be reinforced by empirical monitoring data.	Comment noted. Further development of PRAM is being considered in support of the national permit.
7	Enormous variation in the PCB concentrations, this drives the need for a probabilistic assessment and examining the uncertainties and the transferability.	Comment noted. Further development of PRAM is being considered in support of the national permit.

A.2.1 Attachment 1 to Response to Comments (Round 1)

Evaluation Criteria

The following evaluation criteria were used to evaluate the results of the ecological risk analysis. Short-term ecological risks (0 –2 years) were evaluated using the data obtained from the TDM coupled to PRAM. The long-term ecological risk (steady state) was evaluated using the results of PRAM under steady state conditions. The exposure point concentrations estimated by PRAM were compared to the conservative and less conservative benchmarks for each applicable exposure pathway and assessment endpoint (Table 21). The following diagram depicts the evaluation criteria applied for the risk analysis:



If the exposure point concentration did not exceed the most conservative benchmark (e.g. no effects level), the risk analysis concluded that there was no indication of risk to the assessment endpoint. However, if the exposure point concentration exceeded either the most conservative or less conservative benchmark (e.g. low effects level) an indication of risk relative to that benchmark was suggested and the available toxicological data was evaluated to aid in the interpretation of ecological risks. The evaluation was conducted by comparing the exposure point estimate from PRAM to the toxicological data available in the literature.

Table 21. Summary of media, exposure pathways, benchmarks, endpoints, and stressors evaluated for the ecorisk analysis.

Media	Exposure Pathway	Benchmarks[a]	Endpoint/Receptor	Stressor
Water	Water	Water Quality Criteria WQC-Chronic, WQC-Acute	Primary Producer	Total PCB
			Primary Consumer	Total PCB
			Secondary Consumer	Total PCB
			Tertiary Consumer	Total PCB
Sediment	Sediment	Potential Sediment Effects TEL, PEL	Primary Producer	Total PCB
			Primary Consumer	Total PCB
			Secondary Consumer	Total PCB
Tissue Residue	Food Chain	Potential Bioaccumulation Effects TSV, Bcv	Primary Producer	Total PCB
			Primary Consumer	Total PCB
			Secondary Consumer	Total PCB
			Tertiary Consumer	Total PCB
Tissue Residue	Food Chain	Critical Body Residues NOED, LOED	Primary Consumer	Total PCB
			Secondary Consumer	Total PCB
			Tertiary Consumer	Total PCB, TEQ
Tissue Residue	Food Chain	Dietary Exposure NOAEL, LOAEL	Avian Omnivore (Herring Gull)	Total PCB, TEQ
			Avian Piscivore (Cormorant)	Total PCB, TEQ
			Secondary Consumer (Sea Turtle)	Total PCB
			Tertiary Consumer (Dolphin)	Total PCB, TEQ
			Tertiary Consumer (Shark)	Total PCB

[a] Benchmarks listed are for conservative and less conservative, respectively.

Example:

The interior water concentration exceeded the most conservative benchmark (WQC-Chronic). The toxicity data developed in support of WQC are shown in Figure Example1 and Table A1 (see below, Data from US EPA 1980, Ambient Water Quality Criteria for Polychlorinated Biphenyl). In the example below, the interior water concentration predicted by PRAM was at the lower end of the range of concentrations measured as causing toxicity in laboratory studies (U.S. EPA 1980, see Table Example1). This analysis assumes that the toxicity of technical Aroclor 1254 tested under laboratory conditions is similar to the toxicity of Total PCBs leached from the ship and modeled by PRAM. This is reasonable because the Aroclor mixtures were the "Total PCB" exposed during the bioassay tests and weathering or biodegradation of PCBs is not included in the PRAM model. There is uncertainty about interspecies differences and the differences between controlled laboratory experiments and actual situations in the real world. The results, limitations, uncertainty, and conclusions derived using the approach described above will be included in the revised final report.

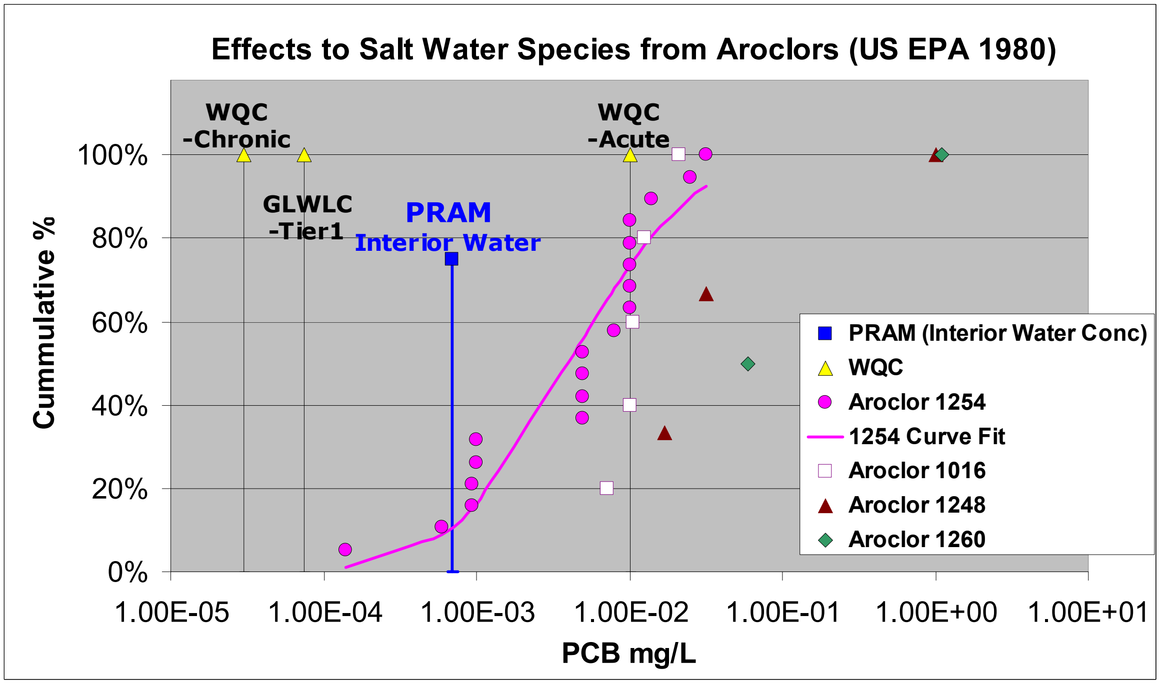


Figure Example1. Effects data for salt-water species exposed to technical Aroclors (U.S. EPA 1980), the WQC benchmarks, and the interior water concentration predicted by PRAM.

The figure shows the lognormal cumulative distribution of effects to marine organisms from water exposure to Aroclor 1254 (magenta circles and curved line), the benchmarks for water exposure, and the exposure point estimate for internal vessel water concentrations (PRAM) based on steady state conditions. Toxicity data (circles) are from US EPA 1980, Ambient Water Quality Criteria for Polychlorinated Biphenyl. Note that based on the data available, Aroclor 1254 is the most toxic Aroclor. Since the benchmark exceeded (WQC-Chronic) by the PRAM estimate for interior water is based on water quality criteria, is it appropriate to use the toxicity data used to support the criterion (U.S. EPA 1980, see data table below) to evaluate potential ecological effects.

Table Example1. Data from US EPA 1980.

Table	Water	Species	Aroclor	Duration	Effect Classification	Effect	Reference	Result (ug/l	mg/L
6	saltwater	Sheepshead minnow	1254	28 days	chronic	affected reproduction	Hansen et al. 1973	0.14	0.00014
6	saltwater	Communities of Organis	1254	4 mos	chronic	affected composition	Hansen 1974	0.6	0.00060
6	saltwater	Sheepshead minnow	1254	21 days	chronic	LC50	Schimmel et al. 1974	0.93	0.00093
6	saltwater	Pink Shrimp	1254	15 days	chronic	51% mortality	Nimmo et al. 1971	0.94	0.00094
6	saltwater	Ciliate protozoans	1254	96 hour	chronic	reduced growth	Cooley et al. 1973	1	0.00100
6	saltwater	Pink Shrimp	1254	15 days	chronic	LC	Nimmo & Bahner 1976	1	0.00100
6	saltwater	Eastern oyster	1254	24 weeks	chronic	reduced growth	Lowe undated	5	0.00500
6	saltwater	Pinfish	1254	14-35 days	chronic	41 to 66% mortality	Hansen et al. 1971	5	0.00500
6	saltwater	Spot	1254	20-45 days	chronic	51 to 62 % mortality	Hansen et al. 1971	5	0.00500
6	saltwater	Spot	1254	15 days	chronic	liver pathogenesis	Nimmo et al. 1971	5	0.00500
6	saltwater	Fiddler Crab	1254	38 days	chronic	inhibited molting	Finerman & Fingerman 1978	8	0.00800
6	saltwater	Amphipod	1254	30 days	chronic	mortality	Wildish 1970	10	0.01000
6	saltwater	Grass shrimp	1254	1 hour	chronic	avoidance	Hansen et al. 1974b	10	0.01000
6	saltwater	Pinfish	1254	1 hour	chronic	avoidance	Hansen et al. 1974b	10	0.01000
6	saltwater	Sheepshead minnow	1254	28 days	chronic	lethargy, reduced feedir	Hansen et al. 1973	10	0.01000
6	saltwater	Sheepshead minnow	1254	21 days	chronic	mortality	Schimmel et al. 1974	10	0.01000
1	saltwater	Eastern oyster	1254	24 hr	acute	EC50 growth	Lowe undated	14	0.01400
6	saltwater	Grass shrimp	1254	4 days	chronic	water efflux affected an	Roesijadi et al. 1976a,b	25	0.02500
6	saltwater	Pink Shrimp	1254	48 hrs	chronic	LC	Lowe undated	32	0.03200

Table	Water	Species	Aroclor	Duration	Effect Classification	Effect	Reference	Result (ug/L)
2	saltwater	Sheepshead minnow	1016	96 hr	chronic		Hansen et al. 1975	7.14
1	saltwater	Eastern oyster	1016	24 hr	acute	EC50 growth	Hansen et al. 1974a	10.2
1	saltwater	Brown shrimp	1016	24 hr	acute	LC50 survival	Hansen et al. 1974a	10.5
1	saltwater	Grass shrimp	1016	24 hr	acute	LC50 survival	Hansen et al. 1974a	12.5
6	Saltwater	Pinfish	1016	42 days	chronic	50% mortality	Hansen et al., 1974b	21
1	saltwater	Eastern oyster	1248	24 hr	acute	EC50 growth	Lowe undated	17
6	Saltwater	Pink Shrimp	1248	48 hrs	chronic	LC	Lowe, undated	32
6	Saltwater	Ciliate protozoans	1248	96 hour	chronic	reduced growth	Cooley et al., 1973	1000
1	saltwater	Eastern oyster	1260	24 hr	acute	EC50 growth	Lowe undated	60
6	Saltwater	Ciliate protozoans	1260	96 hour	chronic	reduced growth	Cooley et al., 1973	1000

The interior water concentration is very dependent on the rate of water exchange with lower water column. The default value was set at 1% of the bottom current or 9.26 m/h. There is much uncertainty about this number and it was assumed that 1% was a very conservative estimate. It is reasonable to assume that the exchange rate is proportional to the bottom current because as the bottom current increases, higher velocity water will come into contact with the ship resulting in greater ventilation of the hull. The exchange with lower water column will be dependent on how "porous" the hull is with respect to water getting in and out. The figure below shows the change in the concentration of pentachlorobiphenyl in the interior water simulated by the TDM at the maximum leaching rate, as a function of the interior vessel exchange rate. Pentachlorobiphenyl accounts for about half of the Total PCBs released into the interior of the ship. The figure shows the relationship between interior water concentration and the exchange rate.

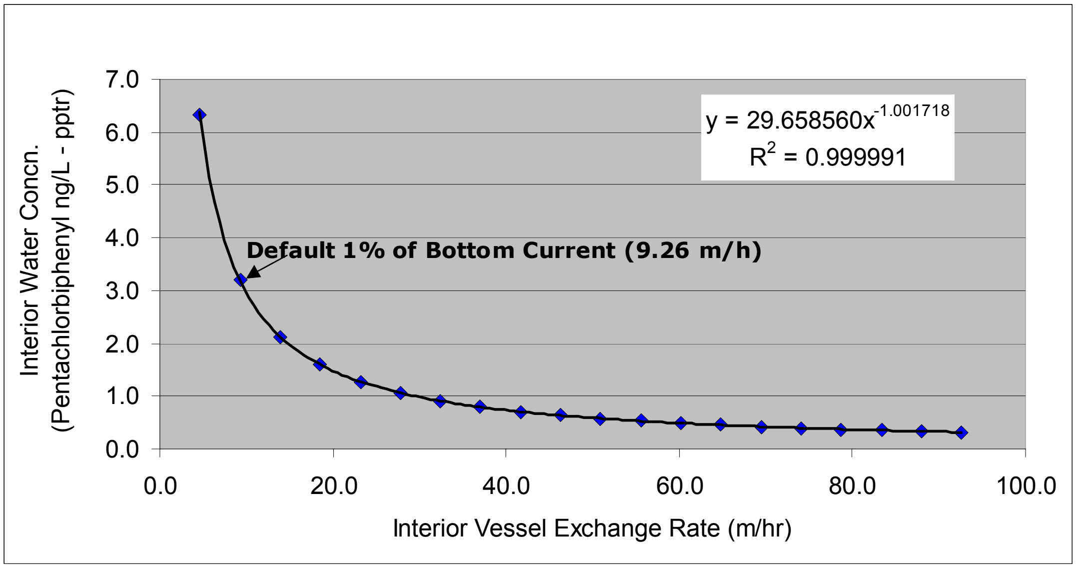


Figure. The concentration of pentachlorobiphenyl in the interior of the ship modeled by TDM as function of fraction of bottom current which was held constant at 926 m/h (0.5 nautical miles per hour).

A.3 Response to Comments from U.S. EPA Round 2

The following are the Response to Follow-up Comments received from the EPA on Dec 2, 2005.

#	EPA Comment	Response
10	Specific Comment 10 - Direct exposure route: EPA commented on the ERA's assignment of "minor importance" of the direct exposure pathway. The Navy's response was to defend that position by explaining that; 1) microbial biofilms isolate and inhibit releases of contaminants from solid materials containing PCBs, 2) attached organisms make contact primarily with chemically inert structures and 3) grazing and predation in epiphytic communities was primarily "incidental". It has been demonstrated that microbial biofilms may become infused with bioavailable compounds within the underlying solid materials. The contaminated biofilm becomes a potential pathway for contaminant exposure to organisms that come into contact with it. It has also been demonstrated that both sessile and motile epifauna in highly contaminated environments uptake bioavailable chemical compounds. By "direct exposure" EPA refers to direct contact with PCB bearing materials, including PCB contaminated biofilms rather than by contact with contaminated water to attached organisms. Though, as the Navy notes, some organisms may attach by way of inert materials such as threads, shells etc., many sessile and motile organisms comprising the epifaunal community may be exposed to PCB via absorption through living membranes that touch vessel materials or covering biofilms. These may include a variety of sponges, ascidians, bryozoans, cnidarians, polychaetes, gastropods and echinoderms. In addition, because the vessel surfaces and biofilms will likely contain much higher PCB concentrations than the surrounding water, direct tissue contact may be a comparably significant exposure route. The epifaunal community is a diverse and complex ecosystem in its own right consisting of sessile and motile organisms. Predators include a variety of large and small invertebrates and fish. We agree with the Navy that predators do not feed on shells and tests, however many predators are well adapted to feed on the soft bodied animals living within as well as on the wide variety of soft bodied epiphytic animals without shells or tests. Predation rates among epifauna are high. The	With respect to the direct exposure pathway the report will be revised as follows: Another potential pathway is direct contact by marine organisms to the PCB-bearing materials onboard the ship. Encrusting organisms or other epibenthic organisms could come into direct contact with PCBs held within the solid matrices of the materials. Direct exposure was assumed to be a relatively minor exposure pathway compared to aqueous-phase releases of PCBs and no attempt was made to model bioaccumulation from direct exposure in PRAM. On the ex-ORISKANY the vast majority of PCB-containing materials will be in electrical cable (97.6% of the PCBs by mass, see Table 4). The PCBs are contained within the insulation of the cable, which is found inside the outer braided-metal shielding. The electrical cable and other PCB-containing materials – bulkhead insulation (0.94%), black rubber (0.06%), and ventilation gaskets (0.01%) – would most likely be located within the interior of ship where they would not be easily colonized by epibenthic organisms that need a constant source of food from the outside of the vessel. Additionally, most all exposed surfaces on the ship were painted many times during the life of vessel, further isolating the solid matrices containing PCBs from direct contact with encrusting organisms. Yet, there is a small portion of the PCBs that are associated with aluminized paint (1.4%) that could be on the exterior of the ship and there is uncertainty about whether the PCB-bearing materials were manufactured with PCBs or if their surfaces became contaminated with PCBs during the life of the ship or both. A further consideration is that the formation of concretions by encrusting organisms (barnacles, tubeworms, tunicates, bryzoans, sponges, and other fouling organisms) would serve to further isolate the PCB-bearing materials and inhibit the release. The dramatic decrease in the release of toxic substances from antifouling paint on ship hulls within days of cleaning due to the build-up of biofilms and recolonization by fouling organisms (Schiff et al. 2003) is an example of this process. Studies on the release of contaminants from artificial reefs made of scrap tires showed that the release rate of contaminants decreased over time probably because of the depletion of contaminants from the surface of the tires (Collins et al. 1995) and the build-up

	assumption that the epiphytic community makes an insignificant energy contribution to the remaining components of the reef food web is not supported.	colonizing organisms (Collins 1999, Collins et al. 2002). While the build-up of encrusting organisms on surfaces may impede the release of PCBs, fish and other invertebrates can prey on encrusting organisms and extreme events, such as hurricanes, could also cause fouling organisms to be broken off exposing new surfaces to aqueous-phase leaching. It is also unlikely that marine organisms would actually "eat" the materials containing PCBs. Most of the materials are covered with metal or plastic shielding (electrical cables), bolted between flanges (rubber gaskets), and enclosed by paneling or painted surfaces (bulkhead insulation) which means that the main route of release would be from the surfaces being wetted and dissolution of PCBs into the aqueous phase. Although some organisms could incidentally consume the solid material (e.g. a snail grazing on a contaminated surface, or a crab feeding on fouling organisms), it was assumed that this pathway was very minor in comparison to aqueous releases. For the purposes of this risk assessment it was assumed that the predominant route of exposure from any PCBs contained in solid materials on the ship was from aqueous-phase leaching that could occur during or after the process of sinking. Collins, K. J., Jensen, A. C., and Albert, S. 1995. A review of waste tyre utilisation in the marine environment. Chemistry and Ecology, 10: 205–216. Collins, Ken 1999. Environmental impact assessment of a scrap tyre artificial reef. University of Southampton, UK. 7th International Conference on Artificial Reefs and Related Aquatic Habitats (7th CARAH) October 7-15, 1999, Sanremo, Italy Collins, K. J., Jensen, A. C., Mallinson, J. J., Roenelle, V., and Smith, I. P. 2002. Environmental impact assessment of a scrap tyre artificial reef. – ICES Journal of Marine Science, 59: S243–S249. Schiff Kenneth, Dario Diehl, Aldis Valkirs 2003. Copper Emissions From Antifouling Paint on Recreational Vessels. Technical Report #405, June 22, 2003. Southern California Coastal Water Research Project. Westminster, CA. www.sccwrp.org
35	Specific Comment 35: As noted in EPA's earlier comments, the calculated Hazard Quotient (HQs) inside the vessel for the saltwater chronic ambient water quality criterion and two other criteria were exceeded. In their response to Comment 35, the Navy responded with additional information referred to as "Attachment # 1". There are two components to the Attachment. The first component consists of an explanation that the interior water concentration is very dependent upon	The evaluation criteria (Attachment 1) have been revised to be more consistent with OPPTS guidance. If the exposure point concentration did not exceed the most conservative benchmark (e.g. no effects level), the risk analysis concluded that there was no indication of risk to the assessment endpoint. However, if the exposure point concentration exceeded either the most conservative or less

	the rate of the water exchange with a lower water column. The Navy also stated that the default setting was set at a very conservative 1% of the bottom and provided a graph to show the relationship between “Pentachlorbiphenyl mg/l” and “Fraction of Bottom Current.” The bottom line is that the Navy believes the internal PCB concentrations are very conservative but this needs to be evaluated further. The second component consists of a flow chart showing the decision logic of assessing risks to the assessment endpoints. This is followed by an example of how the exceedence of the saltwater water quality criterion was addressed. It appears that what the Navy did was to prepare a cumulative distribution graph with the toxicity values used to derive the saltwater criterion and compare the internal concentration to the graph. A table for using various cutoffs to determine negligible risk, very low risk and so forth is then presented. In doing so, the point is being missed that a risk has been identified and that perhaps some risk management options or further exposure scenarios should be considered. Arguing that because only a small percent of the individual test organism toxicity endpoints were exceeded means low risk does not negate the concern for risk indicated by exceeding the actual saltwater criterion. Given concerns raised by other reviewers about how high the actual amounts of PCBs in the wiring of the ship actually are, further analyses of potential exposure scenarios would be warranted. Given that the Agency has to address the risks posed by proposed future ship sinkings, it is important to agree on what the limits of a screening risk assessment are and adhere to them. Thus, if a risk is identified, agree on subsequent steps. The Navy has proposed such a scheme but I think additional exposure assessments need to be included as well as risk management options. This is particularly true down the road when the Agency has to consider the potential risks due to additional PCB loadings.	conservative benchmark (e.g. low effects level) an indication of risk relative to that benchmark was suggested and the available toxicological data was evaluated to aid in the interpretation of ecological risks. The evaluation was conducted by comparing the exposure point estimate from PRAM to the toxicological data available from the literature without using subjective “cut off” values to determine the level of risk (see attachment 1). The ecological significance of the interior water exceeding water quality benchmarks will be discussed in the revised report. Because of the limited exchange between the interior water and the lower water column surrounding the reef, the interior of the vessel is not expected to be readily colonized by epibenthic organisms that need a constant source of food from the outside of the vessel. Therefore, it is was assumed that the predominant route of exposure from the interior water would be from bioaccumulation and trophic transfer in the food chain rather than toxic effects from direct exposure. Quantitative modeling of other exposure scenarios and identification of appropriate risk management options are under consideration for development of the national permit.
36	Specific Comment 36: In EPA's original comment, a question was posed about what, if any, uncertainty factors were used in the risk assessment. In their response to this comment, the Navy indicated that an uncertainty factor of 1 was used. It was not apparent at the time of the review but an uncertainty factor of 1 was shown in their tables. For Risk Assessments in OPPT, an uncertainty factor (a.k.a. Assessment Factor, MOE) of at least 10 (provided it is derived from valid chronic data) is required for ecological risk assessments. EPA recommends that the risks to mammalian, avian and turtle species be reevaluated using an uncertainty factor of 10.	The report will be revised to use “assessment factors” where appropriate. The benchmarks for critical body residues and dietary exposure to dolphins, birds, turtles, and sharks will be divided by an assessment factor of 10 to account for species-to-species differences in the effects levels. The application of uncertainty factors and assessment factors will be clearly documented in the final report.
44	Specific Comment 44: The second part of that comment addresses the	The following information will be added to the report to clarify the exposure

	apparent discrepancy in how the predictions of the TDM are reported and compared to those of PRAM. The Navy's proposal is unresponsive to this issue. If our understanding the meaning of these data is correct, values shown for TDM predictions under-report the concentrations that should be used to compare to PRAM predictions. The bigger implication here is that the Navy may have underestimated short-term, transient risks by treating the TDM predictions inappropriately. This issue needs to be discussed and evaluated to ensure that the comparisons and risk estimates are appropriate. The basic issue here is whether results from only the selected bins (in TDM lingo) are being compared to PRAM outputs and are used in risk calculations, as opposed to concentrations averaged spatially across all bins shipward from that indicated. If the former, and with an assumption that concentrations fall off geometrically with distance from the ship, the concentration reported would necessarily be lower than its PRAM counterpart (which, by definition, reflects all waters shipward to the ZOI boundary).	scenarios. The TDM estimates are based on exposure concentrations within defined volumes, just as the PRAM estimates are of exposure concentrations within defined volumes. The TDM volumes are defined in terms of 15-meter wide annuli. The height of these annuli are a fixed height, such that data presented on figures simple state the width of the annuli, rather than reiterating the height of each annulus. If the figure indicates that the data are for the “0-15 m bin”, it means that the concentrations indicated were calculated for the annulus that is 15 m wide, and which begins at the exterior of the ship and extends laterally away from the ship to a distance of 15 m. For the lower water column, the height of the annulus is from the sediment up to the pycnocline; for the upper water column, the height of the annulus is from the top of the pycnocline to the surface of the water. A distance-averaged concentration was used for the TDM/PRAM model. The TDM provided exposure concentrations for bins 0-15m, 15-30m, 30-45m, 45–60m, etc. away from the ship, while PRAM provided an estimate of the steady state concentration for the whole volume as a function of ZOI. A ZOI=2 (14.7m) is roughly equivalent to the TDM bin of 0-15m and ZOI=5 (48.8m) falls at the boundary of the 30-45m and 45-60m TDM bins. For the TDM/PRAM model the abiotic exposure concentrations were obtained from the TDM model. The TDM output was input into PRAM, for each time interval, by calculating the PCB concentration provided for the 0-15m bin, 0-45m interval (average of 0-15m, 15-30m, and 30-45m bins), and 0-60m interval (average of 0-15m, 15-30m, 30-45m, and 45-60m bins). The concentration for each bin was averaged over the appropriate time interval (eg. 1d (average for day 1), 7d (average from day 2 to 7), 14d (average from day 8 – 14), 28d (average from day 15 – 28), etc). TDM/PRAM then calculated the resulting steady concentrations for the biological compartments. This explanation will be provided in the revised report. The TDM/PRAM results plotted in Figs 31, 32, 34-37 should be labeled as “0 – 15 m from Reef”, likewise Figs 33, 38-39 should be labeled “0 – 45 m” and “0 – 60 m” from the Reef. This will be made clear in the revised report.

Appendix B: 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 0 Appendix B.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 B- 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 5.38×10^4 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,[19] 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:

$$C_{BW} = C_{W\_FD} + TSS \times C_{TSS} + DOC \times C_{DOC} \text{ [mg/L]} \quad [33]$$

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 B.2.2 PRAM Default Parameters (ZOI =2)) changing the ZOI from 1 to 10 resulted in about a 40% to 75% decrease in the

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[19] 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.

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 6.7×10^{-4} mg/L (Figure B- 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 B- 3, NEHC/SSC-SD 2005a, 2006a). Slight increases in the concentration of Total PCB in the air compartment were modeled as a function of ZOI (Figure B- 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 B- 5 and summarized in Table B - 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}):

$$BAF_{LIPID} = C_{Lipid} / C_{W\_FD} \qquad [34]$$

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 B- 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 B- 7, Table B - 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.

$$C_{Salmon(i)} = \mathbf{m_i}(C_{Prey(i)}) + \mathbf{b_i} \qquad [35]$$

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 B- 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 B- 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 B- 10) and Total PCB (Figure B- 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 B- 8 and Figure B- 10 show that accumulation for individual congeners from Jackson (et al. 2001) and homologs from PRAM while Figure B- 9 and Figure B- 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 B- 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):

$$BMF_{TLC} = \frac{C_{PRED\_L} / C_{PREY\_L}}{TL_{PRED} / TL_{PREY}} \quad [36]$$

The TL for the PRAM food chain was calculated based on the weighted average of each component of a organism's diet:

$$TL_{(j)} = 1 + \Sigma f_{diet(i)} \times TL_{Prey(i)} \quad [37]$$

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 B - 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 B- 12, Table B - 3). 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 δN^{13} and δC^{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 B- 13) to the BAFs predicted by PRAM as a function of Kow (Figure B- 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 δN^{13} and δC^{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):

$$\mathrm{FWMF} = e^{b} \qquad [38]$$

Where b is the slope of the log-linear (natural log) regression between PCB concentration and TL:

$$\mathrm{Ln(PCB)} = a + b(\mathrm{TL}) \qquad [39]$$

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 B- 15, Figure B- 16, Figure B- 17 and Table B - 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 B- 18).

The highest FWMFs obtained from PRAM were for the hexa-, hepta-, and nonachlorobiphenyls in the reef and pelagic communities. The homologs with $\text{Log}(K_{ow}) < 5.6$ 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 B- 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 B Tables

Table B-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 B-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 B-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 B-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 B-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 B-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 B-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 B-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 B **Figures**

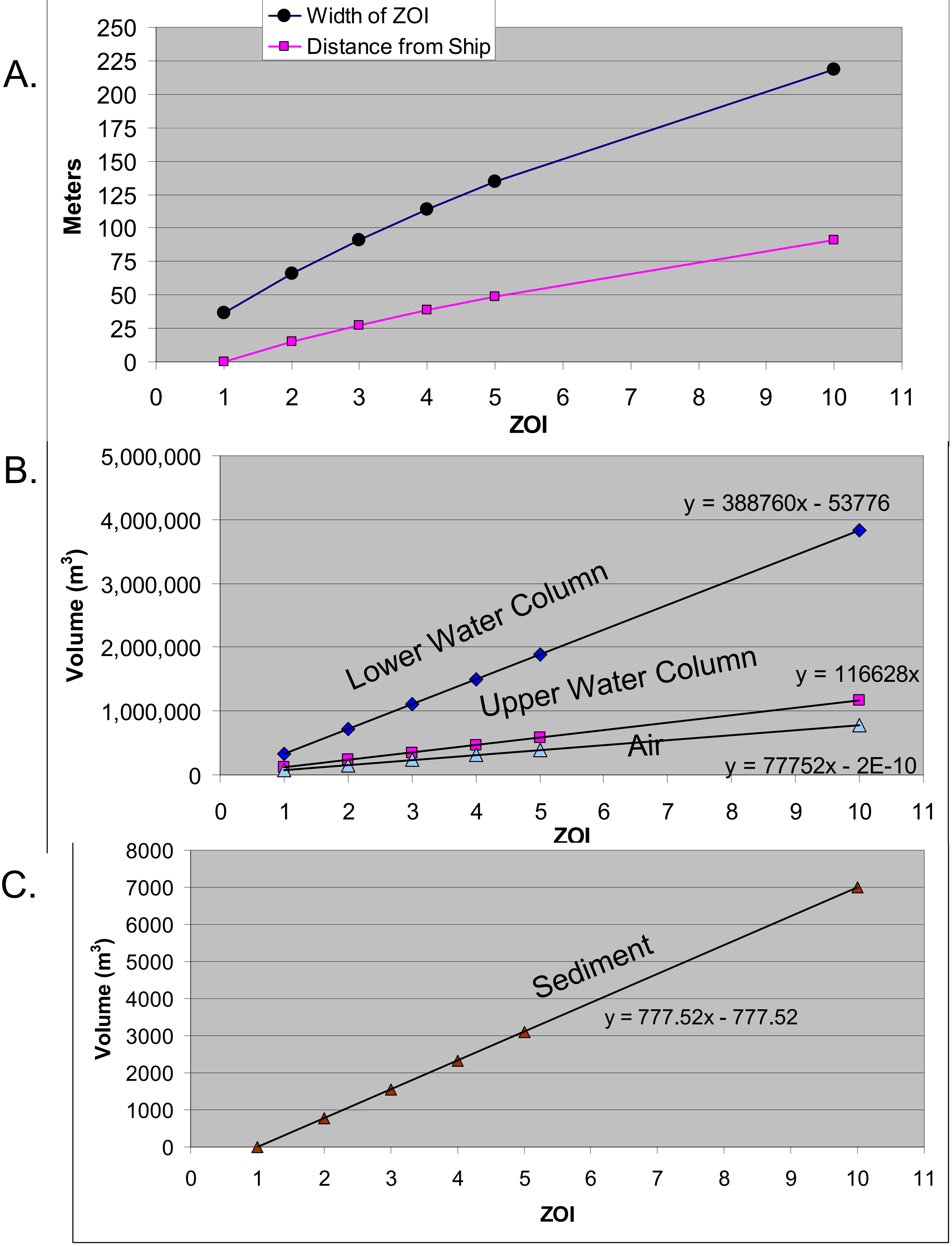


Fig. B-1. The change in physical dimensions of PRAM as a function of ZOI for distance from ship (A), the volumes of the upper and lower water columns (B), and the sediment bed (C). The interior vessel volume remains constant at 5.38 x 10^4 m^3.

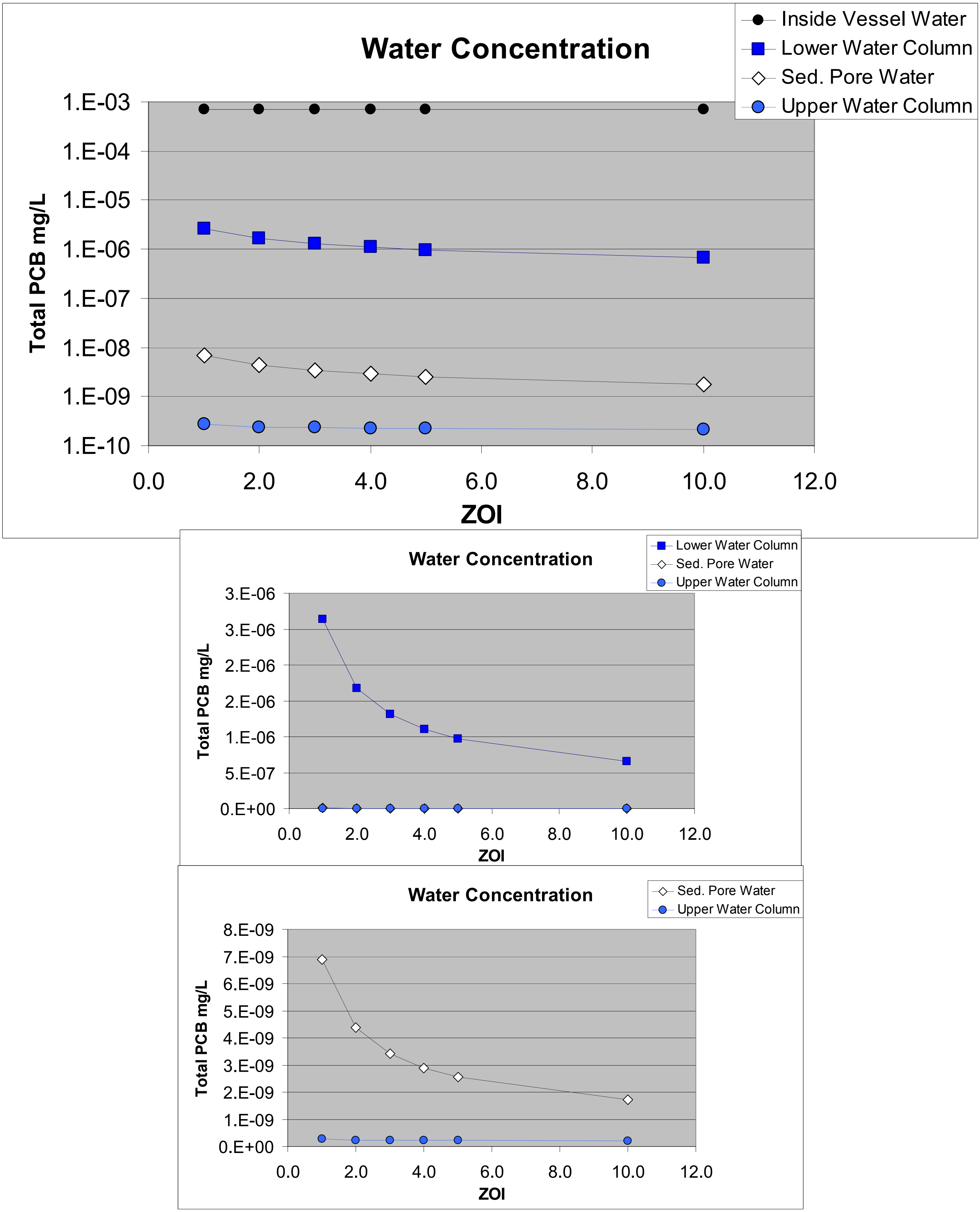
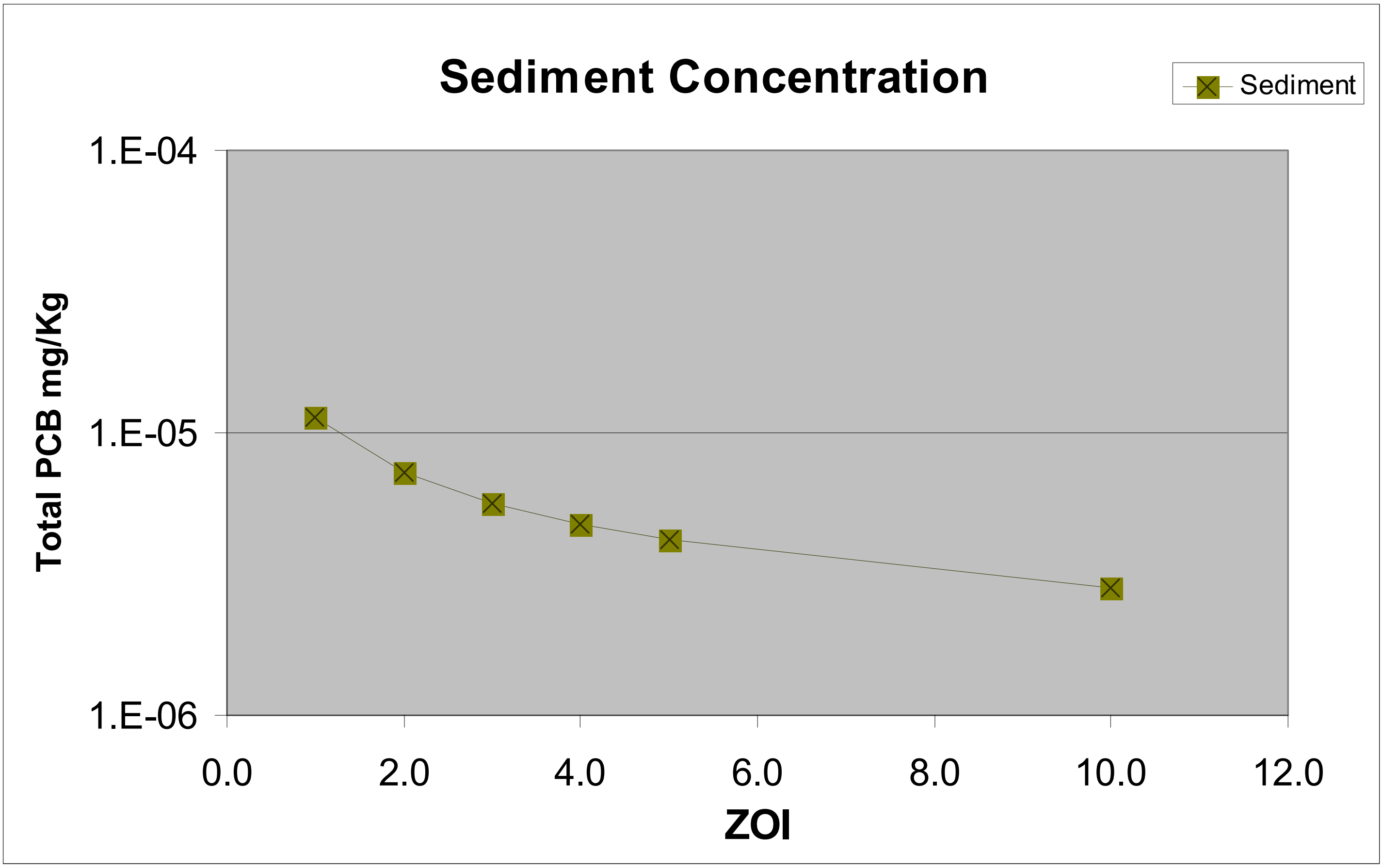


Fig. B-2. Changes in Total PCB concentration in bulk water compartments in PRAM as a function of changing ZOI. Note that the concentration of Total PCB inside the vessel did not change as a function of ZOI.



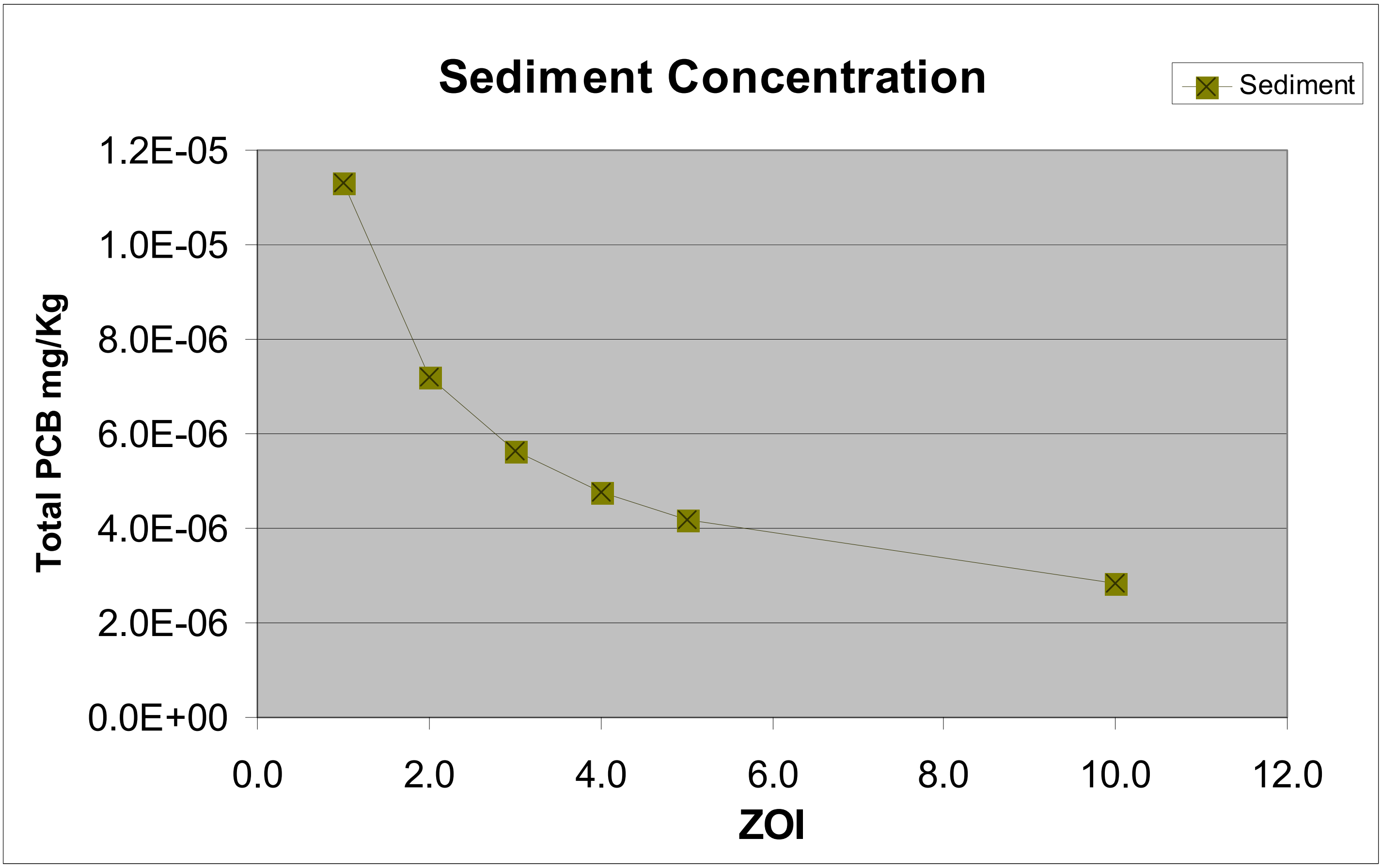
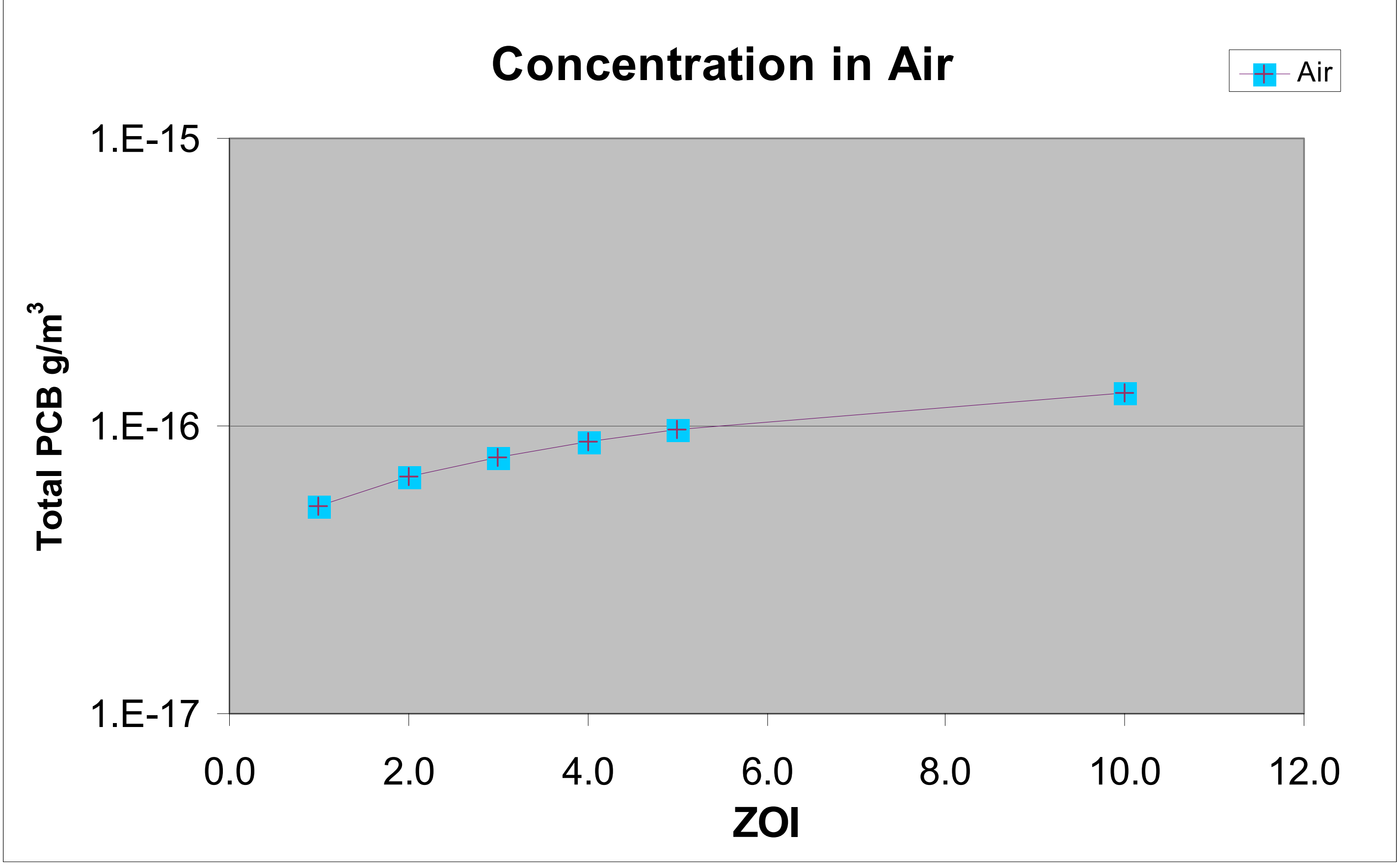


Fig. B-3. Concentrations of Total PCB in the bulk sediment compartment of PRAM as a function of ZOI.



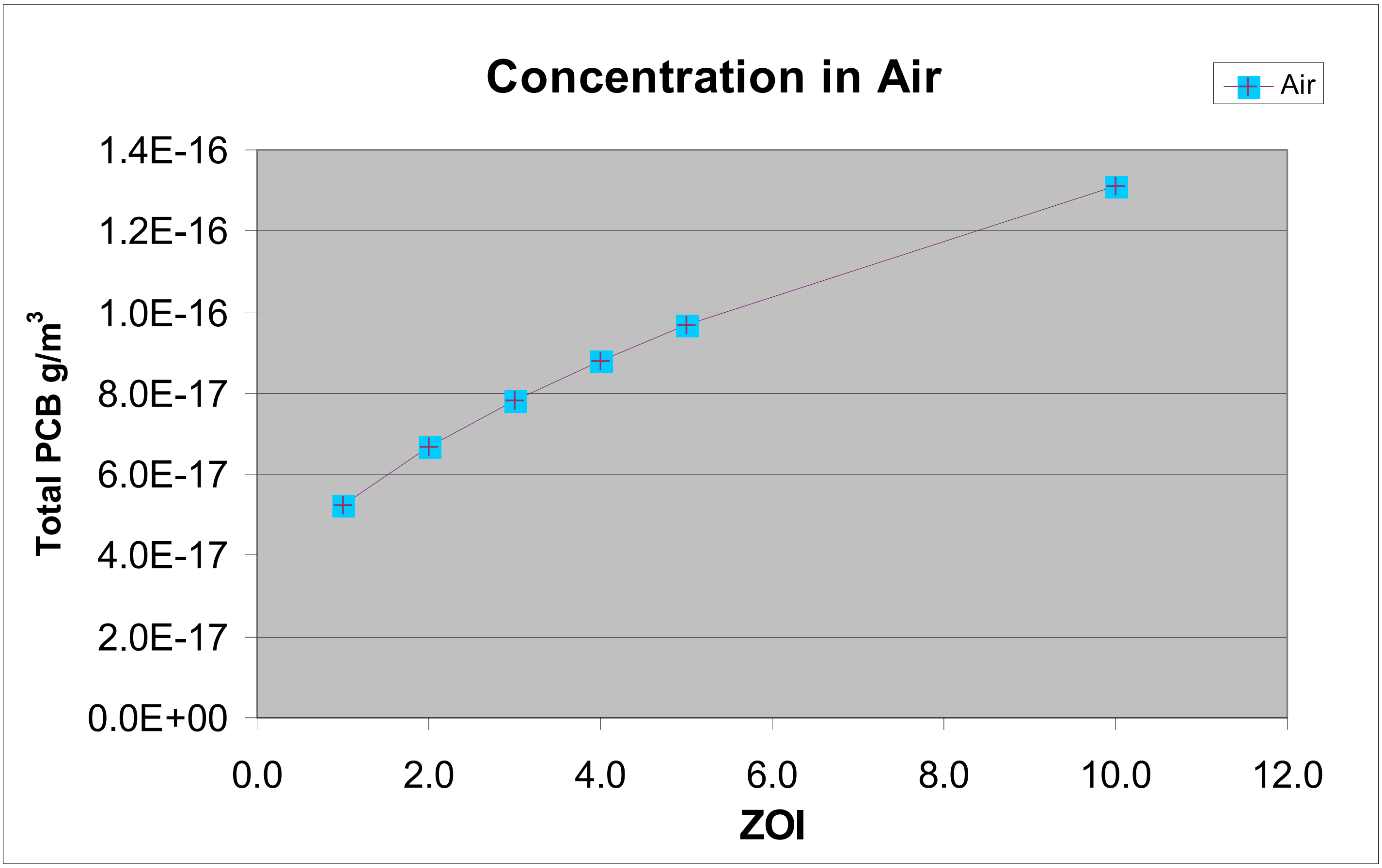


Fig. B-4. The concentration of Total PCB in the air compartment of PRAM as a function of ZOI.

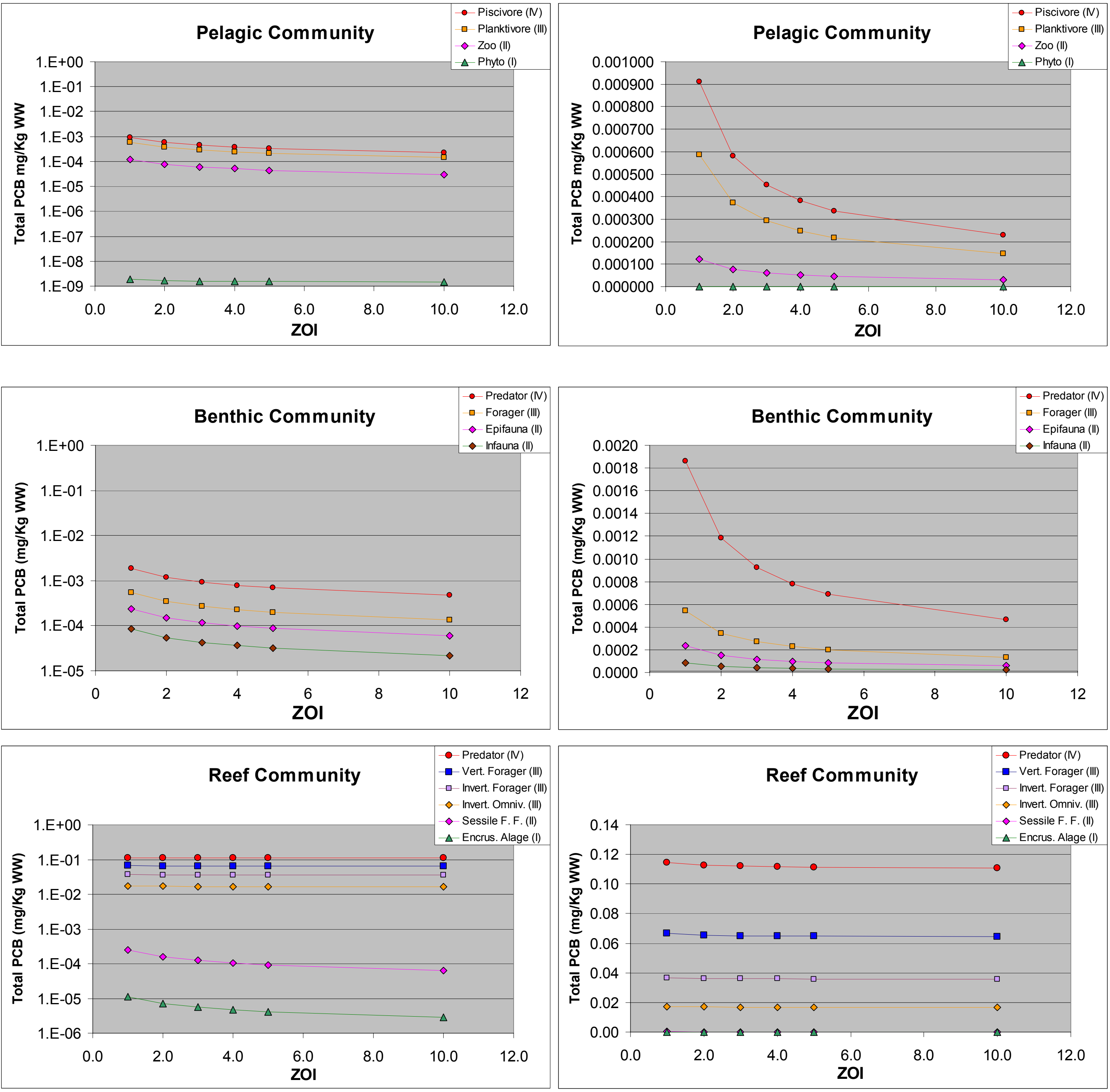


Fig. B-5. Change in concentration of Total PCB in food chains of pelagic, benthic, and reef communities modeled by PRAM as a function of changes in the ZOI. Data are ploted on log (left panels) and linear (right panels) y-axes.

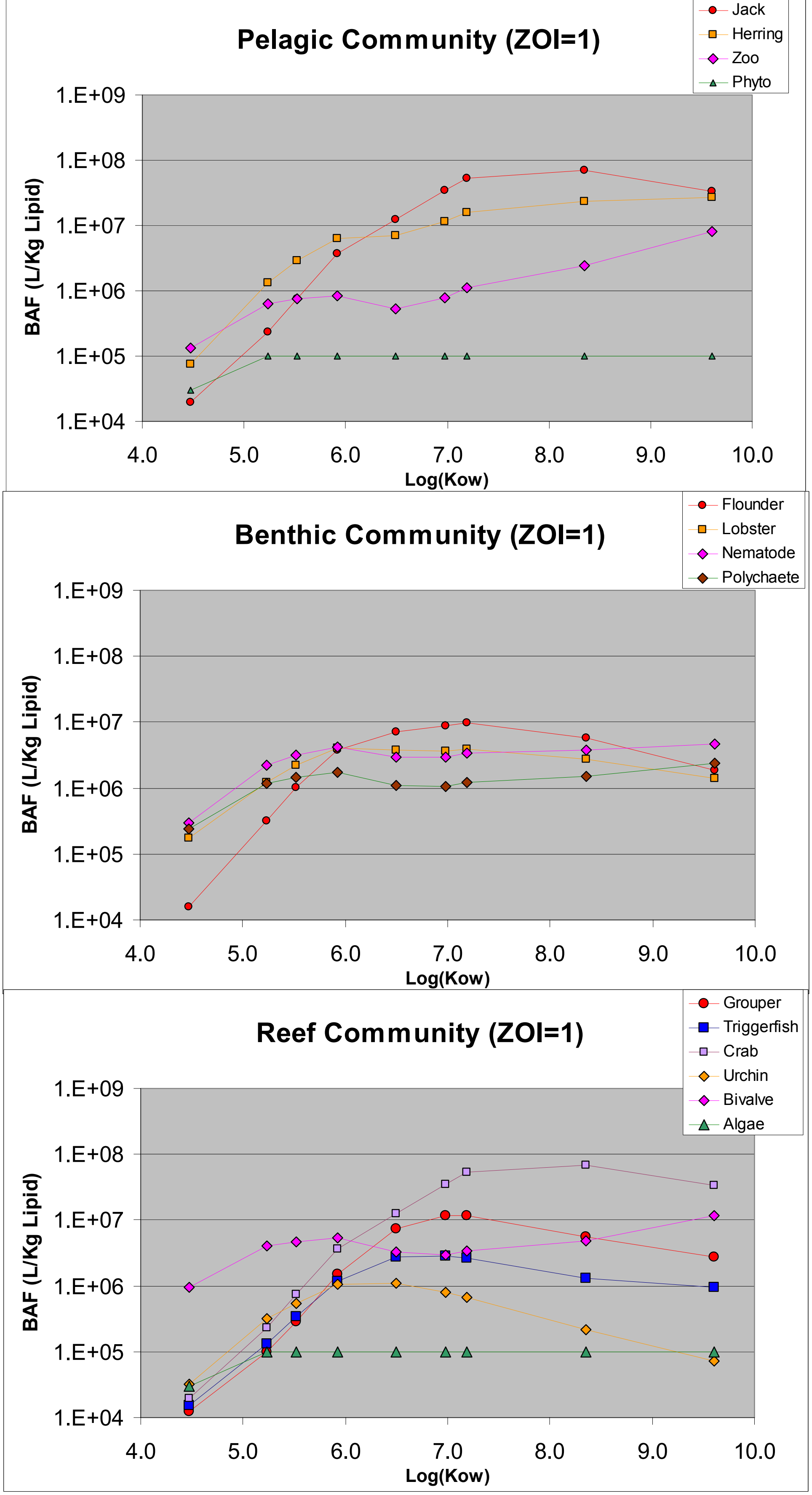


Fig. B-6. The BAF_{LIPID} obtained from PRAM with a ZOI=1 for the components of the pelagic, benthic, and reef communities as a function of Log(Kow).

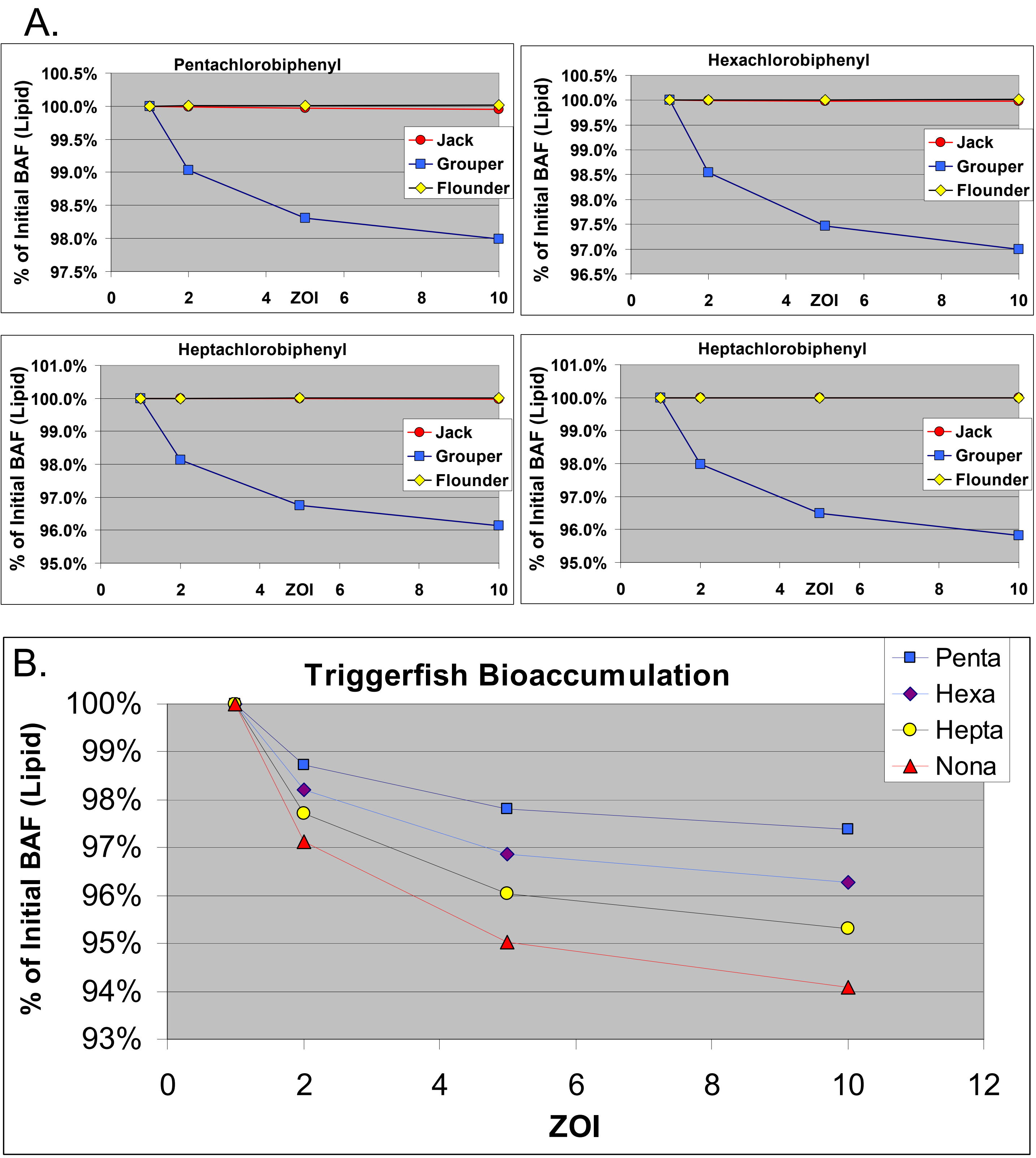


Fig. B-7. Changes in the BAF_{LIPID} for the upper trophic level (TL=IV) fishes (A) and for triggerfish (TL=3, B) as a function of ZOI and homolog.

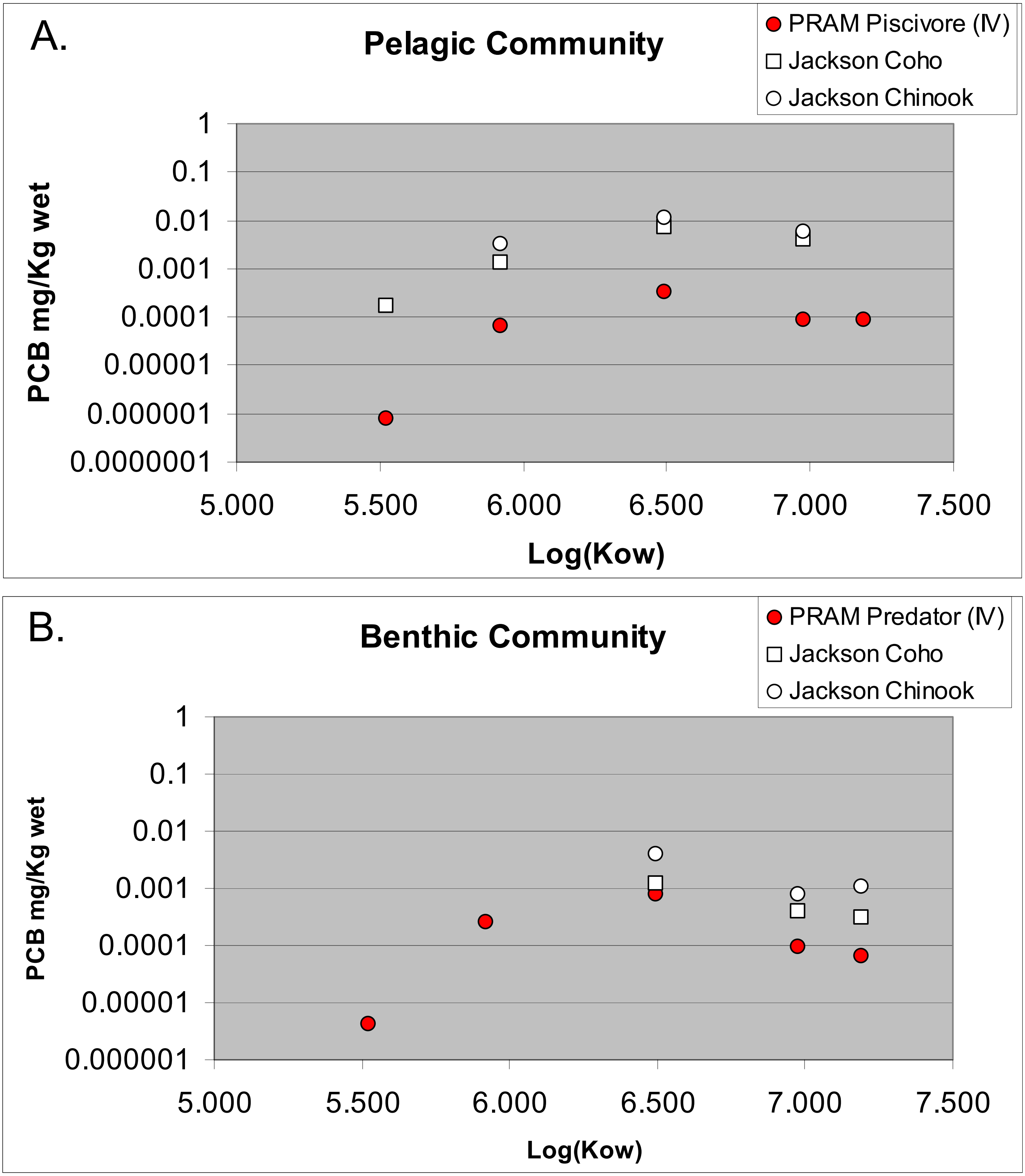


Fig. B-8. PCB homolog concentrations in top predators in the pelagic and benthic food chains predicted by PRAM compared to the concentrations predicted for Coho and Chinook salmon using the slope and intercept of the regressions reported by Jackson et al. 2001.

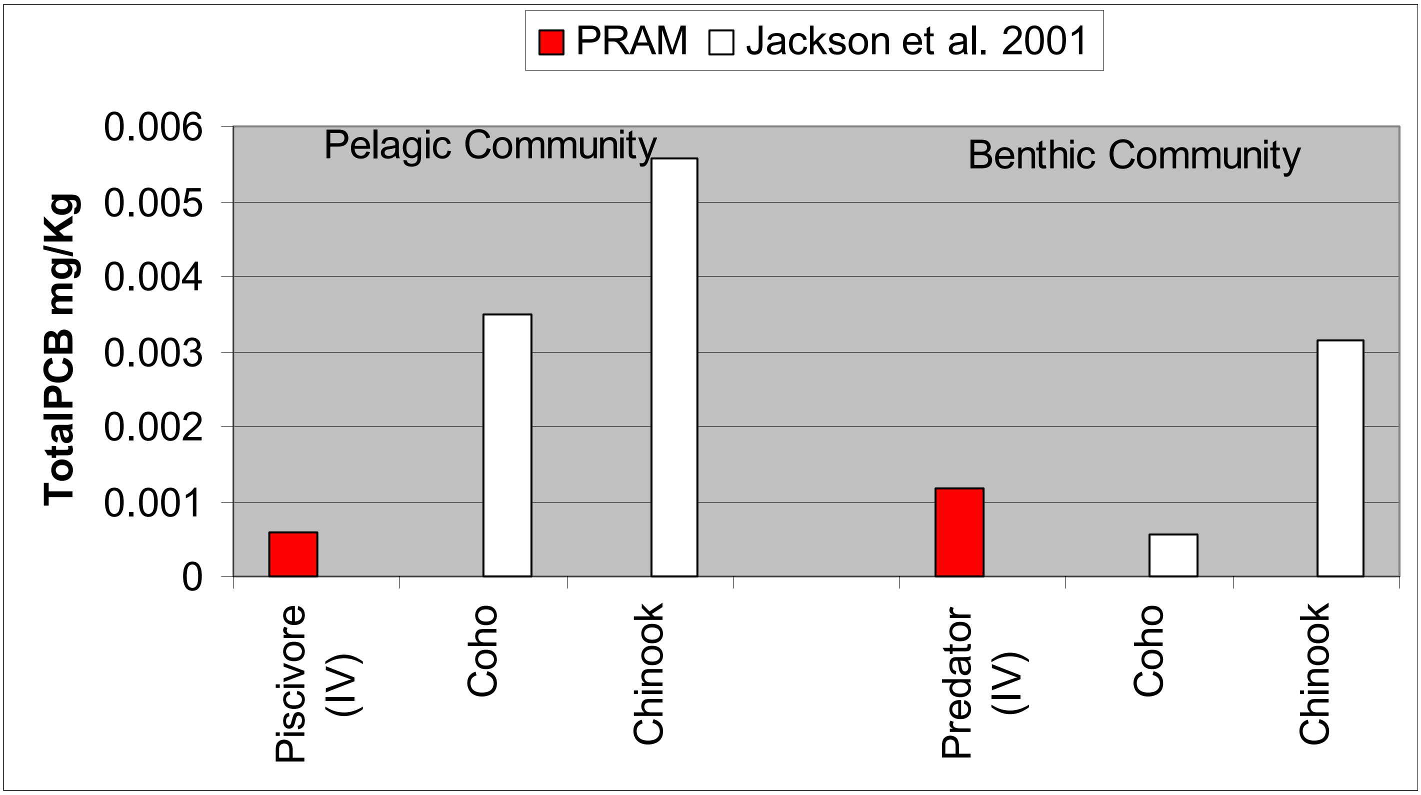
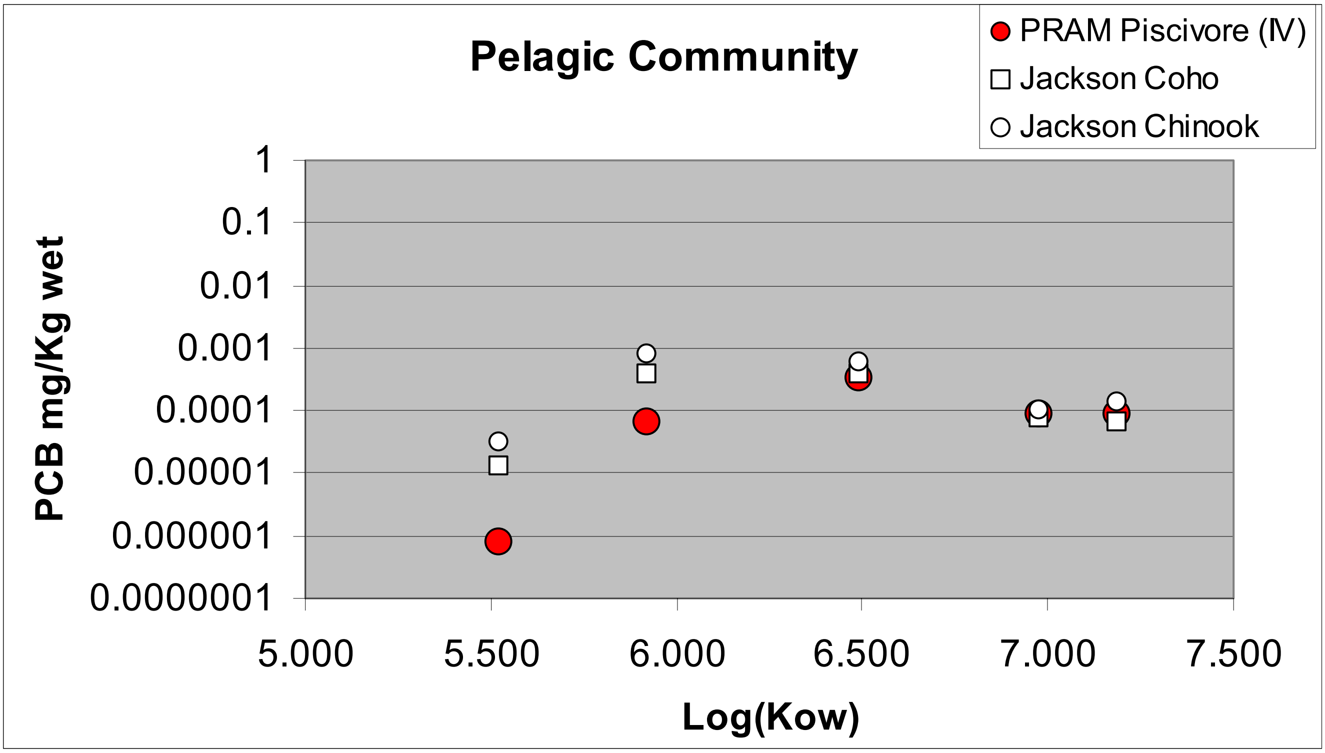


Fig. B-9. Total PCB concentrations in top predators in the Pelagic and Benthic food chains predicted by PRAM compared to the concentrations predicted for Coho and Chinook salmon using the slope and intercept of the regressions reported by Jackson et al. 2001.



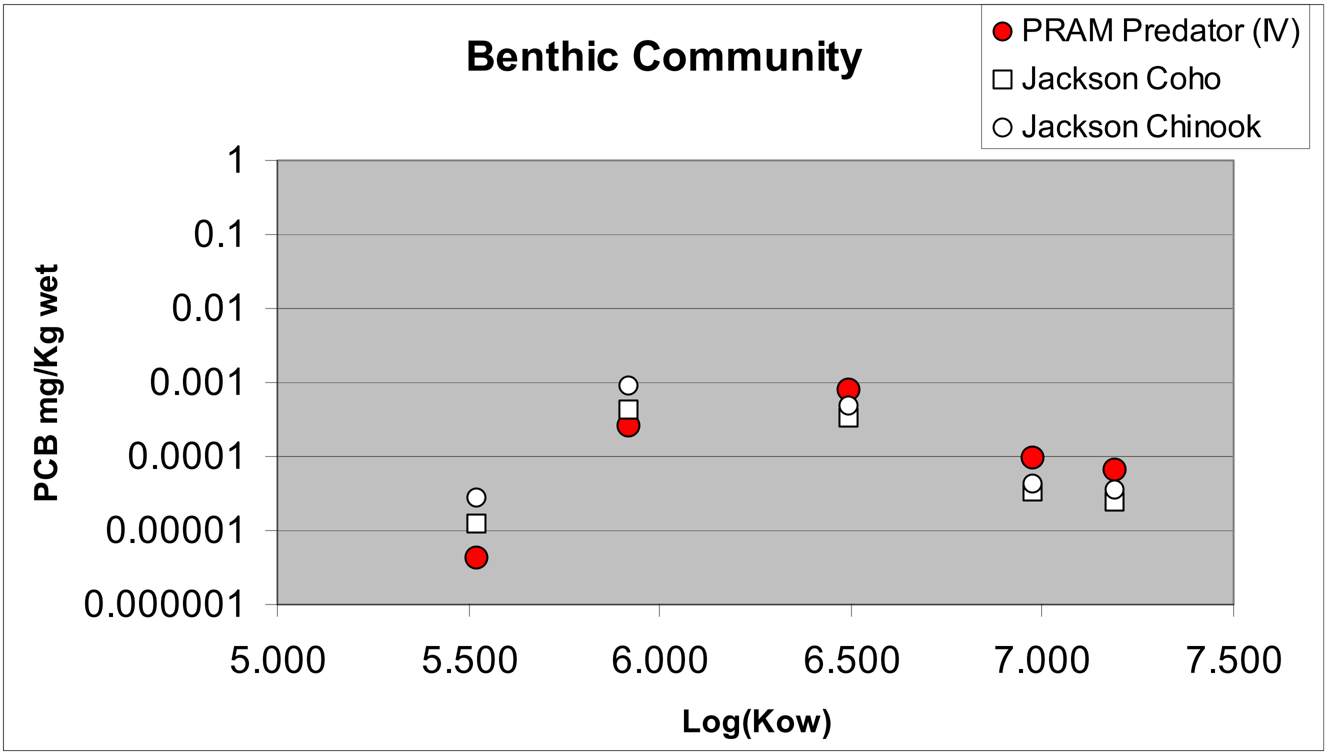


Fig. B-10. PCB homolog concentrations in top predators in the Pelagic and Benthic food chains predicted by PRAM compared to the concentrations predicted for Coho and Chinook salmon using <u>just the slope</u> of the regressions reported by Jackson et al. 2001.

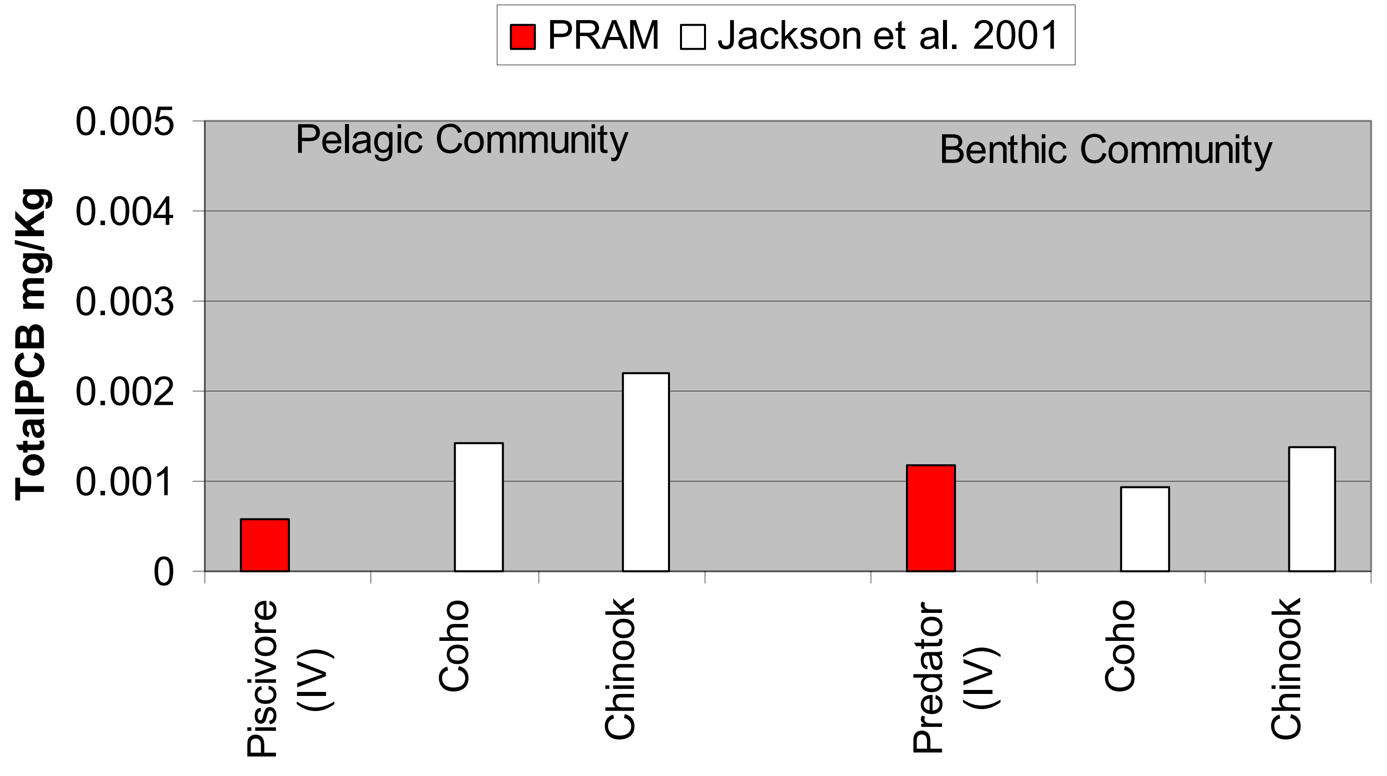


Fig. B-11. Total PCB concentrations in top predators in the Pelagic and Benthic food chains predicted by PRAM compared to the concentrations predicted for Coho and Chinook salmon using <u>just the slope</u> of the regressions reported by Jackson et al. 2001.

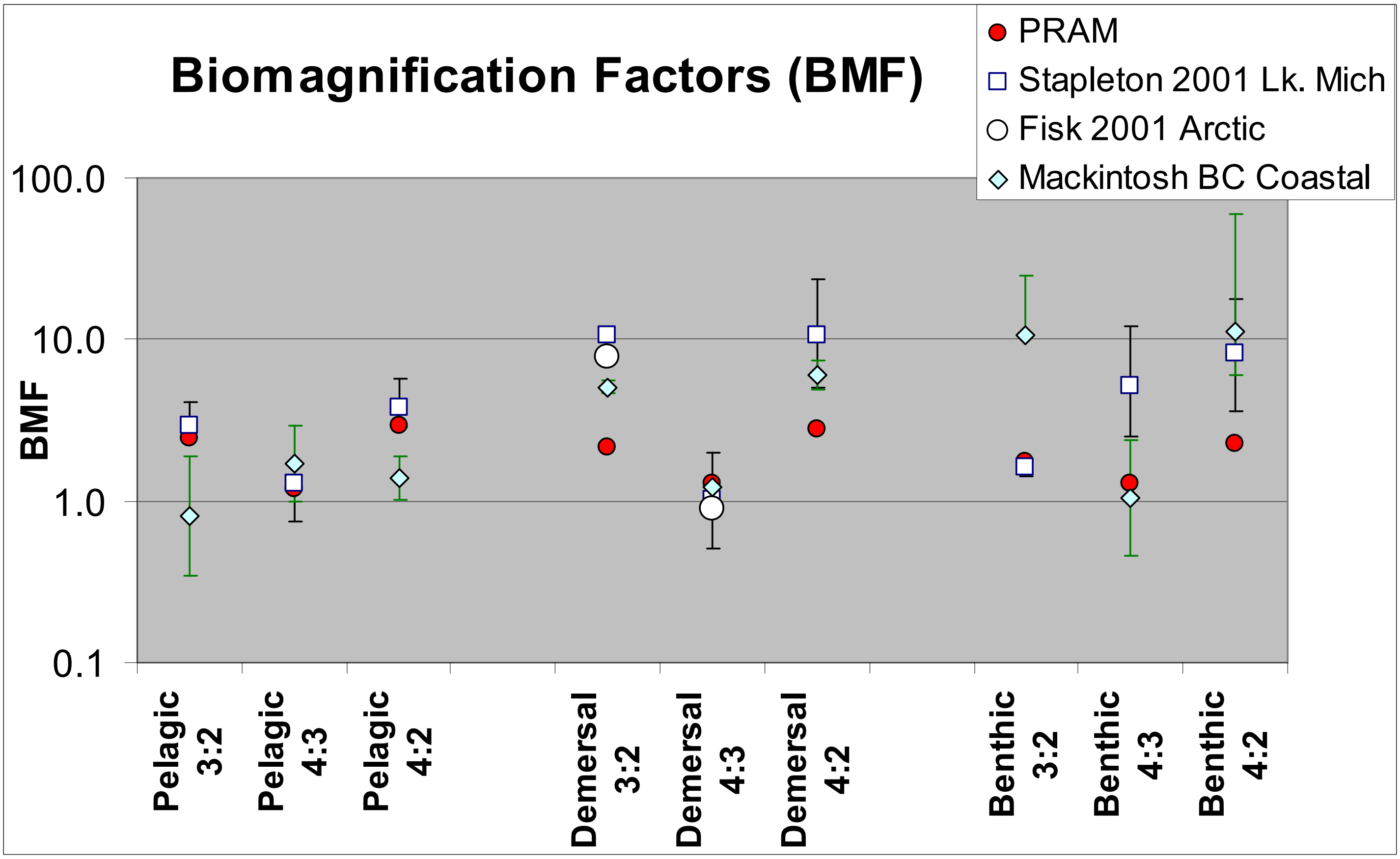


Fig. B-12. Comparison of PCB biomagnification factors (BMF_{TLC}) for trophic levels 3:2, 4:3, and 4:2 predicted by PRAM and observed in pelagic, demersal, and benthic food webs from Grand Traverse Bay, Lake Michigan (Stapleton et al. 2001), False Creek Harbor, Vancouver, BC Canada (Mackintosh et al. 2004), and a demersal food web from the Northwater Polynya, Arctic (Fisk, Hobson, & Norstrom 2001).

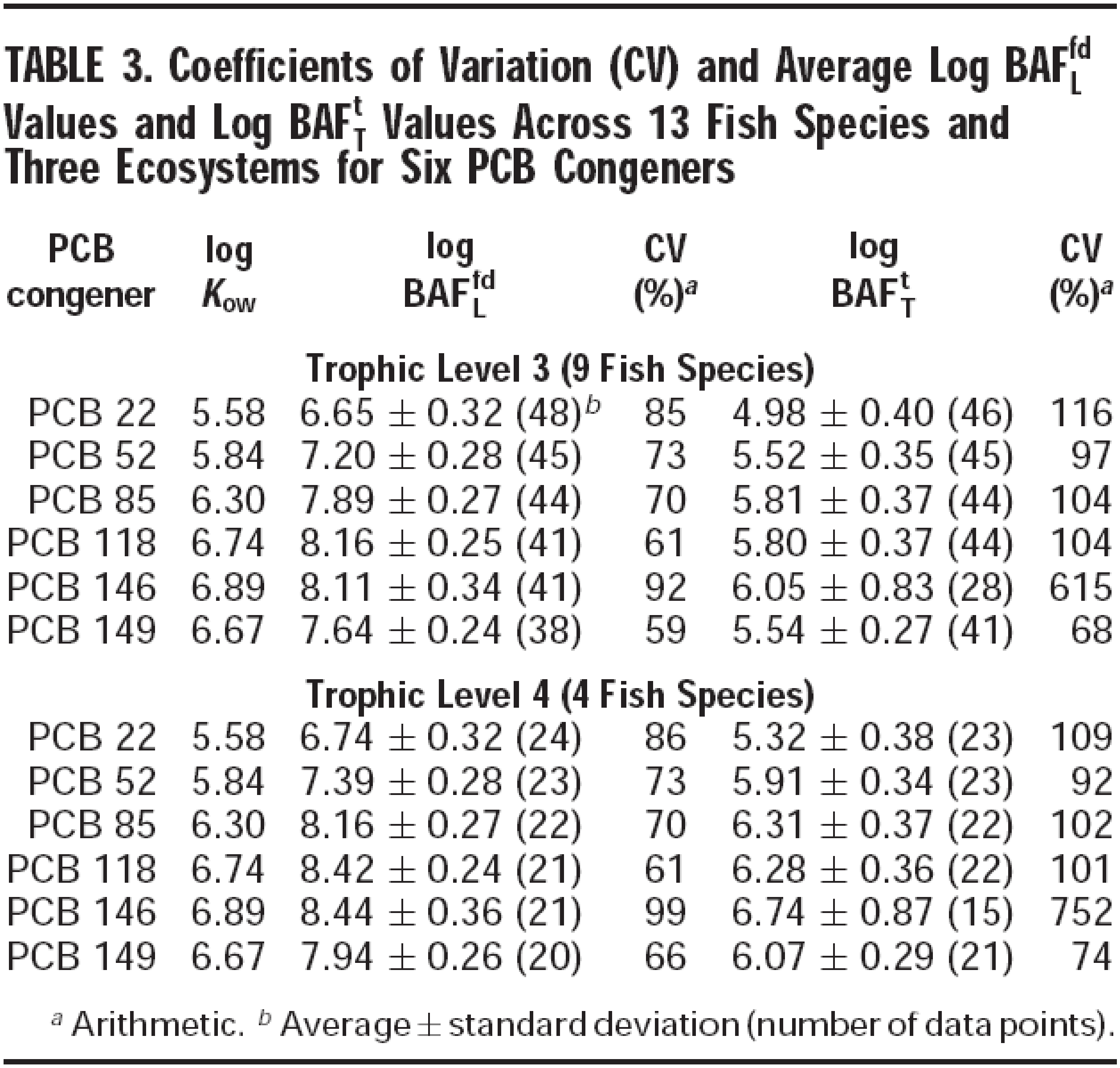
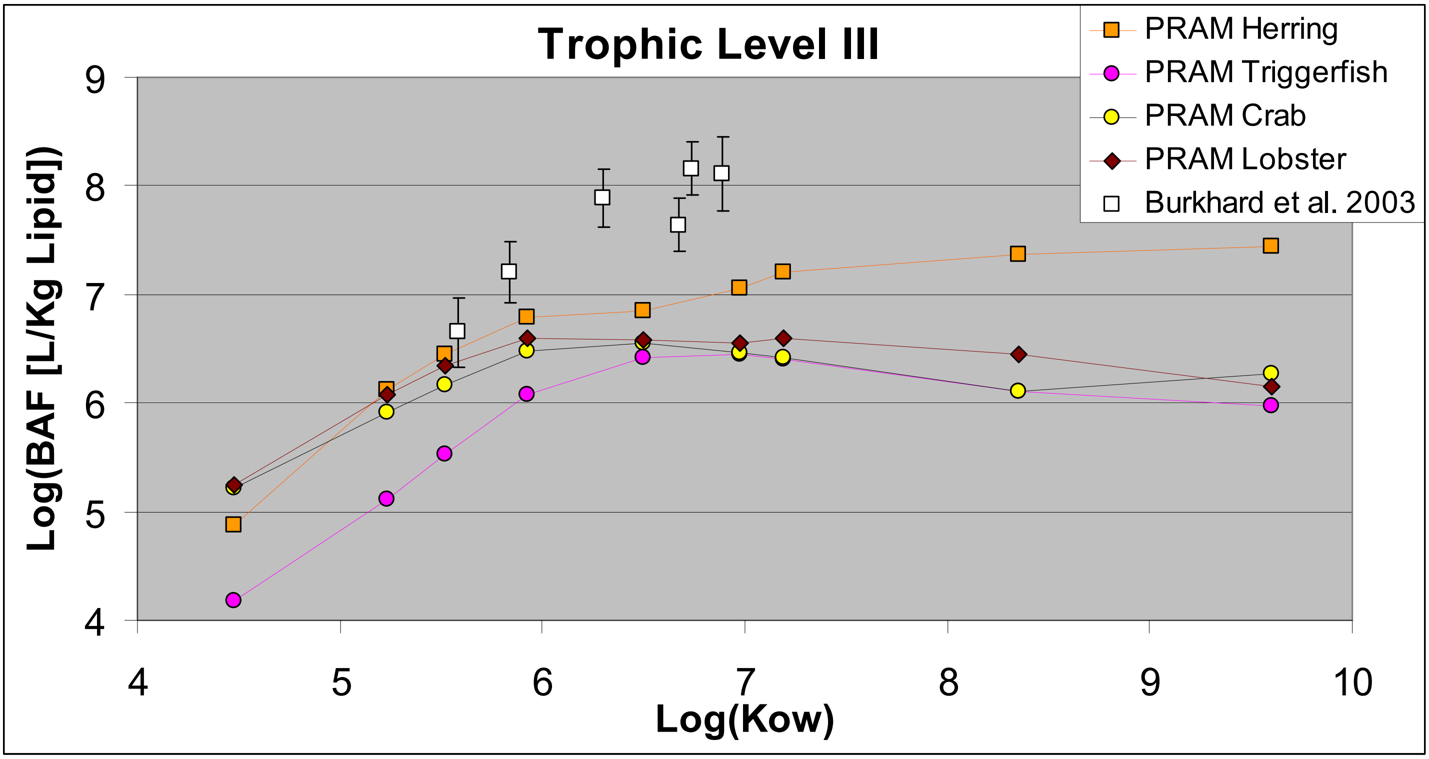


TABLE 3. Coefficients of Variation (CV) and Average Log BAF_L^{fd} Values and Log BAF_T^t Values Across 13 Fish Species and Three Ecosystems for Six PCB Congeners

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. B-13. BAF_{LIPID} s reported for PCB congeners in Burkhard et al. (2003).



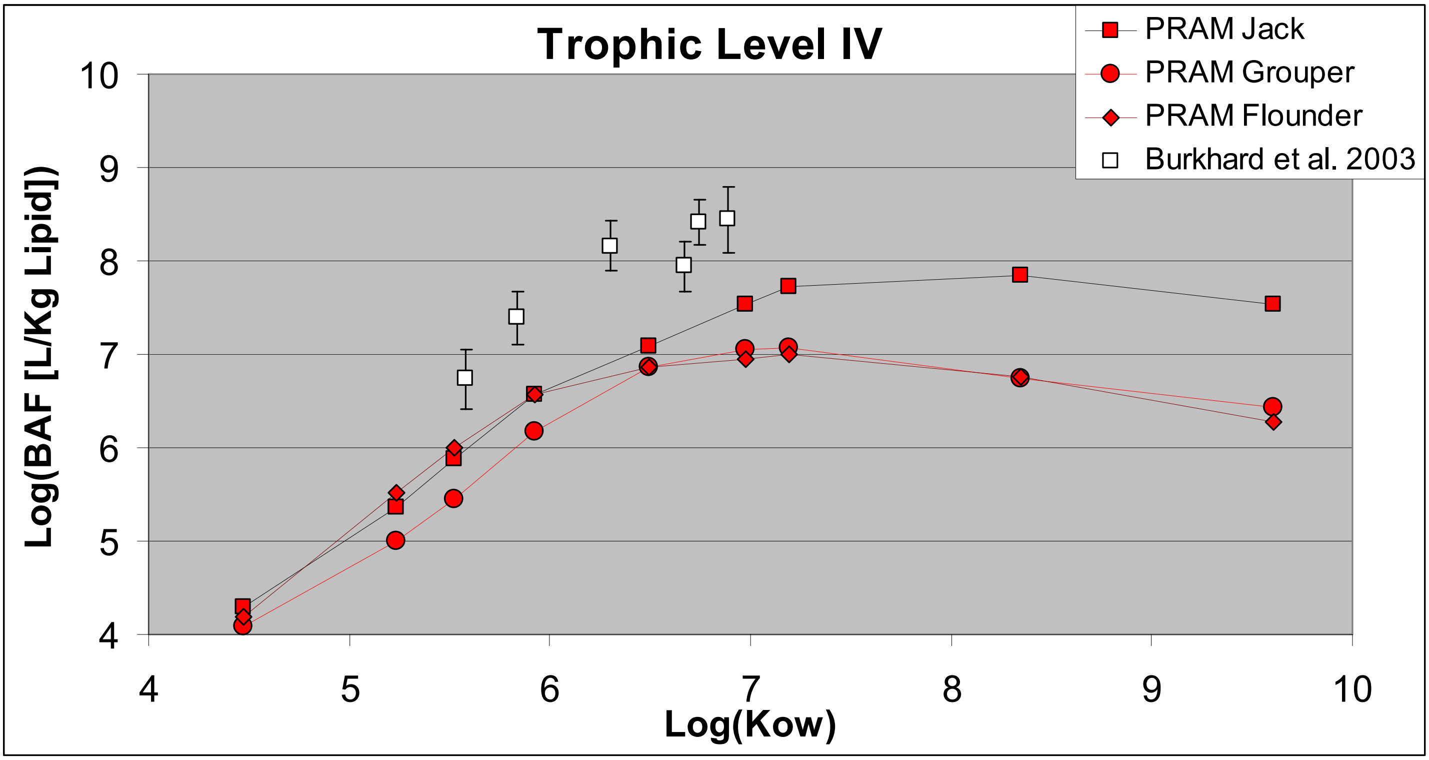


Fig. B-14. Comparison of the lipid-based bioaccumulation factors (BAF_{LIPID} s) predicted by PRAM and BAFs reported in the literature from Green Bay Lake Michigan, the Hudson River, and Lake Ontario for Trophic Level III (A) and Trophic Level IV (B) predators.

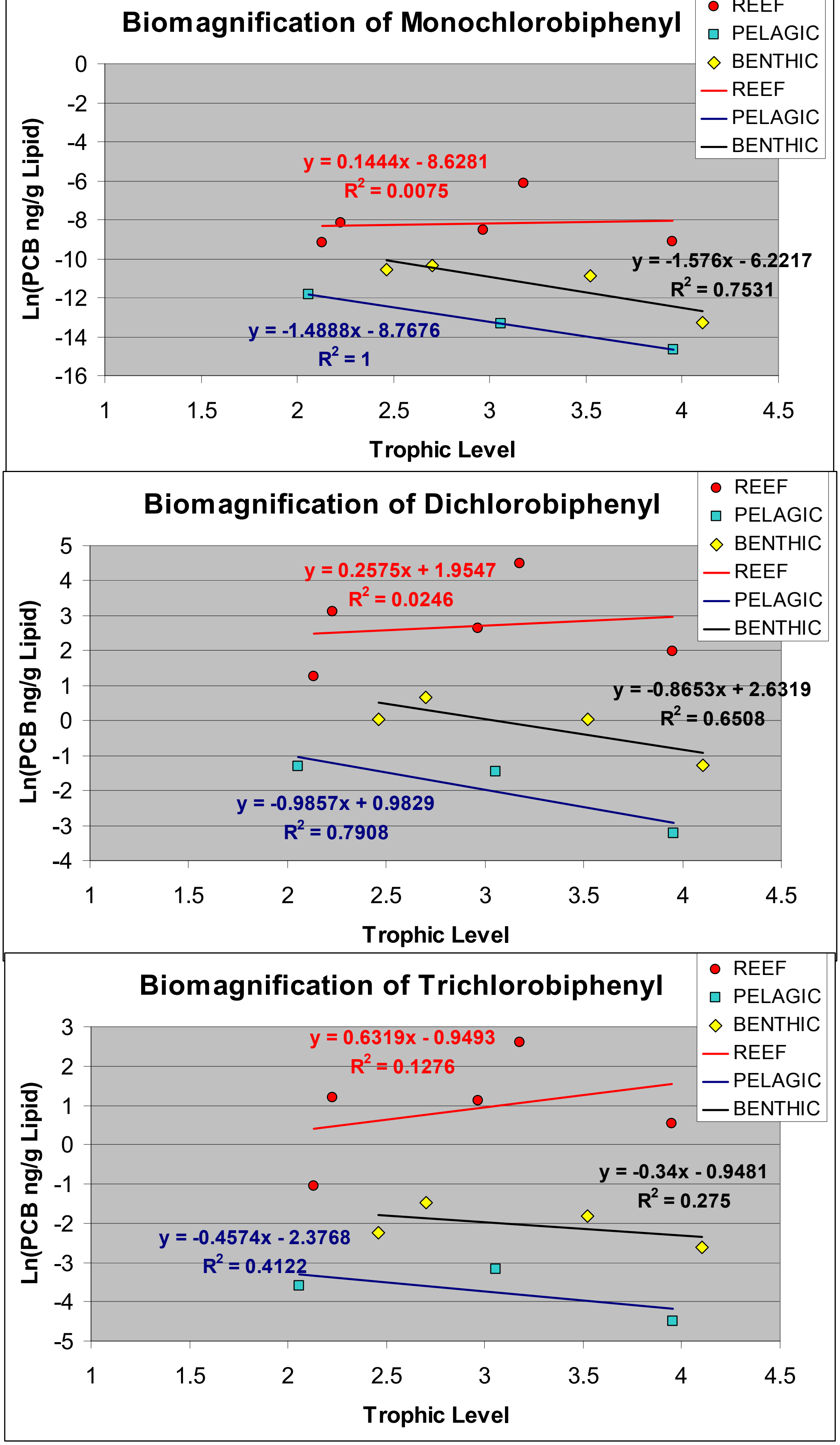


Fig. B-15. Biomagnification of mono-, di-, and trichlorobiphenyl predicted by PRAM.

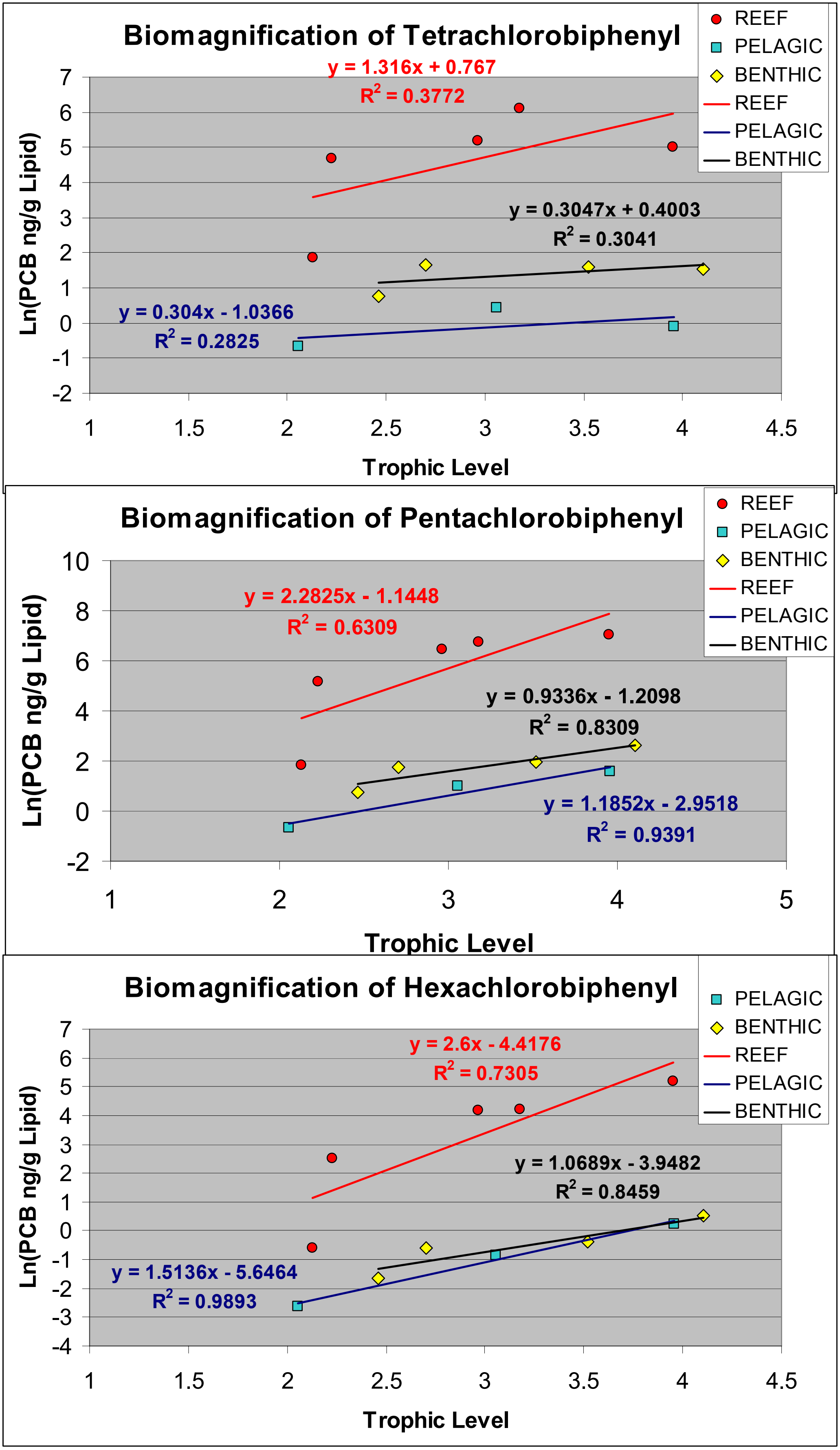


Fig. B-16. Biomagnification of tetra-, penta-, and hexachlorobiphenyl predicted by PRAM.

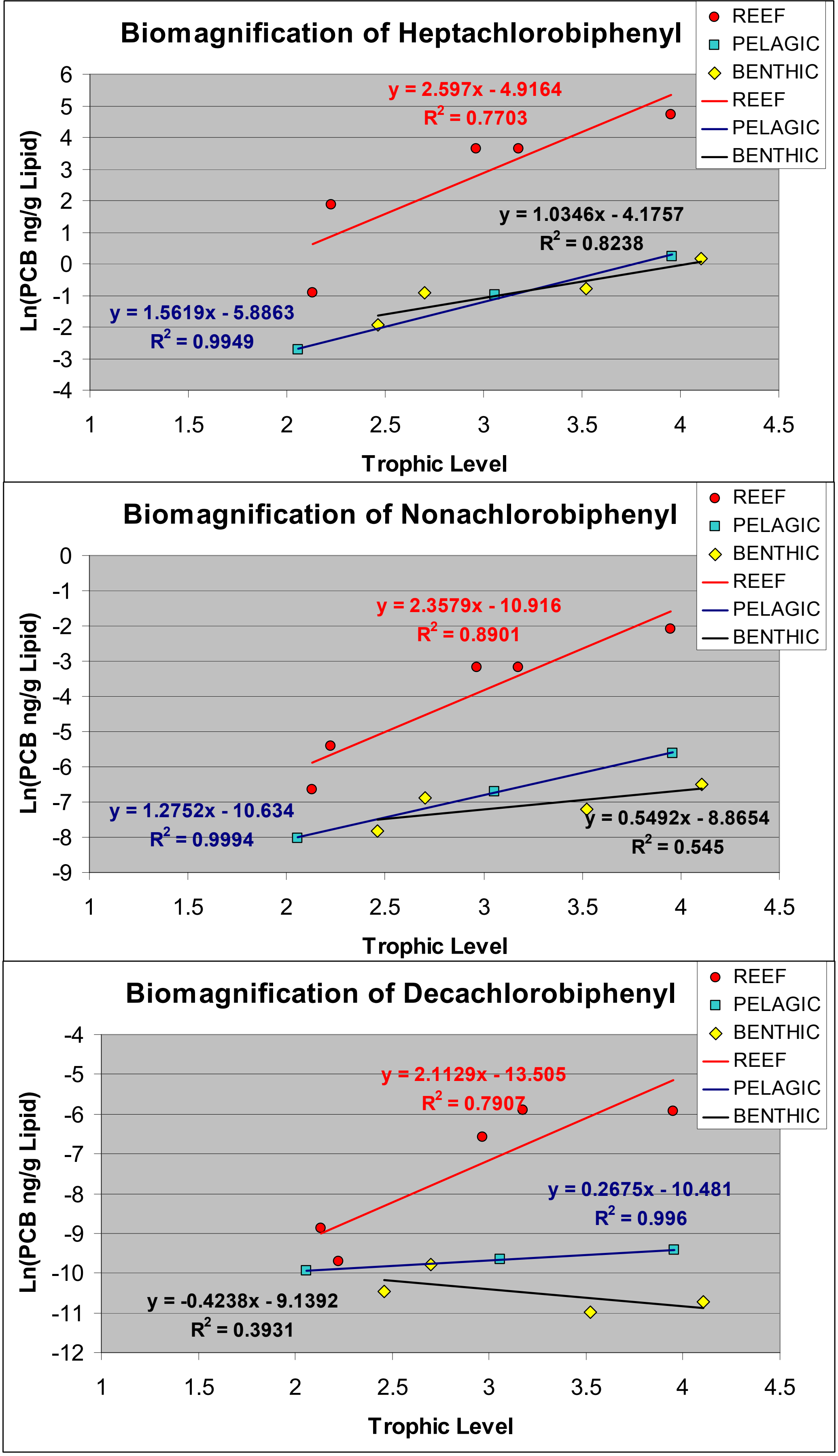
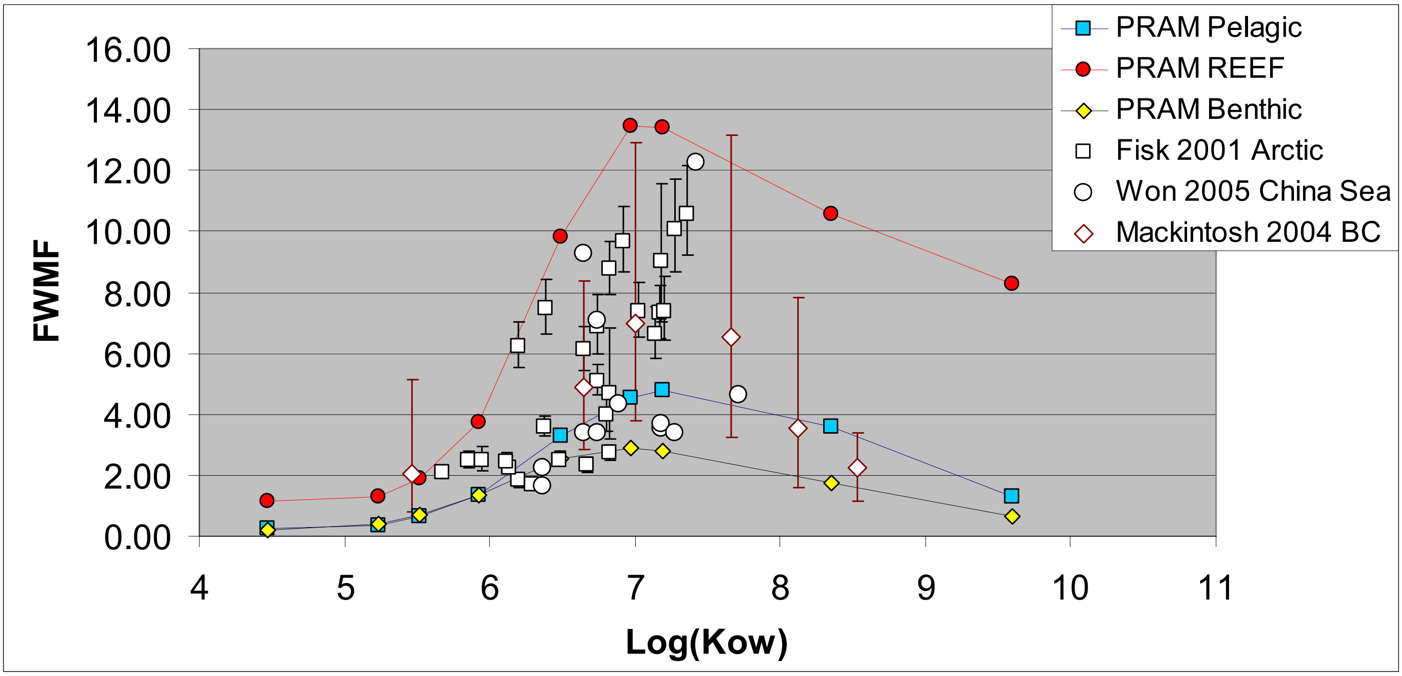


Fig. B-17. Biomagnification of hepta-, nona-, and decachlorobiphenyl predicted by PRAM.



error bars on Mackintosh 2004 are 95th% CL
error bars on Fisk 2001 are +/- 1 Std error

Fig. B-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).

Appendix B References (Please See Section 9 References for references listed in this Appendix)

Appendix B.2 PRAM Output for Varying ZOI

B.2.1 PRAM Output ZOI = 1

Risk Estimate

Supplemental Information

B.2.2 PRAM Default Parameters (ZOI =2)

Risk Estimate

Supplemental Information

B.2.3 PRAM Output ZOI = 3

Risk Estimate

Supplemental Information

B.2.4 PRAM Output ZOI = 4

Risk Estimate

Supplemental Information

B.2.5 PRAM Output ZOI = 5

Risk Estimate

Supplemental Information

B.2.6 PRAM Output ZOI = 10

Risk Estimate

Supplemental Information

B.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

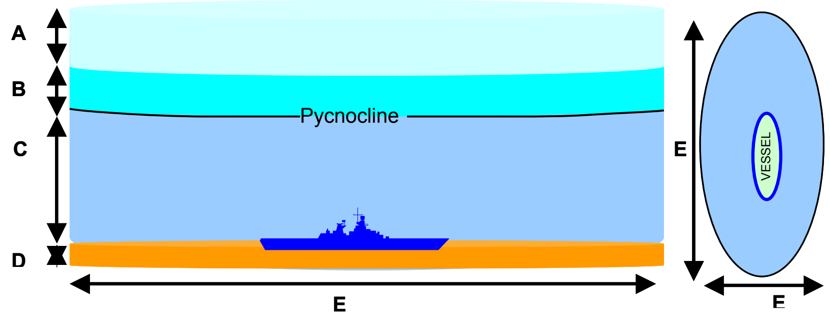
RISK INPUTS - Adult	RME	CTE
Body Weight (BWc) (kg)	70	70
Ingestion Rate (IRc) (kg/day)	0.0261	0.0072
Exposure Duration (EDc) (years)	24	3
Exposure Frequency (EFc) (days)	365	365
Averaging Time for cancer (ATc)	25550	25550
Slope Factor (mg/kg-day)	2	1
Reference dose for PCBs (RfD) (mg/kg-day)	0.00002	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%

PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION
RISK ESTIMATES FOR Ex-Oriskany CV34
Supplemental Information

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

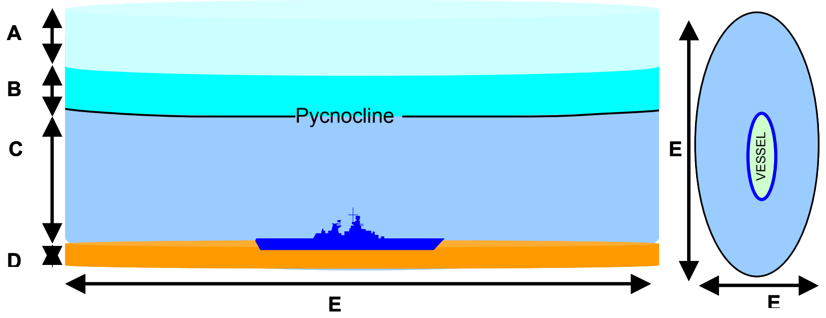
RISK INPUTS - Adult	RME	CTE
Body Weight (BWc) (kg)	70	70
Ingestion Rate (IRc) (kg/day)	0.0261	0.0072
Exposure Duration (EDc) (years)	24	3
Exposure Frequency (EFc) (days)	365	365
Averaging Time for cancer (ATc)	25550	25550
Slope Factor (mg/kg-day)	2	1
Reference dose for PCBs (RfD) (mg/kg-day)	0.00002	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-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
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				Resp. Rate	Resp. Rate	Consumption	Growth Rate	Consumption	Consumption	
Pelagic Community		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-d	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%

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
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
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

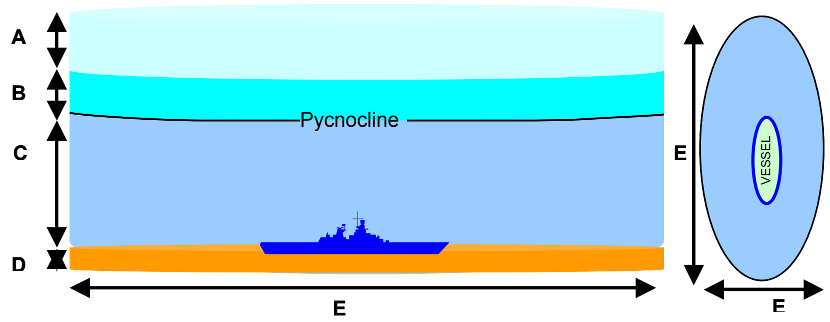
RISK INPUTS - Adult	RME	CTE
Body Weight (BWc) (kg)	70	70
Ingestion Rate (IRc) (kg/day)	0.0261	0.0072
Exposure Duration (EDc) (years)	24	3
Exposure Frequency (EFc) (days)	365	365
Averaging Time for cancer (ATc)	25550	25550
Slope Factor (mg/kg-day)	2	1
Reference dose for PCBs (RfD) (mg/kg-day)	0.00002	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-II)	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%

PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION
RISK ESTIMATES FOR Ex-Oriskany CV34
Supplemental Information

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	0.000847751	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

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

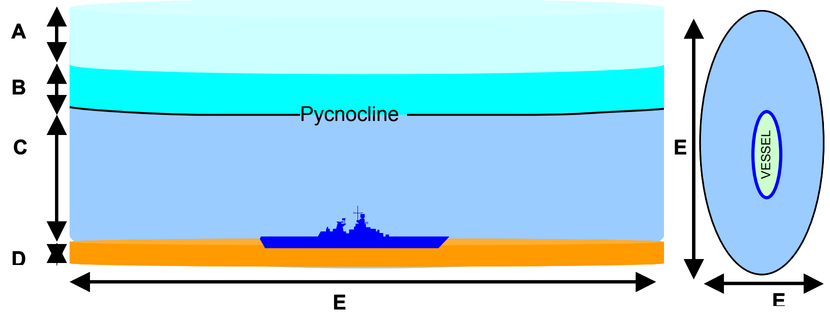
RISK INPUTS - Adult	RME	CTE
Body Weight (BWc) (kg)	70	70
Ingestion Rate (IRc) (kg/day)	0.0261	0.0072
Exposure Duration (EDc) (years)	24	3
Exposure Frequency (EFc) (days)	365	365
Averaging Time for cancer (ATc)	25550	25550
Slope Factor (mg/kg-day)	2	1
Reference dose for PCBs (RfD) (mg/kg-day)	0.00002	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	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)	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

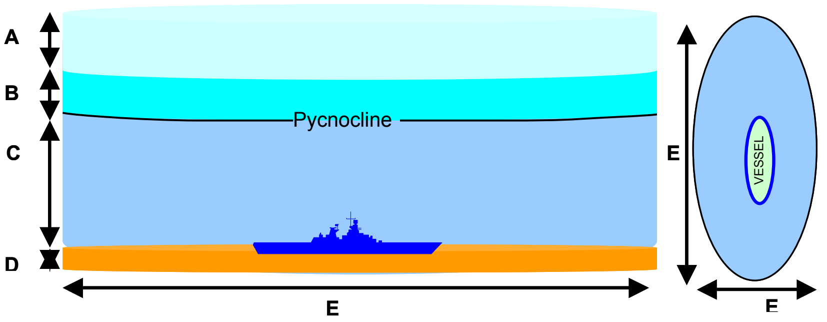
RISK INPUTS - Adult	RME	CTE
Body Weight (BWc) (kg)	70	70
Ingestion Rate (IRc) (kg/day)	0.0261	0.0072
Exposure Duration (EDc) (years)	24	3
Exposure Frequency (EFc) (days)	365	365
Averaging Time for cancer (ATc)	25550	25550
Slope Factor (mg/kg-day)	2	1
Reference dose for PCBs (RfD) (mg/kg-day)	0.00002	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%

PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION
RISK ESTIMATES FOR Ex-Oriskany CV34
Supplemental Information

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

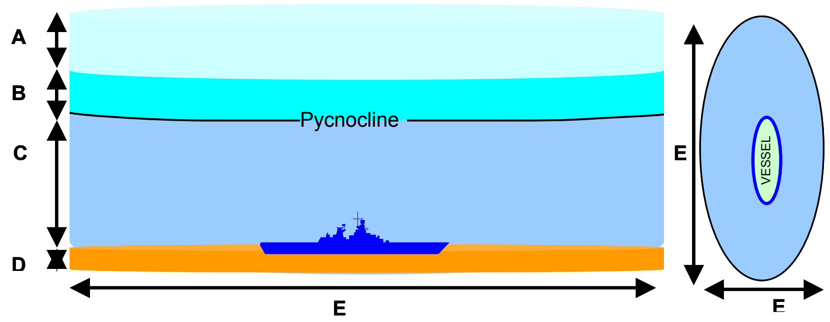
RISK INPUTS - Adult	RME	CTE
Body Weight (BWc) (kg)	70	70
Ingestion Rate (IRc) (kg/day)	0.0261	0.0072
Exposure Duration (EDc) (years)	24	3
Exposure Frequency (EFc) (days)	365	365
Averaging Time for cancer (ATc)	25550	25550
Slope Factor (mg/kg-day)	2	1
Reference dose for PCBs (RfD) (mg/kg-day)	0.00002	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%

PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION
RISK ESTIMATES FOR Ex-Oriskany CV34
Supplemental Information

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	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)	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

Appendix C. Search Results from ERED Database

	Year	Author	Journal	Species	Common Name	Chemical	Conc Wet	Conc Units	Effect	Endpo	Exposure Route	Body Part	Life stage	Comments
	1972	Sanders, H.O., Chandler, J.H.	Bulletin of Environmental Contamination & Toxicology	Orconectes nais	Crayfish	Aroclor 1254	0.04	MG/KG	Mortality	NOED	Combined	Whole Body	Mature	Radiolabeled Compound
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Penaeus duorarum	Shrimp - Pink	PCBs	0.14	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Survival In 48 Hours
Invert. NOED	1991	Velduizen-Tsoerkan, M.B., Holwerda, D.A.,	Arch. Environ. Contam. Toxicol. 20: 259-265	Mytilus edulis	Mussel	PCBs	0.6	MG/KG	Mortality	NA	Combined	Whole Body	Adult	No Significant Decrease In Anoxic Survival Time (control 13 Days)
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	0.76	MG/KG	Growth	NOED	Absorption	Whole Body	Immature	Pcb Dosed With Acetone Carrier; No Effect On Growth (weight or
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	0.76	MG/KG	Growth	NOED	Absorption	Whole Body	Immature	Pcb With No Acetone Carrier; No Effect On Growth (weight or length)
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	0.76	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	Pcb Dosed With Acetone Carrier; No Effect On Mortality
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	0.76	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	Pcb With No Acetone Carrier; No Effect On Mortality
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	0.81	MG/KG	Mortality	NOED	Absorption	Whole Body	Egg-embryo	No Effect On Fry Mortality In 28 Days
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	0.84	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	No Effect On Adult Mortality In 28 Days
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Lagodon rhomboides	Pinfish	PCBs	0.98	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Survival In 48 Hours
	1972	Sanders, H.O., Chandler, J.H.	Bulletin of Environmental Contamination &	Corydalus cornutus	Midge	Aroclor 1254	1.02	MG/KG	Mortality	NOED	Combined	Whole Body	Immature	Radiolabeled Compound
Invert. LOED	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Palaemonetes pugio	Shrimp - Grass	PCBs	1.1	MG/KG	Mortality	LOED	Absorption	Whole Body	Adult	33% Mortality In 96 Hours
	1972	Sanders, H.O., Chandler, J.H.	Bulletin of Environmental Contamination &	Chaoborus punctipennis	Midge	Aroclor 1254	1.2	MG/KG	Mortality	NOED	Combined	Whole Body	Immature	Radiolabeled Compound
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Penaeus duorarum	Shrimp - Pink	PCBs	1.3	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Survival In 48 Hours
	1975	Hogan, J.W., and J.L. Brauhn	The Progressive Fish Culturist 37 (4):229-230	Oncorhynchus mykiss	Trout - Rainbow	Aroclor 1242 or	1.3	MG/KG	Mortality	LOED	NA	Whole Body	Egg	10% Mortality
	1972	Sanders, H.O., Chandler, J.H.	Bulletin of Environmental Contamination &	Pteronarcys dorsata	Giant Black Stonefly	Aroclor 1254	1.4	MG/KG	Mortality	NOED	Combined	Whole Body	Immature	Radiolabeled Compound
	1991	Velduizen-Tsoerkan, M.B., Holwerda, D.A.,	Arch. Environ. Contam. Toxicol. 20: 259-265	Mytilus edulis	Mussel	PCBs	1.4	MG/KG	Mortality	NA	Combined	Whole Body	Adult	Decreased Anoxic Survival Time (control 10.7 Days)
	1991	Velduizen-Tsoerkan, M.B., Holwerda, D.A.,	Arch. Environ. Contam. Toxicol. 20: 259-265	Mytilus edulis	Mussel	PCBs	1.4	MG/KG	Physiolo	NOED	Combined	Whole Body	Adult	No Significant Changes In Adenylate Energy Charge Or
	1973	Sodergren, A., Svensson, B.	Bulletin of Environmental Contamination and	Ephemera danica	Mayfly	PCBs	1.5	MG/KG	Growth	NOED	Combined	Whole Body	Immature	
	1973	Sodergren, A., Svensson, B.	Bulletin of Environmental Contamination and	Ephemera danica	Mayfly	PCBs	1.5	MG/KG	Mortality	NOED	Combined	Whole Body	Immature	
Fish NOED	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	1.5	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	No Effect On Adult Mortality In 28 Days
	1995	Boese, B.L., M. Winsor, H. Lee Li, S.	Environ. Toxicol. Chem. 14:303-310.	Macoma nasuta	Clam - Bent nose	PCBs	1.7	MG/KG	Mortality	NOED	Ingestion	Whole Body	Immature	No Effect On Mortality
Fish LOED 1	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	1.8	MG/KG	Growth	LOED	Absorption	Whole Body	Immature	Pcb With No Acetone Carrier; Enhanced Growth (weight and
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	1.8	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	Pcb With No Acetone Carrier; No Effect On Mortality
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	2.1	MG/KG	Growth	NOED	Absorption	Whole Body	Immature	Pcb With No Acetone Carrier; No Effect On Growth (weight or length)

	Year	Author	Journal	Species	Common Name	Chemical	Conc Wet	Conc Units	Effect	Endpo	Exposure Route	Body Part	Life stage	Comments
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	2.1	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	Pcb With No Acetone Carrier; No Effect On Mortality
Fish LOED 2	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	2.2	MG/KG	Mortality	LOED	Absorption	Whole Body	Immature	5% Mortality In 96 Hours
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	2.3	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Juvenile Mortality In 28 Days
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	2.3	MG/KG	Growth	LOED	Absorption	Whole Body	Immature	Pcb Dosed With Acetone Carrier; Enhanced Growth (weight only; not
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	2.3	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	Pcb Dosed With Acetone Carrier; No Effect On Mortality
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	2.4	MG/KG	Growth	LOED	Absorption	Whole Body	Immature	Pcb Dosed With Acetone Carrier; Enhanced Growth (weight and
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	2.4	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	Pcb Dosed With Acetone Carrier; No Effect On Mortality
	1972	Sanders, H.O., Chandler, J.H.	Bulletin of Environmental Contamination &	Palaemonetes kadiakensis	Shrimp - Grass	Aroclor 1254	3.2	MG/KG	Mortality	NOED	Combined	Whole Body	Mature	Radiolabeled Compound
	1980	Hawkes, J.W., E.H. Gruger, Jr. and O.P. Olson	Environ. Res. 23:149-161.	Oncorhynchus tshawytscha	Salmon - Chinook	PCBs	3.5	MG/KG	Cellular	LOED	Ingestion	Whole Body	Immature	Structure Changes In Intestine Cells, Increased Exfoliation Of Mucosa, Mucosal Cell Inclusions
	1980	Hawkes, J.W., E.H. Gruger, Jr. and O.P.	Environ. Res. 23:149 161.	Oncorhynchus tshawytscha	Salmon - Chinook	PCBs	3.5	MG/KG	Growth	NOED	Ingestion	Whole Body	Immature	No Effect On Weight Gain
	1979	Broyles, R.H. and M.I. Noveck	Toxicology and Applied Pharmacology 50, 299-	Oncorhynchus tshawytscha	Salmon - Chinook	2,4,6,2`- tetrachl	3.7	MG/KG	Survival	LC28	Combined	Whole Body	Fry	
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Lagodon rhomboides	Pinfish	PCBs	3.8	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Survival In 48 Hours
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Penaeus aztecus	Shrimp - Brown	PCBs	3.8	MG/KG	Mortality	LOED	Absorption	Whole Body	NA	8% Mortality In 96 Hours
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Penaeus duorarum	Shrimp - Pink	PCBs	3.9	MG/KG	Mortality	ED10	Absorption	Whole Body	Immature	100% Mortality After 48 Hours
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Crassostrea virginica	Oyster	PCBs	4	MG/KG	Growth	ED10	Absorption	Whole Body	Adult	Reduction In Shell Growth
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	4.2	MG/KG	Develop	NOED	Absorption	Whole Body	Egg-embryo	No Effect On Fertilization Success, Survival Of Embryos To Hatching,
shark NOED	1983	Westin, D.T., Olney, C.E., Rogers, B.A.	Bull. Environm. Contam. Toxicol. 30: 50-57	Morone saxatilis	Striped Bass	PCBs	4.4	MG/KG	Growth	NOED	Ingestion	Whole Body	Immature	Parental Exposure To Pcbs In Field, Then Post Yolk Absorption
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	4.9	MG/KG	Mortality	NOED	Absorption	Whole Body	Egg-embryo	No Effect On Fry Mortality In 28 Days
	1972	Sanders, H.O., Chandler, J.H.	Bulletin of Environmental Contamination &	Culex tarsalis	Mosquito	Aroclor 1254	5.4	MG/KG	Mortality	NOED	Combined	Whole Body	Immature	Radiolabeled Compound
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	5.4	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	No Effect On Adult Mortality In 28 Days
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	5.9	MG/KG	Mortality	NOED	Absorption	Whole Body	Egg-embryo	No Effect On Fry Mortality In 28 Days
shark LOED	1988	Black, D.E., D.K. Phelps and R.L. Lapan	Mar. Environ. Res. 25:45-62.	Pleuronectes americanus	Winter Flounder	PCBs	7.1	MG/KG	Growth	LOED	Combined	Whole Body	Egg-embryo	Reduced Length And Weight Of Larvae
	1972	Sanders, H.O., Chandler, J.H.	Bulletin of Environmental Contamination &	Gammarus pseudolimnaeu	Amphipod	Aroclor 1254	7.8	MG/KG	Mortality	NOED	Combined	Whole Body	Mature	Radiolabeled Compound
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Crassostrea virginica	Oyster	PCBs	8.1	MG/KG	Growth	NA	Absorption	Whole Body	Immature	19% Reduction In Rate Of Shell Growth
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Crassostrea virginica	Oyster	PCBs	8.1	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Survival In 96 Hours

	Year	Author	Journal	Species	Common Name	Chemical	Conc Wet	Conc Units	Effect	Endp	Exposure Route	Body Part	Life stage	Comments
	1979	Broyles, R.H. and M.I. Noveck	Toxicology and Applied Pharmacology 50, 299-	Salvelinus namaycush	Trout -Lake	2,4,6,2`- tetrachl	8.4	MG/KG	Survival	LC87	Combined	Whole Body	Fry	
	1979	Broyles, R.H. and M.I. Noveck	Toxicology and Applied Pharmacology 50, 299-	Salvelinus namaycush	Trout -Lake	2,4,6,2`- tetrachl	8.6	MG/KG	Survival	LC74	Combined	Whole Body	Fry	
	1979	Broyles, R.H. and M.I. Noveck	Toxicology and Applied Pharmacology 50, 299-	Salvelinus namaycush	Trout -Lake	2,4,6,2`- tetrachl	8.8	MG/KG	Survival	LC17	Combined	Whole Body	Fry	
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	8.9	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Juvenile Mortality In 28 Days
	1979	Broyles, R.H. and M.I. Noveck	Toxicology and Applied Pharmacology 50, 299-	Salvelinus namaycush	Trout -Lake	2,4,6,2`- tetrachl	9.2	MG/KG	Survival	LC50	Combined	Whole Body	Fry	
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	10	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Juvenile Mortality In 28 Days
	1972	Sanders, H.O., Chandler, J.H.	Bulletin of Environmental Contamination &	Daphnia magna	Water flea	Aroclor 1254	10.4	MG/KG	Mortality	NOED	Combined	Whole Body	Mature	Radiolabeled Compound
	1976	Hansen, L.G., W.B. Wiekhorst and J. Simon	J. Fish. Res. Bd. Can. 33:1343-1352.	Ictalurus punctatus	Catfish-Channel	PCBs	10.9	MG/KG	Cellular	NOED	Ingestion	Whole Body	Immature	No Effect On Histopathology Of Liver, Brain, Kidney
	1976	Hansen, L.G., W.B. Wiekhorst and J.	J. Fish. Res. Bd. Can. 33:1343-1352.	Ictalurus punctatus	Catfish-Channel	PCBs	10.9	MG/KG	Mortality	NOED	Ingestion	Whole Body	Immature	No Effect On Mortality
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	11	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Juvenile Mortality In 28 Days
	1977	Neff, J.M., Giam, C.S.	Reference Not Available	Limulus polyphemus	Crab - Horseshoe	Aroclor 1016 or	11.2	MG/KG	Growth	NA	Absorption	Whole Body	Immature	Delayed Molting; Less Than 50% Molted After 96 Days Starting With
	1977	Neff, J.M., Giam, C.S.	Reference Not Available	Limulus polyphemus	Crab - Horseshoe	Aroclor 1016 or	11.2	MG/KG	Mortality	NA	Absorption	Whole Body	Immature	Less Than 50% Mortality Starting With T2-stage Crabs
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	12	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	No Effect On Adult Mortality In 28 Days
	1976	Hansen, L.G., W.B. Wiekhorst and J.	J. Fish. Res. Bd. Can. 33:1343-1352.	Ictalurus punctatus	Catfish-Channel	PCBs	14.3	MG/KG	Growth	LOED	Ingestion	Whole Body	Immature	40% Reduction In Mean Weight
	1976	Hansen, L.G., W.B. Wiekhorst and J.	J. Fish. Res. Bd. Can. 33:1343-1352.	Ictalurus punctatus	Catfish-Channel	PCBs	14.3	MG/KG	Morphol	LOED	Ingestion	Whole Body	Immature	Inreased Size Of Liver
	1976	Hansen, L.G., W.B. Wiekhorst and J. Simon	J. Fish. Res. Bd. Can. 33:1343-1352.	Ictalurus punctatus	Catfish-Channel	PCBs	14.3	MG/KG	Cellular	NOED	Ingestion	Whole Body	Immature	No Effect On Histopathology Of Liver, Brain, Kidney
	1976	Hansen, L.G., W.B. Wiekhorst and J.	J. Fish. Res. Bd. Can. 33:1343-1352.	Ictalurus punctatus	Catfish-Channel	PCBs	14.3	MG/KG	Mortality	NOED	Ingestion	Whole Body	Immature	No Effect On Mortality
	1980	Bengtsson, B.E.	Water Res. 14:681-687.	Phoxinus phoxinus	Minnow	PCBs	15	MG/KG	Reprodu	LOED	Ingestion	Whole Body	Adult	Reduction In Time To Hatch, Fry Death
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Penaeus duorarum	Shrimp - Pink	PCBs	16	MG/KG	Mortality	NA	Absorption	Whole Body	Immature	Lethal To 18 Of 25 Fish In 20 Days
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Lagodon rhomboides	Pinfish	PCBs	17	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Survival In 48 Hours
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	17	MG/KG	Develop	NOED	Absorption	Whole Body	Egg-embryo	No Effect On Fertilization Success, Survival Of Embryos To Hatching,
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	21	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Mortality In 96 Hours
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Palaemonetes pugio	Shrimp - Grass	PCBs	22	MG/KG	Mortality	NA	Absorption	Whole Body	Adult	38% Mortality In 96 Hours
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	22	MG/KG	Mortality	NOED	Absorption	Whole Body	Egg-embryo	No Effect On Fry Mortality In 28 Days
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	22	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	No Effect On Adult Mortality In 28 Days

	Year	Author	Journal	Species	Common Name	Chemical	Conc Wet	Conc Units	Effect	Endp	Exposure Route	Body Part	Life stage	Comments
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Callinectes sapidus	Crab - Blue	PCBs	23	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Survival In 20 Days
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	26	MG/KG	Mortality	NOED	Absorption	Whole Body	Egg-embryo	No Effect On Fry Mortality In 28 Days
	1986	Carlberg, G.E., K. Martinsen, A.	Arch. Environ. Contam. Toxicol. 15:543-548.	Salmo salar	Salmon - Atlantic	PCBs	30	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Mortality
	1990	Borgmann, U., N.P. Norwood, and K.M.	Arch. Environ. Contam. Toxicol., 19:558-564	Hyalella azteca	Amphipod - Freshwater	Aroclor 1242 or	30	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	Radiolabeled Compounds, Exp_conc = 3-100
	1977	Neff, J.M., Giam, C.S.	Reference Not Available	Limulus polyphemus	Crab - Horseshoe	Aroclor 1016 or	31.9	MG/KG	Growth	NA	Absorption	Whole Body	Immature	Delayed Molting; Less Than 50% Molted After 96 Days Starting With
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Crassostrea virginica	Oyster	PCBs	32	MG/KG	Growth	NA	Absorption	Whole Body	Adult	Reduction In Shell Growth
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Crassostrea virginica	Oyster	PCBs	33	MG/KG	Growth	NA	Absorption	Whole Body	Immature	41% Reduction In Rate Of Shell Growth
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Crassostrea virginica	Oyster	PCBs	33	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Survival In 96 Hours
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Penaeus duorarum	Shrimp - Pink	PCBs	33	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Survival In 20 Days
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	38	MG/KG	Mortality	NOED	Absorption	Whole Body	Egg-embryo	No Effect On Fry Mortality In 28 Days
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Penaeus aztecus	Shrimp - Brown	PCBs	42	MG/KG	Mortality	NA	Absorption	Whole Body	NA	43% Mortality In 96 Hours
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Palaemonetes pugio	Shrimp - Grass	PCBs	44	MG/KG	Mortality	NA	Absorption	Whole Body	Adult	93% Mortality In 96 Hours
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	46	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	No Effect On Adult Mortality In 28 Days
	1990	Hermens, J.L., S.P. Bradbury and S.J.	Ecotoxicol. Environ. Saf. 20:156-166.	Oncorhynchus mykiss	Trout - Rainbow	PCBs	50	MG/KG	Physiolo	LOED	NA	Whole Body	Immature	Mixed Function Oxidase Induction, Including Benzo(a)pyrene
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	54	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Juvenile Mortality In 28 Days
	1990	Borgmann, U., N.P. Norwood, and K.M.	Arch. Environ. Contam. Toxicol., 19:558-564	Hyalella azteca	Amphipod - Freshwater	PCB 52	54	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	Radiolabeled Compounds, Exp_conc = 3-100
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	57	MG/KG	Mortality	NOED	Absorption	Whole Body	Egg-embryo	No Effect On Fry Mortality In 28 Days
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	65	MG/KG	Mortality	NA	Absorption	Whole Body	Immature	18% Mortality In 96 Hours
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	66	MG/KG	Develop	NOED	Absorption	Whole Body	Egg-embryo	No Effect On Fertilization Success, Survival Of Embryos To Hatching,
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	79	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Juvenile Mortality In 28 Days
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Crassostrea virginica	Oyster	PCBs	95	MG/KG	Growth	NA	Absorption	Whole Body	Adult	Reduction In Shell Growth
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	100	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	No Effect On Adult Mortality In 28 Days
	1990	Hermens, J.L., S.P. Bradbury and S.J.	Ecotoxicol. Environ. Saf. 20:156-166.	Oncorhynchus mykiss	Trout - Rainbow	PCBs	100	MG/KG	Physiolo	NA	NA	Whole Body	Immature	Mixed Function Oxidase Induction, Including Benzo(a)pyrene
	1972	Lowe, J.I., P.R. Parrish, J.M. Patrick, Jr. and J. Forester	Mar. Biol. 17:209-214.	Crassostrea virginica	Oyster	PCBs	101	MG/KG	Cellular	NOED	Absorption	Whole Body	Immature	No Effect On Histopathology Of Digestive Diverticulata
	1972	Lowe, J.I., P.R. Parrish, J.M. Patrick,	Mar. Biol. 17:209-214.	Crassostrea virginica	Oyster	PCBs	101	MG/KG	Growth	NOED	Absorption	Whole Body	Immature	No Effect On Growth

	Year	Author	Journal	Species	Common Name	Chemical	Conc Wet	Conc Units	Effect	Endpo	Exposure Route	Body Part	Life stage	Comments
	1972	Lowe, J.I., P.R. Parrish, J.M. Patrick,	Mar. Biol. 17:209-214.	Crassostrea virginica	Oyster	PCBs	101	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Mortality
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	106	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	50% Mortality
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	106	MG/KG	Cellular	LOED	Absorption	Whole Body	Immature	Liver And Pancreatic Cell Alterations
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	106	MG/KG	Mortality	LOED	Absorption	Whole Body	Immature	Statistically Significant Increase In Mortality
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	110	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	No Effect On Adult Mortality In 28 Days
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	111	MG/KG	Cellular	NOED	Absorption	Whole Body	Immature	No Incidence Of Pathology (liver And Pancreatic Alterations)
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	111	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Statistically Significant Increase In Mortality
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	111	MG/KG	Physiolo	NOED	Absorption	Whole Body	Immature	No Reduced Ability To Survive Osmotic Stress After Exposure
	1985	Freitag, D., L. Ballhorn, H. Geyer and F. Korte	Chemosphere 14:1589-1616.	Leuciscus idus	Golden Ide	2,4,6,2`,4`-	116	MG/KG	Mortality	NOED	Absorption	Whole Body	NA	No Effect On Survivorship In 3 Days
	1985	Freitag, D., L. Ballhorn, H. Geyer and F. Korte	Chemosphere 14:1589-1616.	Leuciscus idus	Golden Ide	2,2` - DBCP	121	MG/KG	Mortality	NOED	Absorption	Whole Body	NA	No Effect On Survivorship In 3 Days
	1985	Freitag, D., L. Ballhorn, H. Geyer and F. Korte	Chemosphere 14:1589-1616.	Leuciscus idus	Golden Ide	2,4,6,2`-tetrachl	158	MG/KG	Mortality	NOED	Absorption	Whole Body	NA	No Effect On Survivorship In 3 Days
	1995	Van Wezel, A.P., Punte, S.S.,	Environ. Toxicol. Chem. 14: 1579-1585	Pimephales promelas	Fathead minnow	PCB 1	167	MG/KG	Mortality	ED10(	Absorption	Whole Body	Adult	Lethal Body Burden Measured Ir Fish Immediately After Death;
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	170	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Statistically Significant Increase In Mortality
	1980	Bengtsson, B.E.	Water Res. 14:681-687.	Phoxinus phoxinus	Minnow	PCBs	170	MG/KG	Growth	LOED	Ingestion	Whole Body	Adult	Increased Growth
	1980	Bengtsson, B.E.	Water Res. 14:681-687.	Phoxinus phoxinus	Minnow	PCBs	170	MG/KG	Mortality	LOED	Ingestion	Whole Body	Adult	Doubling Of Mortality Rate Compared To Controls After 300
	1980	Bengtsson, B.E.	Water Res. 14:681-687.	Phoxinus phoxinus	Minnow	PCBs	170	MG/KG	Reprodu	NA	Ingestion	Whole Body	Adult	85% Reduction In Hatchability Of Eggs
	1985	Freitag, D., L. Ballhorn, H. Geyer and F. Korte	Chemosphere 14:1589-1616.	Leuciscus idus	Golden Ide	2,4`-dichloro	178	MG/KG	Mortality	NOED	Absorption	Whole Body	NA	No Effect On Survivorship In 3 Days
	1985	Freitag, D., L. Ballhorn, H. Geyer and F. Korte	Chemosphere 14:1589-1616.	Leuciscus idus	Golden Ide	PCB 31	193	MG/KG	Mortality	NOED	Absorption	Whole Body	NA	No Effect On Survivorship In 3 Days
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	200	MG/KG	Mortality	LOED	Absorption	Whole Body	Egg-embryo	Lethal To 86% Of Fry In 28 Days
	1990	Hermens, J.L., S.P. Bradbury and S.J.	Ecotoxicol. Environ. Saf. 20:156-166.	Oncorhynchus mykiss	Trout - Rainbow	PCBs	200	MG/KG	Physiolo	NA	NA	Whole Body	Immature	Mixed Function Oxidase Induction, Including Benzo(a)pyrene
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	205	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	50% Mortality
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	205	MG/KG	Morpholo	LOED	Absorption	Whole Body	Immature	Darkened Coloration
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	220	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Juvenile Mortality In 28 Days
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	230	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Juvenile Mortality In 28 Days

	Year	Author	Journal	Species	Common Name	Chemical	Conc Wet	Conc Units	Effect	Endp	Exposure Route	Body Part	Life stage	Comments
	1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	250	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	Lethal Body Burden
	1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	250	MG/KG	Morphol	LOED	Absorption	Whole Body	Immature	Color Changes
	1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	253	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	Lethal Body Burden
	1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	256	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	Lethal Body Burden
	1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	271	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	Lethal Body Burden
	1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	293	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	Lethal Body Burden
	1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	324	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	Lethal Body Burden
	1972	Lowe, J.I., P.R. Parrish, J.M. Patrick, Jr. and J. Forester	Mar. Biol. 17:209-214.	Crassostrea virginica	Oyster	PCBs	425	MG/KG	Cellular	LOED	Absorption	Whole Body	Immature	Atrophy Of Digestive Diverticulata
	1972	Lowe, J.I., P.R. Parrish, J.M. Patrick,	Mar. Biol. 17:209-214.	Crassostrea virginica	Oyster	PCBs	425	MG/KG	Growth	LOED	Absorption	Whole Body	Immature	Reduced Growth
	1972	Lowe, J.I., P.R. Parrish, J.M. Patrick,	Mar. Biol. 17:209-214.	Crassostrea virginica	Oyster	PCBs	425	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Mortality
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	620	MG/KG	Mortality	LOED	Absorption	Whole Body	Immature	Statistically Significant Increase In Mortality
	1977	Mayer, F.L., P.M. Mehrle, and H.O.	Arch. Environ. Contam. 5:501-511	Oncorhynchus kisutch	Salmon-coho	PCBs	645	MG/KG	Mortality	ED10	Ingestion	Whole Body	Immature	Radiolabeled - Contam. Food Fed.
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshea d minnow	PCBs	1100	MG/KG	Morphol	LOED	Absorption	Whole Body	Immature	Darkened Body Coloration, Bod Lesions
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshea d minnow	PCBs	1100	MG/KG	Mortality	LOED	Absorption	Whole Body	Immature	88% Juvenile Mortality In 28 Days

Appendix D. Media Concentrations and Hazard Quotients Calculated for 0-2 Years and Steady-State Ecological Risks

D1 Media Concentrations for Total PCB

Total PCB Concentrations Within 0-15 m (ZOI=2, 1) of the Hull

Total PCB Concentrations Within 0-45 m (ZOI=5) of the Hull

Total PCB Concentrations Within 0-60 m (ZOI=5) of the Hull

D2 Hazard Quotients of Total PCB for Media Within 0-15 m of the Hull

D2.1 HQs for 0-2 Years After Sinking

Day 1

Day 7

Day 14

Day 28

Day 180

Day 365

Day 730

D.2.2 HQs for Steady State (ZOI=2, 0-15 m)

D.2.3 HQs for Steady State (ZOI=1, 0 m)

D3 TEQ Tissue Concentrations for ZOI=1

D3.1 Mammalian Coplanar PCBs, TEQs, and HQs

D3.2 Avian Coplanar PCBs, TEQs, and HQs

D3.3 Fish Egg Coplanar PCBs, TEQs, and HQs

Appendix D1.1 Concentrations in tissue and abiotic compartment predicted by the TDM-PRAM model for day 0 - 2 yr for 15 m from the hull and steady concentrations predicted by PRAM with a ZOI=2 and 1.

								Distance from Ship	
0-15 m of Reef	1day	1wk	2wk	1mon	6mon	1yr	2yr	ZOI=2	ZOI=1
Days Since Sinking	1	7	14	28	180	365	730	765	800
Tissue Conc. (mg/kg-WW)	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB
Pelagic Community								**steady state**	
Phytoplankton (TL1)	3.13E-11	4.16E-11	5.35E-11	5.83E-11	4.66E-11	2.14E-11	1.47E-11	1.67E-09	1.86E-09
Zooplankton (TL-II)	4.94E-05	5.75E-05	7.26E-05	6.76E-05	5.34E-05	2.35E-05	1.82E-05	7.72E-05	1.21E-04
Planktivore (TL-III) Herring	2.36E-04	2.74E-04	3.73E-04	3.74E-04	3.12E-04	1.32E-04	8.95E-05	3.74E-04	5.88E-04
Piscivore (TL-IV) Jack	3.03E-04	3.42E-04	4.85E-04	5.28E-04	4.81E-04	1.93E-04	1.35E-04	5.80E-04	9.13E-04
Reef / Vessel Community									
Attached Algae	4.41E-06	5.17E-06	6.64E-06	6.42E-06	5.21E-06	2.24E-06	1.73E-06	7.23E-06	1.14E-05
Sessile filter feeder (TL-II) Bivalve	1.04E-04	1.21E-04	1.53E-04	1.42E-04	1.10E-04	4.89E-05	3.77E-05	1.58E-04	2.49E-04
Invertibrate Omnivore (TL-II) Urchin	2.12E-02	2.48E-02	3.37E-02	3.32E-02	2.70E-02	1.16E-02	7.74E-03	1.69E-02	1.72E-02
Invertibrate Forager (TL-III) Crab	1.87E-02	2.49E-02	3.75E-02	4.55E-02	4.44E-02	2.21E-02	1.66E-02	3.62E-02	3.67E-02
Vertibrate Forager (TL-III) Triggerfish	1.45E-02	1.70E-02	2.37E-02	3.20E-02	5.68E-02	3.04E-02	3.01E-02	6.55E-02	6.66E-02
Predator (TL-IV) Grouper	1.35E-02	1.57E-02	2.23E-02	2.37E-02	4.84E-02	3.52E-02	5.15E-02	1.13E-01	1.15E-01
Benthic Community									
Infaunal invert. (TL-II)	3.61E-05	4.22E-05	5.37E-05	5.01E-05	3.92E-05	1.74E-05	1.32E-05	5.48E-05	8.62E-05
Epifaunal invert. (TL-II)	1.00E-04	1.17E-04	1.52E-04	1.44E-04	1.14E-04	5.03E-05	3.64E-05	1.51E-04	2.37E-04
Forager (TL-III) Lobster	2.29E-04	2.68E-04	3.61E-04	3.54E-04	2.87E-04	1.24E-04	8.42E-05	3.45E-04	5.42E-04
Predator (TL-IV) Flounder	7.22E-04	8.44E-04	1.20E-03	1.25E-03	1.08E-03	4.49E-04	2.92E-04	1.18E-03	1.86E-03
Air concentration (g/m3)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.68E-17	5.26E-17
Upper Water Column									
Fugacity (Pa)									
Water concentration (mg/L)	1.90E-14	2.53E-14	3.25E-14	3.54E-14	2.83E-14	1.30E-14	8.91E-15	1.02E-12	1.13E-12
Suspended solids concentration (mg/kg)	2.81E-10	3.68E-10	4.62E-10	5.53E-10	5.50E-10	2.32E-10	1.92E-10	1.33E-08	1.48E-08
Dissolved organic carbon (mg/kg)	1.87E-09	2.45E-09	3.08E-09	3.69E-09	3.66E-09	1.55E-09	1.28E-09	1.78E-07	1.98E-07
Bulk Upper Water Col (mg/L)	3.95E-12	5.18E-12	6.50E-12	7.78E-12	7.72E-12	3.27E-12	2.70E-12	2.40E-10	2.67E-10
Lower Water Column									
Fugacity (Pa)									
Water concentration (mg/L)	2.68E-09	3.14E-09	4.03E-09	3.89E-09	3.16E-09	1.36E-09	1.05E-09	4.39E-09	6.90E-09
Suspended solids concentration (mg/kg)	4.42E-05	4.46E-05	5.67E-05	6.04E-05	6.17E-05	2.37E-05	2.20E-05	1.08E-04	1.70E-04
Dissolved organic carbon (mg/kg)	2.95E-04	2.97E-04	3.78E-04	4.03E-04	4.11E-04	1.58E-04	1.47E-04	9.88E-04	1.55E-03
Bulk Lower Water Col (mg/L)	6.22E-07	6.27E-07	7.98E-07	8.49E-07	8.67E-07	3.33E-07	3.09E-07	1.68E-06	2.64E-06

Appendix D1.1 TPCB 0-15m Cont.

0-15 m of Reef	1day	1wk	2wk	1mon	6mon	1yr	2yr	ZOI=2	ZOI=1
Days Since Sinking	1	7	14	28	180	365	730	765	800
Tissue Conc. (mg/kg-WW)	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB
Inside the Vessel									
Fugacity (Pa)									
Water concentration (mg/L)	2.08E-06	2.44E-06	3.13E-06	3.03E-06	2.46E-06	1.06E-06	8.16E-07	1.80E-06	1.80E-06
Suspended solids concentration (mg/kg)	3.44E-02	3.47E-02	4.41E-02	4.70E-02	4.80E-02	1.84E-02	1.71E-02	4.44E-02	4.44E-02
Dissolved organic carbon (mg/kg)	2.30E-01	2.31E-01	2.94E-01	3.13E-01	3.20E-01	1.23E-01	1.14E-01	4.06E-01	4.06E-01
Bulk Water Inside Vessel (mg/L)	4.84E-04	4.88E-04	6.21E-04	6.61E-04	6.74E-04	2.59E-04	2.40E-04	6.89E-04	6.89E-04
Sediment Bed									
Fugacity (Pa)									
Pore Water concentration (mg/L)	2.68E-09	3.14E-09	4.03E-09	3.89E-09	3.16E-09	1.36E-09	1.05E-09	4.39E-09	6.90E-09
Sediment concentration (mg/kg)	1.62E-06	2.39E-06	3.06E-06	4.58E-06	4.79E-06	3.94E-06	3.75E-06	7.19E-06	1.13E-05

Appendix D1.2. Concentrations in tissue and abiotic compartment predicted by the TDM-PRAM model for day 0 - 2 yr for 0-45 m from the hull and steady concentrations predicted by PRAM with a ZOI=5.

	0 - 45 m From Reef							
	1	1wk	2wk	1mon	6mon	1yr	2yr	ZOI=5
Days Since Sinking	1	7	14	28	180	365	730	800
Tissue Conc. (mg/kg-WW)	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB
Pelagic Community								steady state
Phytoplankton (TL1)	5.12E-11	6.81E-11	8.76E-11	9.54E-11	7.62E-11	3.51E-11	2.40E-11	1.54E-09
Zooplankton (TL-II)	4.26E-05	4.96E-05	6.26E-05	5.83E-05	4.60E-05	2.02E-05	1.57E-05	4.48E-05
Planktivore (TL-III) Herring	2.04E-04	2.36E-04	3.22E-04	3.22E-04	2.69E-04	1.14E-04	7.72E-05	2.17E-04
Piscivore (TL-IV) Jack	2.61E-04	2.95E-04	4.18E-04	4.55E-04	4.15E-04	1.66E-04	1.17E-04	3.37E-04
Reef / Vessel Community								
Attached Algae	3.80E-06	4.45E-06	5.72E-06	5.53E-06	4.49E-06	1.93E-06	1.49E-06	4.20E-06
Sessile filter feeder (TL-II) Bivalve	8.94E-05	1.05E-04	1.32E-04	1.22E-04	9.52E-05	4.22E-05	3.25E-05	9.19E-05
Invertibrate Omnivore (TL-II) Urchin	2.11E-02	2.48E-02	3.36E-02	3.32E-02	2.69E-02	1.16E-02	7.73E-03	1.67E-02
Invertibrate Forager (TL-III) Crab	1.87E-02	2.49E-02	3.75E-02	4.54E-02	4.44E-02	2.20E-02	1.66E-02	3.59E-02
Vertibrate Forager (TL-III) Triggerfish	1.44E-02	1.68E-02	2.35E-02	3.18E-02	5.66E-02	3.03E-02	3.01E-02	6.47E-02
Predator (TL-IV) Grouper	1.34E-02	1.56E-02	2.21E-02	2.35E-02	4.83E-02	3.51E-02	5.14E-02	1.11E-01
Benthic Community								
Infaunal invert. (TL-II)	3.11E-05	3.64E-05	4.63E-05	4.32E-05	3.38E-05	1.50E-05	1.14E-05	3.18E-05
Epifaunal invert. (TL-II)	8.65E-05	1.01E-04	1.31E-04	1.24E-04	9.83E-05	4.33E-05	3.13E-05	8.74E-05
Forager (TL-III) Lobster	1.97E-04	2.31E-04	3.11E-04	3.05E-04	2.48E-04	1.07E-04	7.25E-05	2.00E-04
Predator (TL-IV) Flounder	6.22E-04	7.27E-04	1.03E-03	1.08E-03	9.27E-04	3.87E-04	2.52E-04	6.88E-04
Abiotic Conc.								
Air concentration (g/m3)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.68E-17
Upper Water Column								
Fugacity (Pa)								
Water concentration (mg/L)	3.10E-14	4.14E-14	5.32E-14	5.79E-14	4.62E-14	2.13E-14	1.46E-14	9.32E-13
Suspended solids concentration (mg/kg)	4.60E-10	6.02E-10	7.56E-10	9.05E-10	8.99E-10	3.80E-10	3.14E-10	1.22E-08
Dissolved organic carbon (mg/kg)	3.06E-09	4.02E-09	5.04E-09	6.03E-09	6.00E-09	2.53E-09	2.09E-09	1.63E-07
Bulk Upper Water Col (mg/L)	6.46E-12	8.47E-12	1.06E-11	1.27E-11	1.26E-11	5.34E-12	4.41E-12	2.21E-10
Lower Water Column								
Fugacity (Pa)								
Water concentration (mg/L)	2.31E-09	2.70E-09	3.47E-09	3.36E-09	2.73E-09	1.17E-09	9.05E-10	2.55E-09
Suspended solids concentration (mg/kg)	3.81E-05	3.84E-05	4.89E-05	5.21E-05	5.32E-05	2.04E-05	1.90E-05	6.27E-05
Dissolved organic carbon (mg/kg)	2.54E-04	2.56E-04	3.26E-04	3.47E-04	3.54E-04	1.36E-04	1.26E-04	5.74E-04
Bulk Lower Water Col (mg/L)	5.36E-07	5.40E-07	6.88E-07	7.32E-07	7.47E-07	2.87E-07	2.66E-07	9.73E-07

D1.2 TPCB 0-45m Cont.

	1	1wk	2wk	1mon	6mon	1yr	2yr	ZOI=5
Days Since Sinking	1	7	14	28	180	365	730	800
Tissue Conc. (mg/kg-WW)	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB
Inside the Vessel								
Fugacity (Pa)								
Water concentration (mg/L)	2.08E-06	2.44E-06	3.13E-06	3.03E-06	2.46E-06	1.06E-06	8.16E-07	1.80E-06
Suspended solids concentration (mg/kg)	3.44E-02	3.47E-02	4.41E-02	4.70E-02	4.80E-02	1.84E-02	1.71E-02	4.44E-02
Dissolved organic carbon (mg/kg)	2.30E-01	2.31E-01	2.94E-01	3.13E-01	3.20E-01	1.23E-01	1.14E-01	4.06E-01
Bulk Water Inside Vessel (mg/L)	4.84E-04	4.88E-04	6.21E-04	6.61E-04	6.74E-04	2.59E-04	2.40E-04	6.89E-04
Sediment Bed								
Fugacity (Pa)								
Pore Water concentration (mg/L)	2.31E-09	2.70E-09	3.47E-09	3.36E-09	2.73E-09	1.17E-09	9.05E-10	2.55E-09
Sediment concentration (mg/kg)	1.39E-06	2.06E-06	2.64E-06	3.95E-06	4.13E-06	3.39E-06	3.23E-06	4.18E-06

Appendix D1.3 Concentrations in tissue and abiotic compartments predicted by the TDM-PRAM model for day 0-2 yr for 0-60 m from the hull and steady concentrations predicted by PRAM with a ZOI=5.

0-60 m from Reef	1	1wk	2wk	1mon	6mon	1yr	2yr	ZOI=5
Days Since Sinking	1	7	14	28	180	365	730	steady state
Tissue Conc. (mg/kg-WW)	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB
Pelagic Community								
Phytoplankton (TL1)	5.87E-11	7.82E-11	1.01E-10	1.09E-10	8.75E-11	4.03E-11	2.76E-11	1.54E-09
Zooplankton (TL-II)	4.00E-05	4.65E-05	5.88E-05	5.47E-05	4.32E-05	1.90E-05	1.47E-05	4.48E-05
Planktivore (TL-III) Herring	1.91E-04	2.22E-04	3.02E-04	3.02E-04	2.52E-04	1.07E-04	7.24E-05	2.17E-04
Piscivore (TL-IV) Jack	2.45E-04	2.77E-04	3.93E-04	4.27E-04	3.90E-04	1.56E-04	1.09E-04	3.37E-04
Reef / Vessel Community								
Attached Algae	3.57E-06	4.18E-06	5.37E-06	5.19E-06	4.22E-06	1.81E-06	1.40E-06	4.20E-06
Sessile filter feeder (TL-II) Bivalve	8.39E-05	9.82E-05	1.24E-04	1.15E-04	8.94E-05	3.96E-05	3.05E-05	9.19E-05
Invertibrate Omnivore (TL-II) Urchin	2.11E-02	2.48E-02	3.36E-02	3.32E-02	2.69E-02	1.16E-02	7.72E-03	1.67E-02
Invertibrate Forager (TL-III) Crab	1.87E-02	2.49E-02	3.75E-02	4.54E-02	4.43E-02	2.20E-02	1.66E-02	3.59E-02
Vertibrate Forager (TL-III) Triggerfish	1.44E-02	1.68E-02	2.35E-02	3.17E-02	5.65E-02	3.03E-02	3.01E-02	6.47E-02
Predator (TL-IV) Grouper	1.34E-02	1.56E-02	2.21E-02	2.35E-02	4.82E-02	3.51E-02	5.13E-02	1.11E-01
Benthic Community								
Infaunal invert. (TL-II)	2.92E-05	3.42E-05	4.35E-05	4.06E-05	3.17E-05	1.41E-05	1.07E-05	3.18E-05
Epifaunal invert. (TL-II)	8.12E-05	9.50E-05	1.23E-04	1.17E-04	9.23E-05	4.07E-05	2.94E-05	8.74E-05
Forager (TL-III) Lobster	1.85E-04	2.17E-04	2.92E-04	2.87E-04	2.33E-04	1.01E-04	6.81E-05	2.00E-04
Predator (TL-IV) Flounder	5.84E-04	6.83E-04	9.68E-04	1.01E-03	8.71E-04	3.63E-04	2.36E-04	6.88E-04
Air concentration (g/m3)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.68E-17
Upper Water Column								
Fugacity (Pa)								
Water concentration (mg/L)	3.56E-14	4.75E-14	6.10E-14	6.64E-14	5.31E-14	2.44E-14	1.67E-14	9.32E-13
Suspended solids concentration (mg/kg)	5.27E-10	6.92E-10	8.67E-10	1.04E-09	1.03E-09	4.36E-10	3.61E-10	1.22E-08
Dissolved organic carbon (mg/kg)	3.52E-09	4.61E-09	5.78E-09	6.92E-09	6.88E-09	2.91E-09	2.40E-09	1.63E-07
Bulk Upper Water Col (mg/L)	7.42E-12	9.73E-12	1.22E-11	1.46E-11	1.45E-11	6.13E-12	5.06E-12	2.21E-10
Lower Water Column								
Fugacity (Pa)								
Water concentration (mg/L)	2.16E-09	2.54E-09	3.26E-09	3.15E-09	2.56E-09	1.10E-09	8.49E-10	2.55E-09
Suspended solids concentration (mg/kg)	3.58E-05	3.61E-05	4.59E-05	4.89E-05	4.99E-05	1.92E-05	1.78E-05	6.27E-05
Dissolved organic carbon (mg/kg)	2.38E-04	2.40E-04	3.06E-04	3.26E-04	3.33E-04	1.28E-04	1.19E-04	5.74E-04
Bulk Lower Water Col (mg/L)	5.03E-07	5.07E-07	6.46E-07	6.87E-07	7.01E-07	2.69E-07	2.50E-07	9.73E-07

D1.3 TPCB 0-60m Cont.

0-60 m from Reef	1	1wk	2wk	1mon	6mon	1yr	2yr	ZOI=5
Days Since Sinking	1	7	14	28	180	365	730	steady state
Tissue Conc. (mg/kg-WW)	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB
Inside the Vessel								
Fugacity (Pa)								
Water concentration (mg/L)	2.08E-06	2.44E-06	3.13E-06	3.03E-06	2.46E-06	1.06E-06	8.16E-07	1.80E-06
Suspended solids concentration (mg/kg)	3.44E-02	3.47E-02	4.41E-02	4.70E-02	4.80E-02	1.84E-02	1.71E-02	4.44E-02
Dissolved organic carbon (mg/kg)	2.30E-01	2.31E-01	2.94E-01	3.13E-01	3.20E-01	1.23E-01	1.14E-01	4.06E-01
Bulk Water Inside Vessel (mg/L)	4.84E-04	4.88E-04	6.21E-04	6.61E-04	6.74E-04	2.59E-04	2.40E-04	6.89E-04
Sediment Bed								
Fugacity (Pa)								
Pore Water concentration (mg/L)	2.16E-09	2.54E-09	3.26E-09	3.15E-09	2.56E-09	1.10E-09	8.49E-10	2.55E-09
Sediment concentration (mg/kg)	1.31E-06	1.93E-06	2.48E-06	3.71E-06	3.87E-06	3.19E-06	3.04E-06	4.18E-06

D2.1 HQ1day

Days Since Sinking	1		
	Water Benchmarks		
	WQC-Chronic	GLWLC-Tier1	GLWLC
mg/L	0.00003	7.40E-05	1.40E-04
	Hazard Quotients (HQ)		
Upper Water Column	0.0000001	0.0000001	0.0000000
Lower Water Column	0.0207356	0.0084063	0.0044433
Inside the Vessel	16.1414750	6.5438412	3.4588875
Sediment Pore Water	0.0000892	0.0000362	0.0000191

	Sediment Benchmarks	
	TEL	PEL
mg/Kg	0.0216000	0.1890000
	Hazard Quotients (HQ)	
Bulk sediment	0.0539845	0.0218856

	Tissue Residue Benchmarks						
OPPTS Assessment Factor	1	1	1	10	10	10	10
	TSV	Bcv-Invert	Bcv-Fish	Invert-NOED	Invert-LOED	Fish-NOED	Fish-LOED
mg/Kg wet	0.4368	0.9360	7.4463	0.0600	0.1100	0.1500	0.1800
Pelagic Community	Hazard Quotients (HQ)						
Phytoplankton (TL1)	0.0000000	0.0000000		0.0000000	0.0000000		
Zooplankton (TL-II)	0.0001132	0.0000528		0.0008240	0.0004495		
Planktivore (TL-III) Herring	0.0005412		0.0000317			0.0015761	0.0013134
Piscivore (TL-IV) Jack	0.0006933		0.0000407			0.0020188	0.0016823
Reef / Vessel Community							
Attached Algae	0.0000101	0.0000047		0.0000735	0.0000401		
Sessile filter feeder (TL-II) Bivalv	0.0002374	0.0001108		0.0017283	0.0009427		
Invertibrate Omnivore (TL-II) Urcl	0.0484856	0.0226266		0.3529755	0.1925321		
Invertibrate Forager (TL-III) Crab	0.0428151	0.0199804		0.3116941	0.1700150		
Vertibrate Forager (TL-III) Trigge	0.0332622		0.0019512			0.0968595	0.0807162
Predator (TL-IV) Grouper	0.0309351		0.0018147			0.0900829	0.0750691
Benthic Community							
Infaunal invert. (TL-II)	0.0000826	0.0000385		0.0006010	0.0003278		
Epifaunal invert. (TL-II)	0.0002299	0.0001073		0.0016735	0.0009128		
Forager (TL-III) Lobster	0.0005246	0.0002448		0.0038189	0.0020831		
Predator (TL-IV) Flounder	0.0016536		0.0000970			0.0048152	0.0040126

D2.1 HQ1day

Days Since Sinking 1

mg/L

Upper Water Column Hazard Quotients
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg

Bulk sediment

Benchmark

OPPTS Assessment Factor	10	10	10	10	10	10	10
	Dolphin-NOAEl	Dolphin-LOAEL	Cormor-NOAEl	Cormor-LOAEL	Gull-NOAEL	Gull-LOAEL	Turtle-NOAEL
mg/Kg wet	0.0317	0.1583	0.0800	0.8000	0.0833	0.8333	0.2179
Pelagic Community							
Phytoplankton (TL1)							
Zooplankton (TL-II)							
Planktivore (TL-III) Herring	0.0074682	0.0014936	0.0029551	0.0002955	0.0028369	0.0002837	
Piscivore (TL-IV) Jack	0.0095663	0.0019133	0.0037853	0.0003785	0.0036339	0.0003634	
Reef / Vessel Community							
Attached Algae							
Sessile filter feeder (TL-II) Bivalv	0.0032760	0.0006552			0.0012444	0.0001244	0.0004760
Invertibrate Omnivore (TL-II) Urcl	0.6690410	0.1338082			0.2541424	0.0254142	0.0972032
Invertibrate Forager (TL-III) Crab	0.5907948	0.1181590			0.2244197	0.0224420	0.0858350
Vertibrate Forager (TL-III) Trigge	0.4589763	0.0917953	0.1816115	0.0181612	0.1743471	0.0174347	
Predator (TL-IV) Grouper	0.4268651	0.0853730	0.1689055	0.0168906	0.1621493	0.0162149	
Benthic Community							
Infaunal invert. (TL-II)					0.0004327	0.0000433	0.0001655
Epifaunal invert. (TL-II)	0.0031720	0.0006344			0.0012049	0.0001205	0.0004608
Forager (TL-III) Lobster	0.0072385	0.0014477			0.0027496	0.0002750	0.0010517
Predator (TL-IV) Flounder	0.0228170	0.0045634	0.0090284	0.0009028	0.0086673	0.0008667	

D2.1 HQ1day

Days Since Sinking	1

mg/L
Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg
Bulk sediment

OPPTS Assessment Factor	10	10	10
	Turtle-LOAEL	Shark-NOAEL	Shark-LOAEL
mg/Kg wet	1.0894	0.2520	0.4066
Pelagic Community			
Phytoplankton (TL1)			
Zooplankton (TL-II)			
Planktivore (TL-III) Herring		0.0009383	0.0005815
Piscivore (TL-IV) Jack		0.0012018	0.0007448
Reef / Vessel Community			
Attached Algae			
Sessile filter feeder (TL-II) Bivalv	0.0000952		
Invertibrate Omnivore (TL-II) Urcl	0.0194406		
Invertibrate Forager (TL-III) Crab	0.0171670		
Vertibrate Forager (TL-III) Trigge		0.0576626	0.0357346
Predator (TL-IV) Grouper		0.0536283	0.0332345
Benthic Community			
Infaunal invert. (TL-II)	0.0000331		
Epifaunal invert. (TL-II)	0.0000922		
Forager (TL-III) Lobster	0.0002103		
Predator (TL-IV) Flounder		0.0028666	0.0017765

D2.1 HQ7day

Days Since Sinking 7

Water Benchmarks	WQC-Chronic	GLWLC-Tier1	GLWLC
mg/L	0.00003	7.40E-05	1.40E-04
	Hazard Quotients (HQ)		
Upper Water Column	0.0000002	0.0000001	3.70E-08
Lower Water Column	0.0209016	0.0084736	0.0044789
Inside the Vessel	16.2590946	6.5915249	3.4840917
Sediment Pore Water	0.0001045	0.0000424	0.0000224

Sediment Benchmarks	TEL	PEL
mg/Kg	0.0216000	0.1890000
	Hazard Quotients (HQ)	
Bulk sediment	0.0797240	0.0323206

	Tissue Residue Benchmarks						
OPPTS Assessment Factor	1	1	1	10	10	10	10
7	TSV	Bcv-Invert	Bcv-Fish	Invert-NOED	Invert-LOED	Fish-NOED	Fish-LOED
mg/Kg wet	0.4368	0.9360	7.4463	0.0600	0.1100	0.1500	0.1800
Pelagic Community	Hazard Quotients (HQ)						
Phytoplankton (TL1)	0.0000000	0.0000000		0.0000000	0.0000000		
Zooplankton (TL-II)	0.0001317	0.0000614		0.0009584	0.0005228		
Planktivore (TL-III) Herring	0.0006268		0.0000368			0.0018251	0.0015209
Piscivore (TL-IV) Jack	0.0007825		0.0000459			0.0022786	0.0018989
Reef / Vessel Community							
Attached Algae	0.0000118	0.0000055		0.0000861	0.0000470		
Sessile filter feeder (TL-II) Bivalve	0.0002777	0.0001296		0.0020219	0.0011029		
Invertibrate Omnivore (TL-II) Urchin	0.0568812	0.0265445		0.4140948	0.2258699		
Invertibrate Forager (TL-III) Crab	0.0570099	0.0266046		0.4150321	0.2263812		
Vertibrate Forager (TL-III) Triggerfish	0.0388250		0.0022775			0.1130583	0.0942153
Predator (TL-IV) Grouper	0.0359396		0.0021082			0.1046561	0.0872134
Benthic Community							
Infaunal invert. (TL-II)	0.0000967	0.0000451		0.0007036	0.0003838		
Epifaunal invert. (TL-II)	0.0002688	0.0001255		0.0019572	0.0010675		
Forager (TL-III) Lobster	0.0006139	0.0002865		0.0044693	0.0024378		
Predator (TL-IV) Flounder	0.0019318		0.0001133			0.0056254	0.0046878

D2.1 HQ7day

Days Since Sinking 7

Water Benchmarks

mg/L

Upper Water Column

Lower Water Column

Inside the Vessel

Sediment Pore Water

Sediment Benchmarks

mg/Kg

Bulk sediment

Hazard Quotients

Benchmark

OPPTS Assessment Factor	10	10	10	10	10	10	10
7	Dolphin-NOAEl	Dolphin-LOAEL	Cormor-NOAEl	Cormor-LOAEL	Gull-NOAEL	Gull-LOAEL	Turtle-NOAEL
mg/Kg wet	0.0317	0.1583	0.0800	0.8000	0.0833	0.8333	0.2179
Pelagic Community							
Phytoplankton (TL1)							
Zooplankton (TL-II)							
Planktivore (TL-III) Herring	0.0086485	0.0017297	0.0034221	0.0003422	0.0032852	0.0003285	
Piscivore (TL-IV) Jack	0.0107975	0.0021595	0.0042724	0.0004272	0.0041015	0.0004102	
Reef / Vessel Community							
Attached Algae							
Sessile filter feeder (TL-II) Bivalve	0.0038324	0.0007665			0.0014558	0.0001456	0.0005568
Invertibrate Omnivore (TL-II) Urchin	0.7848884	0.1569777			0.2981483	0.0298148	0.1140344
Invertibrate Forager (TL-III) Crab	0.7866650	0.1573330			0.2988231	0.0298823	0.1142925
Vertibrate Forager (TL-III) Triggerfish	0.5357359	0.1071472	0.2119844	0.0211984	0.2035050	0.0203505	
Predator (TL-IV) Grouper	0.4959213	0.0991843	0.1962302	0.0196230	0.1883810	0.0188381	
Benthic Community							
Infaunal invert. (TL-II)					0.0005066	0.0000507	0.0001938
Epifaunal invert. (TL-II)	0.0037097	0.0007419			0.0014092	0.0001409	0.0005390
Forager (TL-III) Lobster	0.0084712	0.0016942			0.0032179	0.0003218	0.0012308
Predator (TL-IV) Flounder	0.0266563	0.0053313	0.0105476	0.0010548	0.0101257	0.0010126	

D2.1 HQ7day

Days Since Sinking	7

Water Benchmarks

	mg/L
Upper Water Column	
Lower Water Column	
Inside the Vessel	
Sediment Pore Water	

Sediment Benchmarks

	mg/Kg
Bulk sediment	

OPPTS Assessment Factor	10	10	10
7	Turtle-LOAEL	Shark-NOAEL	Shark-LOAEL
mg/Kg wet	1.0894	0.2520	0.4066
Pelagic Community			
Phytoplankton (TL1)			
Zooplankton (TL-II)			
Planktivore (TL-III) Herring		0.0010865	0.0006733
Piscivore (TL-IV) Jack		0.0013565	0.0008407
Reef / Vessel Community			
Attached Algae			
Sessile filter feeder (TL-II) Bivalve	0.0001114		
Invertibrate Omnivore (TL-II) Urchin	0.0228069		
Invertibrate Forager (TL-III) Crab	0.0228585		
Vertibrate Forager (TL-III) Triggerfish		0.0673061	0.0417108
Predator (TL-IV) Grouper		0.0623041	0.0386110
Benthic Community			
Infaunal invert. (TL-II)	0.0000388		
Epifaunal invert. (TL-II)	0.0001078		
Forager (TL-III) Lobster	0.0002462		
Predator (TL-IV) Flounder		0.0033489	0.0020754

D2.1 HQ14day

Days Since Sinking	14		
	Water Benchmarks		
	WQC-Chronic	GLWLC-Tier1	GLWLC
mg/L	0.00003	7.40E-05	1.40E-04
	Hazard Quotients (HQ)		
Upper Water Column	0.0000002	0.0000001	4.64E-08
Lower Water Column	0.0265914	0.0107803	0.0056982
Inside the Vessel	20.6846491	8.3856686	4.4324248
Sediment Pore Water	0.0001342	0.0000544	0.0000288

	Sediment Benchmarks	
	TEL	PEL
mg/Kg	0.0216000	0.1890000
	Hazard Quotients (HQ)	
Bulk sediment	0.1021526	0.0414132

	Tissue Residue Benchmarks						
OPPTS Assessment Factor	1	1	1	10	10	10	10
14	TSV	Bcv-Invert	Bcv-Fish	Invert-NOED	Invert-LOED	Fish-NOED	Fish-LOED
mg/Kg wet	0.4368	0.9360	7.4463	0.0600	0.1100	0.1500	0.1800
Pelagic Community	Hazard Quotients (HQ)						
Phytoplankton (TL1)	0.0000000	0.0000000		0.0000000	0.0000000		
Zooplankton (TL-II)	0.0001662	0.0000776		0.0012100	0.0006600		
Planktivore (TL-III) Herring	0.0008549		0.0000501			0.0024895	0.0020745
Piscivore (TL-IV) Jack	0.0011111		0.0000652			0.0032354	0.0026962
Reef / Vessel Community							
Attached Algae	0.0000152	0.0000071		0.0001106	0.0000603		
Sessile filter feeder (TL-II) E	0.0003503	0.0001635		0.0025504	0.0013911		
Invertibrate Omnivore (TL-II	0.0771842	0.0360193		0.5619008	0.3064914		
Invertibrate Forager (TL-III)	0.0859509	0.0401104		0.6257225	0.3413032		
Vertibrate Forager (TL-III) T	0.0542344		0.0031814			0.1579306	0.1316088
Predator (TL-IV) Grouper	0.0509540		0.0029890			0.1483781	0.1236484
Benthic Community							
Infaunal invert. (TL-II)	0.0001230	0.0000574		0.0008952	0.0004883		
Epifaunal invert. (TL-II)	0.0003489	0.0001628		0.0025400	0.0013854		
Forager (TL-III) Lobster	0.0008270	0.0003859		0.0060206	0.0032840		
Predator (TL-IV) Flounder	0.0027387		0.0001607			0.0079751	0.0066459

D2.1 HQ14day

Days Since Sinking 14

mg/L

Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg

Bulk sediment Hazard Quotients
Benchmark

OPPTS Assessment Factor	10	10	10	10	10	10	10
14	Dolphin-NOAEl	Dolphin-LOAEL	Cormor-NOAEl	Cormor-LOAEL	Gull-NOAEL	Gull-LOAEL	Turtle-NOAEL
mg/Kg wet	0.0317	0.1583	0.0800	0.8000	0.0833	0.8333	0.2179
Pelagic Community							
Phytoplankton (TL1)							
Zooplankton (TL-II)							
Planktivore (TL-III) Herring	0.0117965	0.0023593	0.0046677	0.0004668	0.0044810	0.0004481	
Piscivore (TL-IV) Jack	0.0153314	0.0030663	0.0060665	0.0006066	0.0058238	0.0005824	
Reef / Vessel Community							
Attached Algae							
Sessile filter feeder (TL-II) E	0.0048341	0.0009668			0.0018363	0.0001836	0.0007023
Invertibrate Omnivore (TL-II	1.0650446	0.2130089			0.4045686	0.0404569	0.1547375
Invertibrate Forager (TL-III)	1.1860142	0.2372028			0.4505202	0.0450520	0.1723129
Vertibrate Forager (TL-III) T	0.7483667	0.1496733	0.2961199	0.0296120	0.2842751	0.0284275	
Predator (TL-IV) Grouper	0.7031011	0.1406202	0.2782089	0.0278209	0.2670805	0.0267080	
Benthic Community							
Infaunal invert. (TL-II)					0.0006445	0.0000645	0.0002465
Epifaunal invert. (TL-II)	0.0048144	0.0009629			0.0018288	0.0001829	0.0006995
Forager (TL-III) Lobster	0.0114116	0.0022823			0.0043348	0.0004335	0.0016580
Predator (TL-IV) Flounder	0.0377907	0.0075581	0.0149533	0.0014953	0.0143552	0.0014355	

D2.1 HQ14day

Days Since Sinking 14

mg/L
Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg
Bulk sediment

OPPTS Assessment Factor	10	10	10
14	Turtle-LOAEL	Shark-NOAEL	Shark-LOAEL
mg/Kg wet	1.0894	0.2520	0.4066
Pelagic Community			
Phytoplankton (TL1)			
Zooplankton (TL-II)			
Planktivore (TL-III) Herring		0.0014820	0.0009184
Piscivore (TL-IV) Jack		0.0019261	0.0011937
Reef / Vessel Community			
Attached Algae			
Sessile filter feeder (TL-II) E	0.0001405		
Invertibrate Omnivore (TL-II	0.0309475		
Invertibrate Forager (TL-III)	0.0344626		
Vertibrate Forager (TL-III) T		0.0940196	0.0582656
Predator (TL-IV) Grouper		0.0883327	0.0547414
Benthic Community			
Infaunal invert. (TL-II)	0.0000493		
Epifaunal invert. (TL-II)	0.0001399		
Forager (TL-III) Lobster	0.0003316		
Predator (TL-IV) Flounder		0.0047478	0.0029423

D2.1 HQ28day

Days Since Sinking	28		
	Water Benchmarks		
	WQC-Chronic	GLWLC-Tier1	GLWLC
mg/L	0.00003	7.40E-05	1.40E-04
	Hazard Quotients (HQ)		
Upper Water Column	0.0000003	0.0000001	0.0000001
Lower Water Column	0.0283111	0.0114775	0.0060667
Inside the Vessel	22.0198129	8.9269512	4.7185313
Sediment Pore Water	0.0001298	0.0000526	0.0000278

	Sediment Benchmarks	
	TEL	PEL
mg/Kg	0.0216000	0.1890000
	Hazard Quotients (HQ)	
Bulk sediment	0.1528243	0.0619558

	Tissue Residue Benchmarks						
OPPTS Assessment Factor	1	1	1	10	10	10	10
28	TSV	Bcv-Invert	Bcv-Fish	Invert-NOED	Invert-LOED	Fish-NOED	Fish-LOED
mg/Kg wet	0.4368	0.9360	7.4463	0.0600	0.1100	0.1500	0.1800
Pelagic Community	Hazard Quotients						
Phytoplankton (TL1)	0.0000000	0.0000000		0.0000000	0.0000000		
Zooplankton (TL-II)	0.0001548	0.0000723		0.0011271	0.0006148		
Planktivore (TL-III) Herring	0.0008556		0.0000502			0.0024915	0.0020762
Piscivore (TL-IV) Jack	0.0012079		0.0000709			0.0035173	0.0029311
Reef / Vessel Community							
Attached Algae	0.0000147	0.0000069		0.0001069	0.0000583		
Sessile filter feeder (TL-II) E	0.0003246	0.0001515		0.0023631	0.0012889		
Invertibrate Omnivore (TL-II	0.0761159	0.0355207		0.5541236	0.3022492		
Invertibrate Forager (TL-III)	0.1041676	0.0486116		0.7583404	0.4136402		
Vertibrate Forager (TL-III) T	0.0731544		0.0042913			0.2130256	0.1775214
Predator (TL-IV) Grouper	0.0542258		0.0031809			0.1579055	0.1315879
Benthic Community							
Infaunal invert. (TL-II)	0.0001148	0.0000536		0.0008355	0.0004557		
Epifaunal invert. (TL-II)	0.0003303	0.0001541		0.0024044	0.0013115		
Forager (TL-III) Lobster	0.0008109	0.0003784		0.0059033	0.0032200		
Predator (TL-IV) Flounder	0.0028694		0.0001683			0.0083556	0.0069630

D2.1 HQ28day

Days Since Sinking 28

mg/L

Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg

Bulk sediment

OPPTS Assessment Factor	10	10	10	10	10	10	10
28	Dolphin-NOAEI	Dolphin-LOAEL	Cormor-NOAEI	Cormor-LOAEL	Gull-NOAEL	Gull-LOAEL	Turtle-NOAEL
mg/Kg wet	0.0317	0.1583	0.0800	0.8000	0.0833	0.8333	0.2179
Pelagic Community							
Phytoplankton (TL1)							
Zooplankton (TL-II)							
Planktivore (TL-III) Herring	0.0118061	0.0023612	0.0046715	0.0004672	0.0044847	0.0004485	
Piscivore (TL-IV) Jack	0.0166669	0.0033334	0.0065949	0.0006595	0.0063311	0.0006331	
Reef / Vessel Community							
Attached Algae							
Sessile filter feeder (TL-II) E	0.0044790	0.0008958			0.0017014	0.0001701	0.0006507
Invertibrate Omnivore (TL-II	1.0503033	0.2100607			0.3989690	0.0398969	0.1525958
Invertibrate Forager (TL-III)	1.4373823	0.2874765			0.5460051	0.0546005	0.2088335
Vertibrate Forager (TL-III) T	1.0094387	0.2018877	0.3994230	0.0399423	0.3834461	0.0383446	
Predator (TL-IV) Grouper	0.7482477	0.1496495	0.2960728	0.0296073	0.2842299	0.0284230	
Benthic Community							
Infaunal invert. (TL-II)					0.0006015	0.0000602	0.0002301
Epifaunal invert. (TL-II)	0.0045573	0.0009115			0.0017312	0.0001731	0.0006621
Forager (TL-III) Lobster	0.0111894	0.0022379			0.0042504	0.0004250	0.0016257
Predator (TL-IV) Flounder	0.0395938	0.0079188	0.0156668	0.0015667	0.0150401	0.0015040	

D2.1 HQ28day

Days Since Sinking 28

mg/L

Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg

Bulk sediment

OPPTS Assessment Factor	10	10	10
28	Turtle-LOAEL	Shark-NOAEL	Shark-LOAEL
mg/Kg wet	1.0894	0.2520	0.4066
Pelagic Community			
Phytoplankton (TL1)			
Zooplankton (TL-II)			
Planktivore (TL-III) Herring		0.0014832	0.0009192
Piscivore (TL-IV) Jack		0.0020939	0.0012976
Reef / Vessel Community			
Attached Algae			
Sessile filter feeder (TL-II) E	0.0001301		
Invertibrate Omnivore (TL-II	0.0305192		
Invertibrate Forager (TL-III)	0.0417667		
Vertibrate Forager (TL-III) T		0.1268188	0.0785919
Predator (TL-IV) Grouper		0.0940046	0.0582564
Benthic Community			
Infaunal invert. (TL-II)	0.0000460		
Epifaunal invert. (TL-II)	0.0001324		
Forager (TL-III) Lobster	0.0003251		
Predator (TL-IV) Flounder		0.0049743	0.0030827

Days Since Sinking	180		
	Water Benchmarks		
	WQC-Chronic	GLWLC-Tier1	GLWLC
mg/L	0.00003	7.40E-05	1.40E-04
	Hazard Quotients (HQ)		
Upper Water Column	0.0000003	0.0000001	0.0000001
Lower Water Column	0.0288917	0.0117128	0.0061911
Inside the Vessel	22.4709916	9.1098615	4.8152125
Sediment Pore Water	0.0001054	0.0000427	0.0000226

	Sediment Benchmarks	
	TEL	PEL
mg/Kg	0.0216000	0.1890000
	Hazard Quotients (HQ)	
Bulk sediment	0.1595598	0.0646864

	Tissue Residue Benchmarks						
OPPTS Assessment Factor	1	1	1	10	10	10	10
180	TSV	Bcv-Invert	Bcv-Fish	Invert-NOED	Invert-LOED	Fish-NOED	Fish-LOED
mg/Kg wet	0.4368	0.9360	7.4463	0.0600	0.1100	0.1500	0.1800
Pelagic Community	Hazard Quotients (HQ)						
Phytoplankton (TL1)	0.0000000	0.0000000		0.0000000	0.0000000		
Zooplankton (TL-II)	0.0001221	0.0000570		0.0008892	0.0004850		
Planktivore (TL-III) Herring	0.0007137		0.0000419			0.0020782	0.0017319
Piscivore (TL-IV) Jack	0.0011018		0.0000646			0.0032084	0.0026737
Reef / Vessel Community							
Attached Algae	0.0000119	0.0000056		0.0000869	0.0000474		
Sessile filter feeder (TL-II) E	0.0002529	0.0001180		0.0018411	0.0010042		
Invertibrate Omnivore (TL-II	0.0618117	0.0288454		0.4499889	0.2454485		
Invertibrate Forager (TL-III)	0.1017598	0.0474879		0.7408115	0.4040790		
Vertibrate Forager (TL-III) T	0.1299843		0.0076249			0.3785143	0.3154286
Predator (TL-IV) Grouper	0.1108650		0.0065034			0.3228389	0.2690324
Benthic Community							
Infaunal invert. (TL-II)	0.0000898	0.0000419		0.0006538	0.0003566		
Epifaunal invert. (TL-II)	0.0002610	0.0001218		0.0019001	0.0010364		
Forager (TL-III) Lobster	0.0006577	0.0003069		0.0047881	0.0026117		
Predator (TL-IV) Flounder	0.0024628		0.0001445			0.0071716	0.0059763

D2.1 HQ180day

Days Since Sinking 180

mg/L

Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg

Bulk sediment

Hazard Quotients
Benchmark

OPPTS Assessment Factor	10	10	10	10	10	10	10
180	Dolphin-NOAEl	Dolphin-LOAEL	Cormor-NOAEl	Cormor-LOAEL	Gull-NOAEL	Gull-LOAEL	Turtle-NOAEL
mg/Kg wet	0.0317	0.1583	0.0800	0.8000	0.0833	0.8333	0.2179
Pelagic Community							
Phytoplankton (TL1)							
Zooplankton (TL-II)							
Planktivore (TL-III) Herring	0.0098479	0.0019696	0.0038967	0.0003897	0.0037408	0.0003741	
Piscivore (TL-IV) Jack	0.0152033	0.0030407	0.0060157	0.0006016	0.0057751	0.0005775	
Reef / Vessel Community							
Attached Algae							
Sessile filter feeder (TL-II) E	0.0034897	0.0006979			0.0013256	0.0001326	0.0005070
Invertibrate Omnivore (TL-II	0.8529233	0.1705847			0.3239920	0.0323992	0.1239190
Invertibrate Forager (TL-III)	1.4041576	0.2808315			0.5333843	0.0533384	0.2040064
Vertibrate Forager (TL-III) T	1.7936200	0.3587240	0.7097144	0.0709714	0.6813258	0.0681326	
Predator (TL-IV) Grouper	1.5297977	0.3059595	0.6053230	0.0605323	0.5811100	0.0581110	
Benthic Community							
Infaunal invert. (TL-II)					0.0004707	0.0000471	0.0001800
Epifaunal invert. (TL-II)	0.0036014	0.0007203			0.0013680	0.0001368	0.0005232
Forager (TL-III) Lobster	0.0090755	0.0018151			0.0034474	0.0003447	0.0013186
Predator (TL-IV) Flounder	0.0339831	0.0067966	0.0134467	0.0013447	0.0129088	0.0012909	

D2.1 HQ180day

Days Since Sinking 180

mg/L

Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg

Bulk sediment

OPPTS Assessment Factor	10	10	10
180	Turtle-LOAEL	Shark-NOAEL	Shark-LOAEL
mg/Kg wet	1.0894	0.2520	0.4066
Pelagic Community			
Phytoplankton (TL1)			
Zooplankton (TL-II)			
Planktivore (TL-III) Herring		0.0012372	0.0007667
Piscivore (TL-IV) Jack		0.0019100	0.0011837
Reef / Vessel Community			
Attached Algae			
Sessile filter feeder (TL-II) E	0.0001014		
Invertibrate Omnivore (TL-II	0.0247838		
Invertibrate Forager (TL-III)	0.0408013		
Vertibrate Forager (TL-III) T		0.2253379	0.1396460
Predator (TL-IV) Grouper		0.1921931	0.1191056
Benthic Community			
Infaunal invert. (TL-II)	0.0000360		
Epifaunal invert. (TL-II)	0.0001046		
Forager (TL-III) Lobster	0.0002637		
Predator (TL-IV) Flounder		0.0042694	0.0026458

D2.1 HQ365day

Days Since Sinking	365		
	Water Benchmarks		
	WQC-Chronic	GLWLC-Tier1	GLWLC
mg/L	0.00003	7.40E-05	1.40E-04
	Hazard Quotients (HQ)		
Upper Water Column	0.0000001	0.0000000	0.0000000
Lower Water Column	0.0110950	0.0044980	0.0023775
Inside the Vessel	8.6408607	3.5030516	1.8516130
Sediment Pore Water	0.0000453	0.0000184	0.0000097

	Sediment Benchmarks	
	TEL	PEL
mg/Kg	0.0216000	0.1890000
	Hazard Quotients (HQ)	
Bulk sediment	0.1312531	0.0532107

	Tissue Residue Benchmarks						
OPPTS Assessment Factor	1	1	1	10	10	10	10
365	TSV	Bcv-Invert	Bcv-Fish	Invert-NOED	Invert-LOED	Fish-NOED	Fish-LOED
mg/Kg wet	0.4368	0.9360	7.4463	0.0600	0.1100	0.1500	0.1800
Pelagic Community	Hazard Quotients (HQ)						
Phytoplankton (TL1)	0.0000000	0.0000000		0.0000000	0.0000000		
Zooplankton (TL-II)	0.0000537	0.0000251		0.0003911	0.0002133		
Planktivore (TL-III) Herring	0.0003026		0.0000177			0.0008811	0.0007342
Piscivore (TL-IV) Jack	0.0004418		0.0000259			0.0012864	0.0010720
Reef / Vessel Community							
Attached Algae	0.0000051	0.0000024		0.0000373	0.0000204		
Sessile filter feeder (TL-II) E	0.0001120	0.0000523		0.0008153	0.0004447		
Invertibrate Omnivore (TL-II	0.0266238	0.0124244		0.1938213	0.1057207		
Invertibrate Forager (TL-III)	0.0504933	0.0235635		0.3675911	0.2005042		
Vertibrate Forager (TL-III) T	0.0695140		0.0040777			0.2024249	0.1686874
Predator (TL-IV) Grouper	0.0806254		0.0047295			0.2347811	0.1956509
Benthic Community							
Infaunal invert. (TL-II)	0.0000399	0.0000186		0.0002905	0.0001585		
Epifaunal invert. (TL-II)	0.0001151	0.0000537		0.0008378	0.0004570		
Forager (TL-III) Lobster	0.0002847	0.0001329		0.0020726	0.0011305		
Predator (TL-IV) Flounder	0.0010275		0.0000603			0.0029921	0.0024934

D2.1 HQ365day

Days Since Sinking 365

mg/L

Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg

Bulk sediment

OPPTS Assessment Factor	10	10	10	10	10	10	10
365	Dolphin-NOAEl	Dolphin-LOAEL	Cormor-NOAEl	Cormor-LOAEL	Gull-NOAEL	Gull-LOAEL	Turtle-NOAEL
mg/Kg wet	0.0317	0.1583	0.0800	0.8000	0.0833	0.8333	0.2179
Pelagic Community							
Phytoplankton (TL1)							
Zooplankton (TL-II)							
Planktivore (TL-III) Herring	0.0041749	0.0008350	0.0016520	0.0001652	0.0015859	0.0001586	
Piscivore (TL-IV) Jack	0.0060956	0.0012191	0.0024120	0.0002412	0.0023155	0.0002315	
Reef / Vessel Community							
Attached Algae							
Sessile filter feeder (TL-II) E	0.0015454	0.0003091			0.0005870	0.0000587	0.0002245
Invertibrate Omnivore (TL-II	0.3673750	0.0734750			0.1395513	0.0139551	0.0533750
Invertibrate Forager (TL-III)	0.6967438	0.1393488			0.2646656	0.0264666	0.1012281
Vertibrate Forager (TL-III) T	0.9592064	0.1918413	0.3795467	0.0379547	0.3643648	0.0364365	
Predator (TL-IV) Grouper	1.1125288	0.2225058	0.4402146	0.0440215	0.4226060	0.0422606	
Benthic Community							
Infaunal invert. (TL-II)					0.0002092	0.0000209	0.0000800
Epifaunal invert. (TL-II)	0.0015881	0.0003176			0.0006032	0.0000603	0.0002307
Forager (TL-III) Lobster	0.0039284	0.0007857			0.0014923	0.0001492	0.0005708
Predator (TL-IV) Flounder	0.0141782	0.0028356	0.0056102	0.0005610	0.0053857	0.0005386	

D2.1 HQ365day

Days Since Sinking	365

mg/L

Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg

Bulk sediment

OPPTS Assessment Factor	10	10	10
365	Turtle-LOAEL	Shark-NOAEL	Shark-LOAEL
mg/Kg wet	1.0894	0.2520	0.4066
Pelagic Community			
Phytoplankton (TL1)			
Zooplankton (TL-II)			
Planktivore (TL-III) Herring		0.0005245	0.0003250
Piscivore (TL-IV) Jack		0.0007658	0.0004746
Reef / Vessel Community			
Attached Algae			
Sessile filter feeder (TL-II) E	0.0000449		
Invertibrate Omnivore (TL-II	0.0106750		
Invertibrate Forager (TL-III)	0.0202456		
Vertibrate Forager (TL-III) T		0.1205080	0.0746810
Predator (TL-IV) Grouper		0.1397703	0.0866182
Benthic Community			
Infaunal invert. (TL-II)	0.0000160		
Epifaunal invert. (TL-II)	0.0000461		
Forager (TL-III) Lobster	0.0001142		
Predator (TL-IV) Flounder		0.0017813	0.0011039

D2.1 HQ730day

Days Since Sinking	730		
	Water Benchmarks		
	WQC-Chronic	GLWLC-Tier1	GLWLC
mg/L	0.00003	7.40E-05	1.40E-04
	Hazard Quotients (HQ)		
Upper Water Column	0.0000001	0.0000000	0.0000000
Lower Water Column	0.0103015	0.0041763	0.0022075
Inside the Vessel	8.0079774	3.2464773	1.7159951
Sediment Pore Water	0.0000350	0.0000142	0.0000075

	Sediment Benchmarks	
	TEL	PEL
mg/Kg	0.0216000	0.1890000
	Hazard Quotients (HQ)	
Bulk sediment	0.1250824	0.0507091

	Tissue Residue Benchmarks						
OPPTS Assessment Factor	1	1	1	10	10	10	10
730	TSV	Bcv-Invert	Bcv-Fish	Invert-NOED	Invert-LOED	Fish-NOED	Fish-LOED
mg/Kg wet	0.4368	0.9360	7.4463	0.0600	0.1100	0.1500	0.1800
Pelagic Community	Hazard Quotients (HQ)						
Phytoplankton (TL1)	0.0000000	0.0000000		0.0000000	0.0000000		
Zooplankton (TL-II)	0.0000417	0.0000195		0.0003035	0.0001655		
Planktivore (TL-III) Herring	0.0002049		0.0000120			0.0005967	0.0004973
Piscivore (TL-IV) Jack	0.0003097		0.0000182			0.0009019	0.0007516
Reef / Vessel Community							
Attached Algae	0.0000040	0.0000018		0.0000288	0.0000157		
Sessile filter feeder (TL-II) E	0.0000863	0.0000403		0.0006282	0.0003427		
Invertibrate Omnivore (TL-II	0.0177234	0.0082709		0.1290260	0.0703778		
Invertibrate Forager (TL-III)	0.0380353	0.0177498		0.2768973	0.1510349		
Vertibrate Forager (TL-III) T	0.0690116		0.0040482			0.2009618	0.1674682
Predator (TL-IV) Grouper	0.1178728		0.0069145			0.3432457	0.2860380
Benthic Community							
Infaunal invert. (TL-II)	0.0000302	0.0000141		0.0002198	0.0001199		
Epifaunal invert. (TL-II)	0.0000832	0.0000388		0.0006059	0.0003305		
Forager (TL-III) Lobster	0.0001927	0.0000899		0.0014028	0.0007652		
Predator (TL-IV) Flounder	0.0006683		0.0000392			0.0019460	0.0016216

D2.1 HQ730day

Days Since Sinking 730

mg/L

Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg

Bulk sediment Hazard Quotients
Benchmark

OPPTS Assessment Factor	10	10	10	10	10	10	10
730	Dolphin-NOAEl	Dolphin-LOAEL	Cormor-NOAEl	Cormor-LOAEL	Gull-NOAEL	Gull-LOAEL	Turtle-NOAEL
mg/Kg wet	0.0317	0.1583	0.0800	0.8000	0.0833	0.8333	0.2179
Pelagic Community							
Phytoplankton (TL1)							
Zooplankton (TL-II)							
Planktivore (TL-III) Herring	0.0028276	0.0005655	0.0011189	0.0001119	0.0010741	0.0001074	
Piscivore (TL-IV) Jack	0.0042740	0.0008548	0.0016912	0.0001691	0.0016235	0.0001624	
Reef / Vessel Community							
Attached Algae							
Sessile filter feeder (TL-II) E	0.0011908	0.0002382			0.0004523	0.0000452	0.0001730
Invertibrate Omnivore (TL-II	0.2445600	0.0489120			0.0928987	0.0092899	0.0355315
Invertibrate Forager (TL-III)	0.5248399	0.1049680			0.1993661	0.0199366	0.0762526
Vertibrate Forager (TL-III) T	0.9522733	0.1904547	0.3768034	0.0376803	0.3617312	0.0361731	
Predator (TL-IV) Grouper	1.6264966	0.3252993	0.6435856	0.0643586	0.6178422	0.0617842	
Benthic Community							
Infaunal invert. (TL-II)					0.0001583	0.0000158	0.0000605
Epifaunal invert. (TL-II)	0.0011484	0.0002297			0.0004362	0.0000436	0.0001668
Forager (TL-III) Lobster	0.0026589	0.0005318			0.0010100	0.0001010	0.0003863
Predator (TL-IV) Flounder	0.0092211	0.0018442	0.0036487	0.0003649	0.0035028	0.0003503	

D2.1 HQ730day

Days Since Sinking 730

mg/L
Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg
Bulk sediment

OPPTS Assessment Factor	10	10	10
730	Turtle-LOAEL	Shark-NOAEL	Shark-LOAEL
mg/Kg wet	1.0894	0.2520	0.4066
Pelagic Community			
Phytoplankton (TL1)			
Zooplankton (TL-II)			
Planktivore (TL-III) Herring		0.0003552	0.0002201
Piscivore (TL-IV) Jack		0.0005369	0.0003328
Reef / Vessel Community			
Attached Algae			
Sessile filter feeder (TL-II) E	0.0000346		
Invertibrate Omnivore (TL-II	0.0071063		
Invertibrate Forager (TL-III)	0.0152505		
Vertibrate Forager (TL-III) T		0.1196369	0.0741412
Predator (TL-IV) Grouper		0.2043416	0.1266343
Benthic Community			
Infaunal invert. (TL-II)	0.0000121		
Epifaunal invert. (TL-II)	0.0000334		
Forager (TL-III) Lobster	0.0000773		
Predator (TL-IV) Flounder		0.0011585	0.0007179

D2.2 HQssZOi2

Days Since Sinking	765	Steady State ZOI=1	
	Water Benchmarks		
	WQC-Chronic	GLWLC-Tier1	WQC-Acute
mg/L	0.00003	7.40E-05	1.00E-02
	Hazard Quotients (HQ)		
Upper Water Column	0.0000080	0.0000032	0.0000000
Lower Water Column	0.0558837	0.0226556	0.0001677
Inside the Vessel	22.9796631	9.3160796	0.0689390
Sediment Pore Water	0.0001462	0.0000593	0.0000004

	Sediment Benchmarks	
	TEL	PEL
mg/Kg	0.0216000	0.1890000
	Hazard Quotients (HQ)	
Bulk sediment	0.2398144	0.0972220

	Tissue Residue Benchmarks						
OPPTS Assessment Factor	1	1	1	10	10	10	10
	TSV	Bcv-Invert	Bcv-Fish	Invert-NOED	Invert-LOED	Fish-NOED	Fish-LOED
mg/Kg wet	0.4368	0.9360	7.4463	0.0600	0.1100	0.1500	0.1800
Pelagic Community	Hazard Quotients (HQ)						
Phytoplankton (TL1)	0.0000000	0.0000000		0.0000000	0.0000000		
Zooplankton (TL-II)	0.0001768	0.0000825		0.0012869	0.0007020		
Planktivore (TL-III) Herring	0.0008562		0.0000502			0.0024931	0.0020776
Piscivore (TL-IV) Jack	0.0013288		0.0000780			0.0038696	0.0032247
Reef / Vessel Community							
Attached Algae	0.0000165	0.0000077		0.0001205	0.0000657		
Sessile filter feeder (TL-II) Bival	0.0003625	0.0001692		0.0026392	0.0014396		
Invertibrate Omnivore (TL-II) Ur	0.0387955	0.0181046		0.2824312	0.1540534		
Invertibrate Forager (TL-III) Cra	0.0829777	0.0387229		0.6040777	0.3294969		
Vertibrate Forager (TL-III) Trigg	0.1499466		0.0087959			0.4366446	0.3638705
Predator (TL-IV) Grouper	0.2582687		0.0151501			0.7520786	0.6267322
Benthic Community							
Infaunal invert. (TL-II)	0.0001255	0.0000586		0.0009136	0.0004983		
Epifaunal invert. (TL-II)	0.0003448	0.0001609		0.0025100	0.0013691		
Forager (TL-III) Lobster	0.0007891	0.0003683		0.0057447	0.0031335		
Predator (TL-IV) Flounder	0.0027124		0.0001591			0.0078984	0.0065820

D2.2 HQssZOi2

Days Since Sinking 765 Steady State ZOI=1

mg/L

Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg

Bulk sediment

Hazard Quotients
Benchmark

OPPTS Assessment Factor	10	10	10	10	10	10	10
	Dolphin-NOAEI	Dolphin-LOAEL	Cormor-NOAEI	Cormor-LOAEL	Gull-NOAEL	Gull-LOAEL	Turtle-NOAEL
mg/Kg wet	0.0317	0.1583	0.0800	0.8000	0.0833	0.8333	0.2179
Pelagic Community							
Phytoplankton (TL1)							
Zooplankton (TL-II)							
Planktivore (TL-III) Herring	0.0118138	0.0023628	0.0046746	0.0004675	0.0044876	0.0004488	
Piscivore (TL-IV) Jack	0.0183363	0.0036673	0.0072555	0.0007255	0.0069653	0.0006965	
Reef / Vessel Community							
Attached Algae							
Sessile filter feeder (TL-II) Bival	0.0050025	0.0010005			0.0019002	0.0001900	0.0007268
Invertibrate Omnivore (TL-II) Ur	0.5353290	0.1070658			0.2033505	0.0203350	0.0777765
Invertibrate Forager (TL-III) Cra	1.1449879	0.2289976			0.4349359	0.0434936	0.1663523
Vertibrate Forager (TL-III) Trigg	2.0690749	0.4138150	0.8187086	0.0818709	0.7859603	0.0785960	
Predator (TL-IV) Grouper	3.5637838	0.7127568	1.4101474	0.1410147	1.3537415	0.1353741	
Benthic Community							
Infaunal invert. (TL-II)					0.0006578	0.0000658	0.0002516
Epifaunal invert. (TL-II)	0.0047574	0.0009515			0.0018072	0.0001807	0.0006912
Forager (TL-III) Lobster	0.0108887	0.0021777			0.0041362	0.0004136	0.0015820
Predator (TL-IV) Flounder	0.0374273	0.0074855	0.0148095	0.0014810	0.0142171	0.0014217	

D2.2 HQssZOi2

Days Since Sinking 765 Steady State ZOI=1

mg/L
Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg
Bulk sediment

OPPTS Assessment Factor	10	10	10
	Turtle-LOAEL	Shark-NOAEL	Shark-LOAEL
mg/Kg wet	1.0894	0.2520	0.4066
Pelagic Community			
Phytoplankton (TL1)			
Zooplankton (TL-II)			
Planktivore (TL-III) Herring		0.0014842	0.0009198
Piscivore (TL-IV) Jack		0.0023036	0.0014276
Reef / Vessel Community			
Attached Algae			
Sessile filter feeder (TL-II) Bival	0.0001454		
Invertibrate Omnivore (TL-II) Ur	0.0155553		
Invertibrate Forager (TL-III) Cra	0.0332705		
Vertibrate Forager (TL-III) Trigg		0.2599441	0.1610921
Predator (TL-IV) Grouper		0.4477288	0.2774658
Benthic Community			
Infaunal invert. (TL-II)	0.0000503		
Epifaunal invert. (TL-II)	0.0001382		
Forager (TL-III) Lobster	0.0003164		
Predator (TL-IV) Flounder		0.0047021	0.0029140

D2.3 HQssZOi1

Days Since Sinking	800	Steady State ZOI=1					
	Water Benchmarks						
	WQC-Chronic	GLWLC-Tier1	WQC-Acute				
mg/L	0.00003	7.40E-05	1.00E-02				
	Hazard Quotients (HQ)						
Upper Water Column	0.0000089	0.0000036	0.0000000				
Lower Water Column	0.0878858	0.0356294	0.0002637				
Inside the Vessel	22.9796631	9.3160796	0.0689390		23	9	
Sediment Pore Water	0.0002299	0.0000932	0.0000007				
	Sediment Benchmarks						
	TEL	PEL					
mg/Kg	0.0216000	0.1890000					
	Hazard Quotients (HQ)						
Bulk sediment	0.3771446	0.1528965					
	Tissue Residue Benchmarks						
OPPTS Assessment Factor	1	1	1	10	10	10	10
	TSV	Bcv-Invert	Bcv-Fish	Invert-NOED	Invert-LOED	Fish-NOED	Fish-LOED
mg/Kg wet	0.4368	0.9360	7.4463	0.0600	0.1100	0.1500	0.1800
Pelagic Community	Hazard Quotients (HQ)						
Phytoplankton (TL1)	0.0000000	0.0000000		0.0000000	0.0000000		
Zooplankton (TL-II)	0.0002780	0.0001297		0.0020237	0.0011038		
Planktivore (TL-III) Herring	0.0013463		0.0000790			0.0039203	0.0032669
Piscivore (TL-IV) Jack	0.0020895		0.0001226			0.0060848	0.0050706
Reef / Vessel Community							
Attached Algae	0.0000260	0.0000121		0.0001894	0.0001033		
Sessile filter feeder (TL-II) Bival	0.0005701	0.0002661		0.0041505	0.0022639		
Invertibrate Omnivore (TL-II) Ur	0.0394186	0.0183953		0.2869673	0.1565276		
Invertibrate Forager (TL-III) Cra	0.0841055	0.0392492		0.6122880	0.3339753		
Vertibrate Forager (TL-III) Trigg	0.1524123		0.0089405			0.4438246	0.3698538
Predator (TL-IV) Grouper	0.2624909		0.0153978			0.7643734	0.6369779
Benthic Community							
Infaunal invert. (TL-II)	0.0001974	0.0000921		0.0014368	0.0007837		
Epifaunal invert. (TL-II)	0.0005422	0.0002530		0.0039471	0.0021530		
Forager (TL-III) Lobster	0.0012410	0.0005791		0.0090342	0.0049278		
Predator (TL-IV) Flounder	0.0042655		0.0002502			0.0124211	0.0103509

D2.3 HQssZOi1

Days Since Sinking 800 Steady State ZOI=1

mg/L

Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg

Bulk sediment

Hazard Quotients
Benchmark

OPPTS Assessment Factor	10	10	10	10	10	10	10
	Dolphin-NOAEI	Dolphin-LOAEL	Cormor-NOAEI	Cormor-LOAEL	Gull-NOAEL	Gull-LOAEL	Turtle-NOAEL
mg/Kg wet	0.0317	0.1583	0.0800	0.8000	0.0833	0.8333	0.2179
Pelagic Community							
Phytoplankton (TL1)							
Zooplankton (TL-II)							
Planktivore (TL-III) Herring	0.0185767	0.0037153	0.0073506	0.0007351	0.0070565	0.0007057	
Piscivore (TL-IV) Jack	0.0288331	0.0057666	0.0114089	0.0011409	0.0109526	0.0010953	
Reef / Vessel Community							
Attached Algae							
Sessile filter feeder (TL-II) Bival	0.0078669	0.0015734			0.0029883	0.0002988	0.0011430
Invertibrate Omnivore (TL-II) Ur	0.5439268	0.1087854			0.2066164	0.0206616	0.0790257
Invertibrate Forager (TL-III) Cra	1.1605500	0.2321100			0.4408474	0.0440847	0.1686133
Vertibrate Forager (TL-III) Trigg	2.1030978	0.4206196	0.8321711	0.0832171	0.7988843	0.0798884	
Predator (TL-IV) Grouper	3.6220439	0.7244088	1.4332002	0.1433200	1.3758722	0.1375872	
Benthic Community							
Infaunal invert. (TL-II)					0.0010345	0.0001034	0.0003957
Epifaunal invert. (TL-II)	0.0074815	0.0014963			0.0028419	0.0002842	0.0010870
Forager (TL-III) Lobster	0.0171238	0.0034248			0.0065046	0.0006505	0.0024879
Predator (TL-IV) Flounder	0.0588584	0.0117717	0.0232896	0.0023290	0.0223580	0.0022358	

D2.3 HQssZOi1

Days Since Sinking 800 Steady State ZOI=1

mg/L
Upper Water Column
Lower Water Column
Inside the Vessel
Sediment Pore Water

mg/Kg
Bulk sediment

OPPTS Assessment Factor	10	10	10
	Turtle-LOAEL	Shark-NOAEL	Shark-LOAEL
mg/Kg wet	1.0894	0.2520	0.4066
Pelagic Community			
Phytoplankton (TL1)			
Zooplankton (TL-II)			
Planktivore (TL-III) Herring		0.0023338	0.0014463
Piscivore (TL-IV) Jack		0.0036224	0.0022449
Reef / Vessel Community			
Attached Algae			
Sessile filter feeder (TL-II) Bival	0.0002286		
Invertibrate Omnivore (TL-II) Ur	0.0158051		
Invertibrate Forager (TL-III) Cra	0.0337227		
Vertibrate Forager (TL-III) Trigg		0.2642185	0.1637410
Predator (TL-IV) Grouper		0.4550482	0.2820017
Benthic Community			
Infaunal invert. (TL-II)	0.0000791		
Epifaunal invert. (TL-II)	0.0002174		
Forager (TL-III) Lobster	0.0004976		
Predator (TL-IV) Flounder		0.0073946	0.0045825

Appendix D3.1 Mammalian TEQs calculated from concentrations of homologs (A), estimated coplanar congener concentrations (B), and mammalian dioxin-like TEQs for reef biota (C) and HQ's for dietary exposure to dolphins (D)								
ZOI=1								
A. Tissue Conc. (mg/kg-WW)	Tetra	Penta	Hexa	Hepta	Total PCB			
Pelagic Community								
Phytoplankton (TL1)	5.79E-10	7.61E-10	3.04E-11	1.25E-11	1.86E-09			
Zooplankton (TL-II)	4.28E-05	4.24E-05	6.07E-06	5.40E-06	1.21E-04			
Planktivore (TL-III)	1.69E-04	3.01E-04	4.73E-05	4.11E-05	5.88E-04			
Piscivore (TL-IV)	9.86E-05	5.27E-04	1.42E-04	1.39E-04	9.13E-04			
Reef / Vessel Community								
Attached Algae	3.16E-06	4.98E-06	4.84E-07	3.06E-07	1.14E-05			
Sessile filter feeder (TL-II)	9.20E-05	8.90E-05	7.89E-06	5.71E-06	2.49E-04			
Invertebrate Omnivore (TL-II)	5.67E-03	9.19E-03	6.54E-04	3.45E-04	1.72E-02			
Invertebrate Forager (TL-III)	1.09E-02	2.08E-02	1.65E-03	9.21E-04	3.67E-02			
Vertebrate Forager (TL-III)	1.27E-02	4.53E-02	4.61E-03	2.71E-03	6.66E-02			
Predator (TL-IV)	1.07E-02	8.25E-02	1.27E-02	8.18E-03	1.15E-01			
Benthic Community								
Infaunal invert. (TL-II)	3.19E-05	3.21E-05	2.93E-06	2.14E-06	8.62E-05			
Epifaunal invert. (TL-II)	8.77E-05	9.66E-05	9.26E-06	6.84E-06	2.37E-04			
Forager (TL-III)	1.82E-04	2.72E-04	2.54E-05	1.73E-05	5.42E-04			
Predator (TL-IV)	3.96E-04	1.19E-03	1.43E-04	1.01E-04	1.86E-03			
B. PCB pg/g WW	Tetra		Penta					
Pelagic Community	PCB077	PCB081e	PCB105	PCB114	PCB118	PCB123	PCB126	PCB156
Phytoplankton (TL1)	1.95E-07	1.55E-08	2.12E-05	7.40E-07	4.84E-11	0.00E+00	0.00E+00	2.37E-07
Zooplankton (TL-II)	1.44E-02	1.14E-03	1.18E+00	4.12E-02	2.70E-06	0.00E+00	0.00E+00	4.73E-02
Planktivore (TL-III)	5.68E-02	4.51E-03	8.40E+00	2.92E-01	1.91E-05	0.00E+00	0.00E+00	3.68E-01
Piscivore (TL-IV)	3.32E-02	2.63E-03	1.47E+01	5.13E-01	3.35E-05	0.00E+00	0.00E+00	1.11E+00
Reef / Vessel Community								
Attached Algae	1.06E-03	8.45E-05	1.39E-01	4.84E-03	3.16E-07	0.00E+00	0.00E+00	3.77E-03
Sessile filter feeder (TL-II)	3.09E-02	2.46E-03	2.49E+00	8.66E-02	5.66E-06	0.00E+00	0.00E+00	6.14E-02
Invertebrate Omnivore (TL-II)	1.91E+00	1.51E-01	2.57E+02	8.93E+00	5.84E-04	0.00E+00	0.00E+00	5.09E+00
Invertebrate Forager (TL-III)	3.66E+00	2.91E-01	5.81E+02	2.02E+01	1.32E-03	0.00E+00	0.00E+00	1.29E+01
Vertebrate Forager (TL-III)	4.28E+00	3.40E-01	1.27E+03	4.40E+01	2.88E-03	0.00E+00	0.00E+00	3.59E+01
Predator (TL-IV)	3.58E+00	2.85E-01	2.30E+03	8.02E+01	5.24E-03	0.00E+00	0.00E+00	9.88E+01
Benthic Community								
Infaunal invert. (TL-II)	1.07E-02	8.53E-04	8.95E-01	3.12E-02	2.04E-06	0.00E+00	0.00E+00	2.28E-02
Epifaunal invert. (TL-II)	2.95E-02	2.34E-03	2.70E+00	9.40E-02	6.14E-06	0.00E+00	0.00E+00	7.21E-02
Forager (TL-III)	6.13E-02	4.87E-03	7.59E+00	2.64E-01	1.73E-05	0.00E+00	0.00E+00	1.98E-01
Predator (TL-IV)	1.33E-01	1.06E-02	3.33E+01	1.16E+00	7.58E-05	0.00E+00	0.00E+00	1.12E+00
max pg/g WW	4.28E+00	3.40E-01	2.30E+03	8.02E+01	5.24E-03	0.00E+00	0.00E+00	9.88E+01

C. Mammalian TEQ pg/g WW	Tetra	Tetra	Penta	Penta	Penta	Penta	Penta	Hexa
Pelagic Community	PCB077	PCB081e	PCB105	PCB114	PCB118	PCB123	PCB126	PCB156
Phytoplankton (TL1)	1.95E-11	1.55E-12	2.12E-09	3.70E-10	4.84E-15	0.00E+00	0.00E+00	1.18E-10
Zooplankton (TL-II)	1.44E-06	1.14E-07	1.18E-04	2.06E-05	2.70E-10	0.00E+00	0.00E+00	2.36E-05
Planktivore (TL-III)	5.68E-06	4.51E-07	8.40E-04	1.46E-04	1.91E-09	0.00E+00	0.00E+00	1.84E-04
Piscivore (TL-IV)	3.32E-06	2.63E-07	1.47E-03	2.56E-04	3.35E-09	0.00E+00	0.00E+00	5.53E-04
Reef / Vessel Community								
Attached Algae	1.06E-07	8.45E-09	1.39E-05	2.42E-06	3.16E-11	0.00E+00	0.00E+00	1.88E-06
Sessile filter feeder (TL-II)	3.09E-06	2.46E-07	2.49E-04	4.33E-05	5.66E-10	0.00E+00	0.00E+00	3.07E-05
Invertebrate Omnivore (TL-II)	1.91E-04	1.51E-05	2.57E-02	4.47E-03	5.84E-08	0.00E+00	0.00E+00	2.55E-03
Invertebrate Forager (TL-III)	3.66E-04	2.91E-05	5.81E-02	1.01E-02	1.32E-07	0.00E+00	0.00E+00	6.44E-03
Vertebrate Forager (TL-III)	4.28E-04	3.40E-05	1.27E-01	2.20E-02	2.88E-07	0.00E+00	0.00E+00	1.80E-02
Predator (TL-IV)	3.58E-04	2.85E-05	2.30E-01	4.01E-02	5.24E-07	0.00E+00	0.00E+00	4.94E-02
Benthic Community								
Infaunal invert. (TL-II)	1.07E-06	8.53E-08	8.95E-05	1.56E-05	2.04E-10	0.00E+00	0.00E+00	1.14E-05
Epifaunal invert. (TL-II)	2.95E-06	2.34E-07	2.70E-04	4.70E-05	6.14E-10	0.00E+00	0.00E+00	3.61E-05
Forager (TL-III)	6.13E-06	4.87E-07	7.59E-04	1.32E-04	1.73E-09	0.00E+00	0.00E+00	9.88E-05
Predator (TL-IV)	1.33E-05	1.06E-06	3.33E-03	5.80E-04	7.58E-09	0.00E+00	0.00E+00	5.58E-04
max TEQ pg/g WW	4.28E-04	3.40E-05	2.30E-01	4.01E-02	5.24E-07	0.00E+00	0.00E+00	4.94E-02
	2.30E-01							
	D. HQs By Trophic Level				Dolphin-NOAEL*	Dolphin-LOAEL*		
				TEQ	HQ	HQ		
		Primary Producers	Phyto	2.71E-09	6.91E-09	1.52E-09		
			Algae	2.02E-05	5.15E-05	1.14E-05		
		Primary Consumers	Zoo	1.97E-04	5.03E-04	1.11E-04		
			Bivalve	3.61E-04	9.20E-04	2.03E-04		
			Urchin	3.50E-02	8.92E-02	1.97E-02		
			Polychaete	1.31E-04	3.33E-04	7.36E-05		
			Nematode	3.98E-04	1.01E-03	2.24E-04		
		Secondary Consumers	Herring	1.43E-03	3.64E-03	8.03E-04		
			Crab	8.08E-02	2.06E-01	4.54E-02		
			Triggerfish	1.84E-01	4.68E-01	1.03E-01		
			Lobster	1.10E-03	2.81E-03	6.20E-04		
		Tertiary Consumers	Jack	3.13E-03	7.98E-03	1.76E-03		
			Grouper	3.71E-01	9.45E-01	2.09E-01		
			Flounder	5.11E-03	1.30E-02	2.87E-03		

Appendix D3.1 Mammalian TE mammal							
ZOI=1							
A. Tissue Conc. (mg/kg-WW)							
Pelagic Community							
Phytoplankton (TL1)							
Zooplankton (TL-II)							
Planktivore (TL-III)							
Piscivore (TL-IV)							
Reef / Vessel Community							
Attached Algae							
Sessile filter feeder (TL-II)							
Invertebrate Omnivore (TL-II)							
Invertebrate Forager (TL-III)							
Vertebrate Forager (TL-III)							
Predator (TL-IV)							
Benthic Community							
Infaunal invert. (TL-II)							
Epifaunal invert. (TL-II)							
Forager (TL-III)							
Predator (TL-IV)							
B. PCB pg/g WW	Hexa			Hepta			
Pelagic Community	PCB157	PCB167	PCB169	PCB170	PCB180	PCB189	
Phytoplankton (TL1)	9.88E-09	3.62E-08	0.00E+00	2.60E-07	4.80E-07	0.00E+00	
Zooplankton (TL-II)	1.97E-03	7.23E-03	0.00E+00	1.13E-01	2.08E-01	0.00E+00	
Planktivore (TL-III)	1.54E-02	5.63E-02	0.00E+00	8.56E-01	1.58E+00	0.00E+00	
Piscivore (TL-IV)	4.61E-02	1.69E-01	0.00E+00	2.89E+00	5.35E+00	0.00E+00	
Reef / Vessel Community							
Attached Algae	1.57E-04	5.76E-04	0.00E+00	6.37E-03	1.18E-02	0.00E+00	
Sessile filter feeder (TL-II)	2.56E-03	9.39E-03	0.00E+00	1.19E-01	2.20E-01	0.00E+00	
Invertebrate Omnivore (TL-II)	2.13E-01	7.79E-01	0.00E+00	7.20E+00	1.33E+01	0.00E+00	
Invertebrate Forager (TL-III)	5.37E-01	1.97E+00	0.00E+00	1.92E+01	3.55E+01	0.00E+00	
Vertebrate Forager (TL-III)	1.50E+00	5.49E+00	0.00E+00	5.64E+01	1.04E+02	0.00E+00	
Predator (TL-IV)	4.12E+00	1.51E+01	0.00E+00	1.70E+02	3.15E+02	0.00E+00	
Benthic Community							
Infaunal invert. (TL-II)	9.53E-04	3.49E-03	0.00E+00	4.47E-02	8.26E-02	0.00E+00	
Epifaunal invert. (TL-II)	3.01E-03	1.10E-02	0.00E+00	1.42E-01	2.63E-01	0.00E+00	
Forager (TL-III)	8.25E-03	3.02E-02	0.00E+00	3.60E-01	6.66E-01	0.00E+00	
Predator (TL-IV)	4.66E-02	1.71E-01	0.00E+00	2.11E+00	3.90E+00	0.00E+00	
max pg/g WW	4.12E+00	1.51E+01	0.00E+00	1.70E+02	3.15E+02	0.00E+00	

C. Mammalian TEQ pg/g WW	Hexa	Hexa	Hexa	Hepta	Hepta	Hepta	**C. Mammalian TEQ pg/g WW**
Pelagic Community	PCB157	PCB167	PCB169	PCB170	PCB180	PCB189	TEQ
Phytoplankton (TL1)	4.94E-12	3.62E-13	0.00E+00	2.60E-11	4.80E-11	0.00E+00	2.71E-09
Zooplankton (TL-II)	9.86E-07	7.23E-08	0.00E+00	1.13E-05	2.08E-05	0.00E+00	1.97E-04
Planktivore (TL-III)	7.69E-06	5.63E-07	0.00E+00	8.56E-05	1.58E-04	0.00E+00	1.43E-03
Piscivore (TL-IV)	2.31E-05	1.69E-06	0.00E+00	2.89E-04	5.35E-04	0.00E+00	3.13E-03
Reef / Vessel Community							
Attached Algae	7.86E-08	5.76E-09	0.00E+00	6.37E-07	1.18E-06	0.00E+00	2.02E-05
Sessile filter feeder (TL-II)	1.28E-06	9.39E-08	0.00E+00	1.19E-05	2.20E-05	0.00E+00	3.61E-04
Invertebrate Omnivore (TL-II)	1.06E-04	7.79E-06	0.00E+00	7.20E-04	1.33E-03	0.00E+00	3.50E-02
Invertebrate Forager (TL-III)	2.69E-04	1.97E-05	0.00E+00	1.92E-03	3.55E-03	0.00E+00	8.08E-02
Vertebrate Forager (TL-III)	7.49E-04	5.49E-05	0.00E+00	5.64E-03	1.04E-02	0.00E+00	1.84E-01
Predator (TL-IV)	2.06E-03	1.51E-04	0.00E+00	1.70E-02	3.15E-02	0.00E+00	3.71E-01
Benthic Community							
Infaunal invert. (TL-II)	4.77E-07	3.49E-08	0.00E+00	4.47E-06	8.26E-06	0.00E+00	1.31E-04
Epifaunal invert. (TL-II)	1.50E-06	1.10E-07	0.00E+00	1.42E-05	2.63E-05	0.00E+00	3.98E-04
Forager (TL-III)	4.12E-06	3.02E-07	0.00E+00	3.60E-05	6.66E-05	0.00E+00	1.10E-03
Predator (TL-IV)	2.33E-05	1.71E-06	0.00E+00	2.11E-04	3.90E-04	0.00E+00	5.11E-03
max TEQ pg/g WW	2.06E-03	1.51E-04	0.00E+00	1.70E-02	3.15E-02	0.00E+00	3.71E-01

Appendix D3.2 Avian TEQs calculated from concentrations of homologs (A), estimated coplanar congener concentrations (B), and mammalian dioxin-like TEQs for reef biota (C) and HQ's for dietary exposure to dolphins (D)								
ZOI=1								
A. Tissue Conc. (mg/kg-WW)	Tetra	Penta	Hexa	Hepta	Total PCB			
Pelagic Community								
Phytoplankton (TL1)	5.79E-10	7.61E-10	3.04E-11	1.25E-11	1.86E-09			
Zooplankton (TL-II)	4.28E-05	4.24E-05	6.07E-06	5.40E-06	1.21E-04			
Planktivore (TL-III)	1.69E-04	3.01E-04	4.73E-05	4.11E-05	5.88E-04			
Piscivore (TL-IV)	9.86E-05	5.27E-04	1.42E-04	1.39E-04	9.13E-04			
Reef / Vessel Community								
Attached Algae	3.16E-06	4.98E-06	4.84E-07	3.06E-07	1.14E-05			
Sessile filter feeder (TL-II)	9.20E-05	8.90E-05	7.89E-06	5.71E-06	2.49E-04			
Invertebrate Omnivore (TL-II)	5.67E-03	9.19E-03	6.54E-04	3.45E-04	1.72E-02			
Invertebrate Forager (TL-III)	1.09E-02	2.08E-02	1.65E-03	9.21E-04	3.67E-02			
Vertebrate Forager (TL-III)	1.27E-02	4.53E-02	4.61E-03	2.71E-03	6.66E-02			
Predator (TL-IV)	1.07E-02	8.25E-02	1.27E-02	8.18E-03	1.15E-01			
Benthic Community								
Infaunal invert. (TL-II)	3.19E-05	3.21E-05	2.93E-06	2.14E-06	8.62E-05			
Epifaunal invert. (TL-II)	8.77E-05	9.66E-05	9.26E-06	6.84E-06	2.37E-04			
Forager (TL-III)	1.82E-04	2.72E-04	2.54E-05	1.73E-05	5.42E-04			
Predator (TL-IV)	3.96E-04	1.19E-03	1.43E-04	1.01E-04	1.86E-03			
B. PCB pg/g WW	Tetra		Penta					
Pelagic Community	PCB077	PCB081e	PCB105	PCB114	PCB118	PCB123	PCB126	PCB156
Phytoplankton (TL1)	1.95E-07	1.55E-08	2.12E-05	7.40E-07	4.84E-11	0.00E+00	0.00E+00	2.37E-07
Zooplankton (TL-II)	1.44E-02	1.14E-03	1.18E+00	4.12E-02	2.70E-06	0.00E+00	0.00E+00	4.73E-02
Planktivore (TL-III)	5.68E-02	4.51E-03	8.40E+00	2.92E-01	1.91E-05	0.00E+00	0.00E+00	3.68E-01
Piscivore (TL-IV)	3.32E-02	2.63E-03	1.47E+01	5.13E-01	3.35E-05	0.00E+00	0.00E+00	1.11E+00
Reef / Vessel Community								
Attached Algae	1.06E-03	8.45E-05	1.39E-01	4.84E-03	3.16E-07	0.00E+00	0.00E+00	3.77E-03
Sessile filter feeder (TL-II)	3.09E-02	2.46E-03	2.49E+00	8.66E-02	5.66E-06	0.00E+00	0.00E+00	6.14E-02
Invertebrate Omnivore (TL-II)	1.91E+00	1.51E-01	2.57E+02	8.93E+00	5.84E-04	0.00E+00	0.00E+00	5.09E+00
Invertebrate Forager (TL-III)	3.66E+00	2.91E-01	5.81E+02	2.02E+01	1.32E-03	0.00E+00	0.00E+00	1.29E+01
Vertebrate Forager (TL-III)	**4.28E+00**	**3.40E-01**	1.27E+03	4.40E+01	2.88E-03	0.00E+00	0.00E+00	3.59E+01
Predator (TL-IV)	3.58E+00	2.85E-01	**2.30E+03**	**8.02E+01**	**5.24E-03**	0.00E+00	0.00E+00	**9.88E+01**
Benthic Community								
Infaunal invert. (TL-II)	1.07E-02	8.53E-04	8.95E-01	3.12E-02	2.04E-06	0.00E+00	0.00E+00	2.28E-02
Epifaunal invert. (TL-II)	2.95E-02	2.34E-03	2.70E+00	9.40E-02	6.14E-06	0.00E+00	0.00E+00	7.21E-02
Forager (TL-III)	6.13E-02	4.87E-03	7.59E+00	2.64E-01	1.73E-05	0.00E+00	0.00E+00	1.98E-01
Predator (TL-IV)	1.33E-01	1.06E-02	3.33E+01	1.16E+00	7.58E-05	0.00E+00	0.00E+00	1.12E+00
max pg/g WW	4.28E+00	3.40E-01	2.30E+03	8.02E+01	5.24E-03	0.00E+00	0.00E+00	9.88E+01

C. TEQ pg/g WW	Tetra	Tetra	Penta	Penta	Penta	Penta	Penta	Hexa
Pelagic Community	PCB077	PCB081e	PCB105	PCB114	PCB118	PCB123	PCB126	PCB156
Phytoplankton (TL1)	9.74E-09	1.55E-09	2.12E-09	7.40E-11	4.84E-16	0.00E+00	0.00E+00	2.37E-11
Zooplankton (TL-II)	7.19E-04	1.14E-04	1.18E-04	4.12E-06	2.70E-11	0.00E+00	0.00E+00	4.73E-06
Planktivore (TL-III)	2.84E-03	4.51E-04	8.40E-04	2.92E-05	1.91E-10	0.00E+00	0.00E+00	3.68E-05
Piscivore (TL-IV)	1.66E-03	2.63E-04	1.47E-03	5.13E-05	3.35E-10	0.00E+00	0.00E+00	1.11E-04
Reef / Vessel Community								
Attached Algae	5.31E-05	8.45E-06	1.39E-05	4.84E-07	3.16E-12	0.00E+00	0.00E+00	3.77E-07
Sessile filter feeder (TL-II)	1.55E-03	2.46E-04	2.49E-04	8.66E-06	5.66E-11	0.00E+00	0.00E+00	6.14E-06
Invertebrate Omnivore (TL-II)	9.53E-02	1.51E-02	2.57E-02	8.93E-04	5.84E-09	0.00E+00	0.00E+00	5.09E-04
Invertebrate Forager (TL-III)	1.83E-01	2.91E-02	5.81E-02	2.02E-03	1.32E-08	0.00E+00	0.00E+00	1.29E-03
Vertebrate Forager (TL-III)	**2.14E-01**	**3.40E-02**	1.27E-01	4.40E-03	2.88E-08	0.00E+00	0.00E+00	3.59E-03
Predator (TL-IV)	1.79E-01	2.85E-02	**2.30E-01**	8.02E-03	5.24E-08	0.00E+00	0.00E+00	9.88E-03
Benthic Community								
Infaunal invert. (TL-II)	5.37E-04	8.53E-05	8.95E-05	3.12E-06	2.04E-11	0.00E+00	0.00E+00	2.28E-06
Epifaunal invert. (TL-II)	1.47E-03	2.34E-04	2.70E-04	9.40E-06	6.14E-11	0.00E+00	0.00E+00	7.21E-06
Forager (TL-III)	3.06E-03	4.87E-04	7.59E-04	2.64E-05	1.73E-10	0.00E+00	0.00E+00	1.98E-05
Predator (TL-IV)	6.65E-03	1.06E-03	3.33E-03	1.16E-04	7.58E-10	0.00E+00	0.00E+00	1.12E-04
max TEQ pg/g WW	2.14E-01	3.40E-02	2.30E-01	8.02E-03	5.24E-08	0.00E+00	0.00E+00	9.88E-03
	2.30E-01							
		D. HQ By Trophic Level			Cormor-NOAEL*	Cormor-LOAEL*	Gull-NOAEL*	Gull-LOAEL*
				TEQ	HQ	HQ	HQ	HQ
		Primary Producers	Phyto	1.35E-08	2.17E-09	2.17E-10	2.09E-09	2.09E-10
			Algae	7.66E-05	1.23E-05	1.23E-06	1.18E-05	1.18E-06
		Primary Consumers	Zoo	9.64E-04	1.55E-04	1.55E-05	1.49E-04	1.49E-05
			Bivalve	2.06E-03	3.31E-04	3.31E-05	3.18E-04	3.18E-05
			Urchin	1.38E-01	2.21E-02	2.21E-03	2.12E-02	2.12E-03
			Polychaete	7.18E-04	1.15E-04	1.15E-05	1.11E-04	1.11E-05
			Nematode	2.00E-03	3.21E-04	3.21E-05	3.09E-04	3.09E-05
		Secondary Consumers	Herring	4.22E-03	6.78E-04	6.78E-05	6.51E-04	6.51E-05
			Crab	2.74E-01	4.40E-02	4.40E-03	4.23E-02	4.23E-03
			Triggerfish	3.84E-01	6.18E-02	6.18E-03	5.93E-02	5.93E-03
			Lobster	4.37E-03	7.02E-04	7.02E-05	6.74E-04	6.74E-05
		Tertiary Consumers	Jack	3.64E-03	5.86E-04	5.86E-05	5.62E-04	5.62E-05
			Grouper	4.61E-01	7.42E-02	7.42E-03	7.12E-02	7.12E-03
			Flounder	1.13E-02	1.82E-03	1.82E-04	1.75E-03	1.75E-04

Appendix D3.2 Avian TEQs calcu di							
ZOI=1							
A. Tissue Conc. (mg/kg-WW)							
Pelagic Community							
Phytoplankton (TL1)							
Zooplankton (TL-II)							
Planktivore (TL-III)							
Piscivore (TL-IV)							
Reef / Vessel Community							
Attached Algae							
Sessile filter feeder (TL-II)							
Invertebrate Omnivore (TL-II)							
Invertebrate Forager (TL-III)							
Vertebrate Forager (TL-III)							
Predator (TL-IV)							
Benthic Community							
Infaunal invert. (TL-II)							
Epifaunal invert. (TL-II)							
Forager (TL-III)							
Predator (TL-IV)							
B. PCB pg/g WW	Hexa			Hepta			
Pelagic Community	PCB157	PCB167	PCB169	PCB170	PCB180	PCB189	
Phytoplankton (TL1)	9.88E-09	3.62E-08	0.00E+00	2.60E-07	4.80E-07	0.00E+00	
Zooplankton (TL-II)	1.97E-03	7.23E-03	0.00E+00	1.13E-01	2.08E-01	0.00E+00	
Planktivore (TL-III)	1.54E-02	5.63E-02	0.00E+00	8.56E-01	1.58E+00	0.00E+00	
Piscivore (TL-IV)	4.61E-02	1.69E-01	0.00E+00	2.89E+00	5.35E+00	0.00E+00	
Reef / Vessel Community							
Attached Algae	1.57E-04	5.76E-04	0.00E+00	6.37E-03	1.18E-02	0.00E+00	
Sessile filter feeder (TL-II)	2.56E-03	9.39E-03	0.00E+00	1.19E-01	2.20E-01	0.00E+00	
Invertebrate Omnivore (TL-II)	2.13E-01	7.79E-01	0.00E+00	7.20E+00	1.33E+01	0.00E+00	
Invertebrate Forager (TL-III)	5.37E-01	1.97E+00	0.00E+00	1.92E+01	3.55E+01	0.00E+00	
Vertebrate Forager (TL-III)	1.50E+00	5.49E+00	0.00E+00	5.64E+01	1.04E+02	0.00E+00	
Predator (TL-IV)	**4.12E+00**	**1.51E+01**	0.00E+00	**1.70E+02**	**3.15E+02**	0.00E+00	
Benthic Community							
Infaunal invert. (TL-II)	9.53E-04	3.49E-03	0.00E+00	4.47E-02	8.26E-02	0.00E+00	
Epifaunal invert. (TL-II)	3.01E-03	1.10E-02	0.00E+00	1.42E-01	2.63E-01	0.00E+00	
Forager (TL-III)	8.25E-03	3.02E-02	0.00E+00	3.60E-01	6.66E-01	0.00E+00	
Predator (TL-IV)	4.66E-02	1.71E-01	0.00E+00	2.11E+00	3.90E+00	0.00E+00	
max pg/g WW	4.12E+00	1.51E+01	0.00E+00	1.70E+02	3.15E+02	0.00E+00	

C. TEQ pg/g WW	Hexa	Hexa	Hexa	Hepta	Hepta	Hepta	**Avian TEQ pg/g wet**
Pelagic Community	PCB157	PCB167	PCB169	PCB170	PCB180	PCB189	TEQ
Phytoplankton (TL1)	9.88E-13	3.62E-13	0.00E+00	2.60E-12	4.80E-12	0.00E+00	1.35E-08
Zooplankton (TL-II)	1.97E-07	7.23E-08	0.00E+00	1.13E-06	2.08E-06	0.00E+00	9.64E-04
Planktivore (TL-III)	1.54E-06	5.63E-07	0.00E+00	8.56E-06	1.58E-05	0.00E+00	4.22E-03
Piscivore (TL-IV)	4.61E-06	1.69E-06	0.00E+00	2.89E-05	5.35E-05	0.00E+00	3.64E-03
Reef / Vessel Community							
Attached Algae	1.57E-08	5.76E-09	0.00E+00	6.37E-08	1.18E-07	0.00E+00	7.66E-05
Sessile filter feeder (TL-II)	2.56E-07	9.39E-08	0.00E+00	1.19E-06	2.20E-06	0.00E+00	2.06E-03
Invertebrate Omnivore (TL-II)	2.13E-05	7.79E-06	0.00E+00	7.20E-05	1.33E-04	0.00E+00	1.38E-01
Invertebrate Forager (TL-III)	5.37E-05	1.97E-05	0.00E+00	1.92E-04	3.55E-04	0.00E+00	2.74E-01
Vertebrate Forager (TL-III)	1.50E-04	5.49E-05	0.00E+00	5.64E-04	1.04E-03	0.00E+00	3.84E-01
Predator (TL-IV)	4.12E-04	1.51E-04	0.00E+00	1.70E-03	3.15E-03	0.00E+00	4.61E-01
Benthic Community							
Infaunal invert. (TL-II)	9.53E-08	3.49E-08	0.00E+00	4.47E-07	8.26E-07	0.00E+00	7.18E-04
Epifaunal invert. (TL-II)	3.01E-07	1.10E-07	0.00E+00	1.42E-06	2.63E-06	0.00E+00	2.00E-03
Forager (TL-III)	8.25E-07	3.02E-07	0.00E+00	3.60E-06	6.66E-06	0.00E+00	4.37E-03
Predator (TL-IV)	4.66E-06	1.71E-06	0.00E+00	2.11E-05	3.90E-05	0.00E+00	1.13E-02
max TEQ pg/g WW	4.12E-04	1.51E-04	0.00E+00	1.70E-03	3.15E-03	0.00E+00	

Appendix D3.3. Fish egg TEQs calculated from concentrations of homologs, estimated coplanar congener concentrations, and dioxin-like TECs for reef fish.								
ZOI=1								
A. Tissue Conc. (mg/kg-WW)	Tetra	Penta	Hexa	Hepta	Total PCB			
Pelagic Community								
Phytoplankton (TL1)	3.51E-08	4.62E-08	1.85E-09	7.56E-10	1.13E-07			
Zooplankton (TL-II)	8.10E-04	8.03E-04	1.15E-04	1.02E-04	2.30E-03			
Planktivore (TL-III)	2.40E-03	4.28E-03	6.74E-04	5.85E-04	8.37E-03			
Piscivore (TL-IV)	1.40E-03	7.50E-03	2.02E-03	1.98E-03	1.30E-02			
Reef / Vessel Community								
Attached Algae	1.92E-04	3.02E-04	2.94E-05	1.85E-05	6.90E-04			
Sessile filter feeder (TL-II)	1.02E-02	9.89E-03	8.76E-04	6.34E-04	2.77E-02			
Invertebrate Omnivore (TL-II)	1.09E-01	1.76E-01	1.25E-02	6.62E-03	3.30E-01			
Invertebrate Forager (TL-III)	4.56E-01	8.72E-01	6.93E-02	3.86E-02	1.54E+00			
Vertebrate Forager (TL-III)	1.81E-01	6.45E-01	6.57E-02	3.86E-02	9.48E-01			
Predator (TL-IV)	1.52E-01	1.17E+00	1.81E-01	1.16E-01	1.63E+00			
Benthic Community								
Infaunal invert. (TL-II)	3.34E-03	3.35E-03	3.07E-04	2.24E-04	9.01E-03			
Epifaunal invert. (TL-II)	8.15E-03	8.98E-03	8.61E-04	6.35E-04	2.20E-02			
Forager (TL-III)	7.64E-03	1.14E-02	1.06E-03	7.25E-04	2.27E-02			
Predator (TL-IV)	7.19E-03	2.17E-02	2.61E-03	1.84E-03	3.39E-02			
B. Fish Tissue PCB pg/g Lipid	Tetra		Penta					
Pelagic Community	PCB077	PCB081e	PCB105	PCB114	PCB118	PCB123	PCB126	PCB156
Phytoplankton (TL1)	1.18E-05	9.39E-07	1.29E-03	4.49E-05	2.93E-09	0.00E+00	0.00E+00	1.44E-05
Zooplankton (TL-II)	2.72E-01	2.16E-02	2.24E+01	7.81E-01	5.11E-05	0.00E+00	0.00E+00	8.95E-01
Planktivore (TL-III)	8.08E-01	6.42E-02	1.20E+02	4.16E+00	2.72E-04	0.00E+00	0.00E+00	5.25E+00
Piscivore (TL-IV)	4.72E-01	3.75E-02	2.10E+02	7.30E+00	4.77E-04	0.00E+00	0.00E+00	1.57E+01
Reef / Vessel Community								
Attached Algae	6.45E-02	5.13E-03	8.44E+00	2.94E-01	1.92E-05	0.00E+00	0.00E+00	2.29E-01
Sessile filter feeder (TL-II)	3.44E+00	2.73E-01	2.76E+02	9.62E+00	6.29E-04	0.00E+00	0.00E+00	6.82E+00
Invertebrate Omnivore (TL-II)	3.65E+01	2.90E+00	4.92E+03	1.71E+02	1.12E-02	0.00E+00	0.00E+00	9.76E+01
Invertebrate Forager (TL-III)	1.53E+02	1.22E+01	2.44E+04	8.48E+02	5.54E-02	0.00E+00	0.00E+00	5.39E+02
Vertebrate Forager (TL-III)	6.09E+01	4.84E+00	1.80E+04	6.27E+02	4.10E-02	0.00E+00	0.00E+00	5.11E+02
Predator (TL-IV)	5.10E+01	4.06E+00	3.28E+04	1.14E+03	7.46E-02	0.00E+00	0.00E+00	1.41E+03
Benthic Community								
Infaunal invert. (TL-II)	1.12E+00	8.92E-02	9.36E+01	3.26E+00	2.13E-04	0.00E+00	0.00E+00	2.39E+00
Epifaunal invert. (TL-II)	2.74E+00	2.18E-01	2.51E+02	8.73E+00	5.71E-04	0.00E+00	0.00E+00	6.70E+00
Forager (TL-III)	2.57E+00	2.04E-01	3.18E+02	1.11E+01	7.23E-04	0.00E+00	0.00E+00	8.28E+00
Predator (TL-IV)	2.42E+00	1.92E-01	6.05E+02	2.11E+01	1.38E-03	0.00E+00	0.00E+00	2.03E+01
max pg/g Lipid	1.53E+02	1.22E+01	3.28E+04	1.14E+03	7.46E-02	0.00E+00	0.00E+00	1.41E+03

C. Fish EGG TEQ pg/g Lipid								
Pelagic Community	PCB077	PCB081e	PCB105	PCB114	PCB118	PCB123	PCB126	PCB156
Phytoplankton (TL1)	7.09E-10	2.79E-10	4.12E-09	1.45E-10	9.24E-15	0.00E+00	0.00E+00	3.72E-11
Zooplankton (TL-II)	1.63E-05	6.43E-06	7.18E-05	2.52E-06	1.61E-10	0.00E+00	0.00E+00	2.32E-06
Planktivore (TL-III)	4.84E-05	1.91E-05	3.82E-04	1.35E-05	8.57E-10	0.00E+00	0.00E+00	1.36E-05
Piscivore (TL-IV)	2.83E-05	1.11E-05	6.70E-04	2.36E-05	1.50E-09	0.00E+00	0.00E+00	4.07E-05
Reef / Vessel Community								
Attached Algae	3.87E-06	1.52E-06	2.70E-05	9.49E-07	6.04E-11	0.00E+00	0.00E+00	5.92E-07
Sessile filter feeder (TL-II)	2.06E-04	8.11E-05	8.84E-04	3.11E-05	1.98E-09	0.00E+00	0.00E+00	1.77E-05
Invertebrate Omnivore (TL-II)	2.19E-03	8.62E-04	1.57E-02	5.53E-04	3.52E-08	0.00E+00	0.00E+00	2.53E-04
Invertebrate Forager (TL-III)	9.19E-03	3.62E-03	7.79E-02	2.74E-03	1.74E-07	0.00E+00	0.00E+00	1.40E-03
Vertebrate Forager (TL-III)	3.65E-03	1.44E-03	5.76E-02	2.03E-03	1.29E-07	0.00E+00	0.00E+00	1.32E-03
Predator (TL-IV)	3.06E-03	1.20E-03	1.05E-01	3.69E-03	2.35E-07	0.00E+00	0.00E+00	3.64E-03
Benthic Community								
Infaunal invert. (TL-II)	6.73E-05	2.65E-05	2.99E-04	1.05E-05	6.70E-10	0.00E+00	0.00E+00	6.18E-06
Epifaunal invert. (TL-II)	1.64E-04	6.47E-05	8.02E-04	2.82E-05	1.80E-09	0.00E+00	0.00E+00	1.73E-05
Forager (TL-III)	1.54E-04	6.06E-05	1.02E-03	3.58E-05	2.28E-09	0.00E+00	0.00E+00	2.14E-05
Predator (TL-IV)	1.45E-04	5.71E-05	1.94E-03	6.81E-05	4.34E-09	0.00E+00	0.00E+00	5.26E-05
max TEQ pg/g WW	9.19E-03	3.62E-03	1.05E-01	3.69E-03	2.35E-07	0.00E+00	0.00E+00	3.64E-03
				lipid weight	wet weight			
	D. HQ By Trophic Level			LOEL_Rainbow*	NOED_Rainbow*	NOED_Laketrout*	LOEL_Laketrout*	
		TEQ lipid	TEQ wet	**HQ**	**HQ**	**HQ**	**HQ**	
Secondary Consumers	Herring	5.47E-04	5.96E-05	1.82E-03	1.99E-03	1.19E-04	1.99E-05	
	Triggerfish	7.07E-02	7.72E-03	2.36E-01	2.57E-01	1.54E-02	2.57E-03	
	Jack	1.01E-03	1.10E-04	3.36E-03	3.67E-03	2.20E-04	3.67E-05	
Tertiary Consumers	Grouper	1.31E-01	1.42E-02	4.35E-01	4.75E-01	2.85E-02	4.75E-03	
	Flounder	2.48E-03	2.71E-04	8.27E-03	9.02E-03	5.41E-04	9.02E-05	

Appendix D3.3. Fish egg TEQs ca								
ZOI=1								
A. Tissue Conc. (mg/kg-WW)								
Pelagic Community								
Phytoplankton (TL1)								
Zooplankton (TL-II)								
Planktivore (TL-III)								
Piscivore (TL-IV)								
Reef / Vessel Community								
Attached Algae								
Sessile filter feeder (TL-II)								
Invertebrate Omnivore (TL-II)								
Invertebrate Forager (TL-III)								
Vertebrate Forager (TL-III)								
Predator (TL-IV)								
Benthic Community								
Infaunal invert. (TL-II)								
Epifaunal invert. (TL-II)								
Forager (TL-III)								
Predator (TL-IV)								
B. Fish Tissue PCB pg/g Lipid	Hexa			Hepta				
Pelagic Community	PCB157	PCB167	PCB169	PCB170	PCB180	PCB189		
Phytoplankton (TL1)	5.99E-07	2.20E-06	0.00E+00	1.57E-05	2.91E-05	0.00E+00		
Zooplankton (TL-II)	3.73E-02	1.37E-01	0.00E+00	2.13E+00	3.94E+00	0.00E+00		
Planktivore (TL-III)	2.19E-01	8.02E-01	0.00E+00	1.22E+01	2.25E+01	0.00E+00		
Piscivore (TL-IV)	6.56E-01	2.41E+00	0.00E+00	4.12E+01	7.61E+01	0.00E+00		
Reef / Vessel Community								
Attached Algae	9.54E-03	3.50E-02	0.00E+00	3.86E-01	7.14E-01	0.00E+00		
Sessile filter feeder (TL-II)	2.85E-01	1.04E+00	0.00E+00	1.32E+01	2.44E+01	0.00E+00		
Invertebrate Omnivore (TL-II)	4.07E+00	1.49E+01	0.00E+00	1.38E+02	2.55E+02	0.00E+00		
Invertebrate Forager (TL-III)	2.25E+01	8.25E+01	0.00E+00	8.04E+02	1.49E+03	0.00E+00		
Vertebrate Forager (TL-III)	2.13E+01	7.82E+01	0.00E+00	8.03E+02	1.48E+03	0.00E+00		
Predator (TL-IV)	5.87E+01	2.15E+02	0.00E+00	2.43E+03	4.48E+03	0.00E+00		
Benthic Community								
Infaunal invert. (TL-II)	9.96E-02	3.65E-01	0.00E+00	4.67E+00	8.63E+00	0.00E+00		lipid
Epifaunal invert. (TL-II)	2.80E-01	1.02E+00	0.00E+00	1.32E+01	2.45E+01	0.00E+00		ww
Forager (TL-III)	3.46E-01	1.27E+00	0.00E+00	1.51E+01	2.79E+01	0.00E+00		
Predator (TL-IV)	8.47E-01	3.10E+00	0.00E+00	3.84E+01	7.09E+01	0.00E+00		
max pg/g Lipid	5.87E+01	2.15E+02	0.00E+00	2.43E+03	4.48E+03	0.00E+00		
							egg lipid:wet	1.09E-01

D3.3 diox_fisheggLipid

C. Fish EGG TEQ pg/g Lipid							**TEQ C. Fish EGG TEQ pg/g Lipid**	**Fish EGG TEQ pg/g WW**
Pelagic Community	PCB157	PCB167	PCB169	PCB170	PCB180	PCB189	TEQ	TEQ
Phytoplankton (TL1)	1.60E-12	5.49E-12	0.00E+00	3.05E-11	5.63E-11	0.00E+00	5.39E-09	5.88E-10
Zooplankton (TL-II)	9.97E-08	3.42E-07	0.00E+00	4.12E-06	7.62E-06	0.00E+00	1.12E-04	1.22E-05
Planktivore (TL-III)	5.84E-07	2.00E-06	0.00E+00	2.36E-05	4.35E-05	0.00E+00	5.47E-04	5.96E-05
Piscivore (TL-IV)	1.75E-06	6.01E-06	0.00E+00	7.96E-05	1.47E-04	0.00E+00	1.01E-03	1.10E-04
Reef / Vessel Community								
Attached Algae	2.55E-08	8.74E-08	0.00E+00	7.47E-07	1.38E-06	0.00E+00	3.61E-05	3.94E-06
Sessile filter feeder (TL-II)	7.60E-07	2.61E-06	0.00E+00	2.56E-05	4.73E-05	0.00E+00	1.30E-03	1.41E-04
Invertebrate Omnivore (TL-II)	1.09E-05	3.73E-05	0.00E+00	2.67E-04	4.93E-04	0.00E+00	2.04E-02	2.22E-03
Invertebrate Forager (TL-III)	6.01E-05	2.06E-04	0.00E+00	1.56E-03	2.88E-03	0.00E+00	9.95E-02	1.09E-02
Vertebrate Forager (TL-III)	5.69E-05	1.95E-04	0.00E+00	1.55E-03	2.87E-03	0.00E+00	7.07E-02	7.72E-03
Predator (TL-IV)	1.57E-04	5.38E-04	0.00E+00	4.69E-03	8.67E-03	0.00E+00	1.31E-01	1.42E-02
Benthic Community								
Infaunal invert. (TL-II)	2.66E-07	9.12E-07	0.00E+00	9.03E-06	1.67E-05	0.00E+00	4.37E-04	4.76E-05
Epifaunal invert. (TL-II)	7.46E-07	2.56E-06	0.00E+00	2.56E-05	4.73E-05	0.00E+00	1.15E-03	1.26E-04
Forager (TL-III)	9.22E-07	3.16E-06	0.00E+00	2.92E-05	5.40E-05	0.00E+00	1.38E-03	1.50E-04
Predator (TL-IV)	2.26E-06	7.76E-06	0.00E+00	7.42E-05	1.37E-04	0.00E+00	2.48E-03	2.71E-04
max TEQ pg/g WW	1.57E-04	5.38E-04	0.00E+00	4.69E-03	8.67E-03	0.00E+00	1.39E-01	1.52E-02
Secondary Consumers								
Tertiary Consumers								

Appendix E. Results of Quantitative Uncertainty Analysis

E1 Bottom Current

E2 PCB Release Rate

E3 Bivalve Exposure to Interior Vessel Water

Appendix E1. The effect on PCB concentrations in biotic and abiotic media as function of varying bottom current through the ZOI.

			Default		
bottom current meters/h	93	465	926	1858	9292
Tissue Conc. (mg/kg-WW)	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB
Pelagic Community					
Phytoplankton (TL1)	1.62E-07	6.64E-09	1.67E-09	4.16E-10	1.66E-11
Zooplankton (TL-II)	7.68E-04	1.54E-04	7.72E-05	3.85E-05	7.69E-06
Planktivore (TL-III)	3.72E-03	7.45E-04	3.74E-04	1.86E-04	3.73E-05
Piscivore (TL-IV)	5.78E-03	1.16E-03	5.80E-04	2.89E-04	5.78E-05
Reef / Vessel Community					
Attached Algae	7.17E-05	1.44E-05	7.23E-06	3.60E-06	7.20E-07
Sessile filter feeder (TL-II)	1.57E-03	3.15E-04	1.58E-04	7.89E-05	1.58E-05
Invertebrate Omnivore (TL-II)	2.12E-02	1.74E-02	1.69E-02	1.67E-02	1.65E-02
Invertebrate Forager (TL-III)	4.39E-02	3.71E-02	3.62E-02	3.58E-02	3.55E-02
Vertebrate Forager (TL-III)	8.23E-02	6.74E-02	6.55E-02	6.46E-02	6.38E-02
Predator (TL-IV)	1.42E-01	1.16E-01	1.13E-01	1.11E-01	1.10E-01
Benthic Community					
Infaunal invert. (TL-II)	5.44E-04	1.09E-04	5.48E-05	2.73E-05	5.46E-06
Epifaunal invert. (TL-II)	1.50E-03	3.00E-04	1.51E-04	7.50E-05	1.50E-05
Forager (TL-III)	3.42E-03	6.86E-04	3.45E-04	1.72E-04	3.43E-05
Predator (TL-IV)	1.18E-02	2.36E-03	1.18E-03	5.90E-04	1.18E-04
Air concentration (g/m3)	1.81E-14	1.37E-16	6.68E-17	3.21E-17	5.67E-18
Upper Water Column					
Fugacity (Pa)					
Water concentration (mg/L)	9.83E-11	4.03E-12	1.02E-12	2.52E-13	1.01E-14
Suspended solids concentration (mg/kg)	1.29E-06	5.26E-08	1.33E-08	3.29E-09	1.32E-10
Dissolved organic carbon (mg/kg)	1.73E-05	7.05E-07	1.78E-07	4.42E-08	1.77E-09
Bulk Upper Water Col (mg/L)	2.33E-08	9.53E-10	2.40E-10	5.97E-11	2.39E-12
Lower Water Column					
Fugacity (Pa)					
Water concentration (mg/L)	4.35E-08	8.73E-09	4.39E-09	2.19E-09	4.37E-10
Suspended solids concentration (mg/kg)	1.07E-03	2.15E-04	1.08E-04	5.38E-05	1.08E-05
Dissolved organic carbon (mg/kg)	9.80E-03	1.97E-03	9.88E-04	4.92E-04	9.85E-05
Bulk Lower Water Col (mg/L)	1.66E-05	3.34E-06	1.68E-06	8.35E-07	1.67E-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
Suspended solids concentration (mg/kg)	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
Bulk Water Inside Vessel (mg/L)	6.89E-04	6.89E-04	6.89E-04	6.89E-04	6.89E-04
Sediment Bed					
Fugacity (Pa)					
Pore Water concentration (mg/L)	4.35E-08	8.73E-09	4.39E-09	2.19E-09	4.37E-10
Sediment concentration (mg/kg)	7.14E-05	1.43E-05	7.19E-06	3.58E-06	7.17E-07

Appendix E2. The effect on PCB concentrations in biotic and abiotic media as function of varying the daily PCB release rate.

	B. No BHI	D. 5247kg BHI	**A. PRAM Defaults 14379Kg**	E. 26000 kg BHI	F. 52478 kg BHI (original amount)	
Daily PCB Release Rate (ng/day)	2.4E+08	4.3E+08	7.62E+08	1.18E+09	2.15E+09	
% of BHI on the Ship	0%	10%	27%	50%	100%	
Tissue Conc. (mg/kg-WW)	Total PCB	Total PCB	Total PCB	Total PCB	Total PCB	
Pelagic Community						
Phytoplankton (TL1)	5.13E-10	9.37E-10	1.67E-09	2.61E-09	4.75E-09	
Zooplankton (TL-II)	2.27E-05	4.26E-05	7.72E-05	1.21E-04	2.22E-04	
Planktivore (TL-III)	7.12E-05	1.82E-04	3.74E-04	6.19E-04	1.18E-03	
Piscivore (TL-IV)	1.40E-04	3.00E-04	5.80E-04	9.37E-04	1.75E-03	
Reef / Vessel Community						
Attached Algae	2.11E-06	3.98E-06	7.23E-06	1.14E-05	2.08E-05	
Sessile filter feeder (TL-II)	4.51E-05	8.65E-05	1.58E-04	2.50E-04	4.58E-04	
Invertebrate Omnivore (TL-II)	2.79E-03	7.96E-03	1.69E-02	2.84E-02	5.44E-02	
Invertebrate Forager (TL-III)	5.86E-03	1.69E-02	3.62E-02	6.08E-02	1.17E-01	
Vertebrate Forager (TL-III)	9.24E-03	2.98E-02	6.55E-02	1.11E-01	2.15E-01	
Predator (TL-IV)	1.88E-02	5.31E-02	1.13E-01	1.89E-01	3.62E-01	
Benthic Community						
Infaunal invert. (TL-II)	1.48E-05	2.94E-05	5.48E-05	8.72E-05	1.61E-04	
Epifaunal invert. (TL-II)	3.53E-05	7.74E-05	1.51E-04	2.44E-04	4.56E-04	
Forager (TL-III)	6.19E-05	1.65E-04	3.45E-04	5.73E-04	1.09E-03	
Predator (TL-IV)	1.79E-04	5.46E-04	1.18E-03	2.00E-03	3.85E-03	
Air concentration (g/m3)	2.23E-17	3.86E-17	6.68E-17	1.03E-16	1.85E-16	
Upper Water Column						
Fugacity (Pa)						
Water concentration (mg/L)	3.12E-13	5.69E-13	1.02E-12	1.59E-12	2.88E-12	
Suspended solids concentration (mg/kg)	3.88E-09	7.31E-09	1.33E-08	2.08E-08	3.81E-08	
Dissolved organic carbon (mg/kg)	2.62E-08	8.15E-08	1.78E-07	3.00E-07	5.80E-07	
Bulk Upper Water Col (mg/L)	5.49E-11	1.23E-10	2.40E-10	3.90E-10	7.32E-10	
Lower Water Column						
Fugacity (Pa)						
Water concentration (mg/L)	1.28E-09	2.41E-09	4.39E-09	6.90E-09	1.26E-08	
Suspended solids concentration (mg/kg)	4.86E-05	7.02E-05	1.08E-04	1.56E-04	2.65E-04	
Dissolved organic carbon (mg/kg)	2.34E-04	5.09E-04	9.88E-04	1.60E-03	2.99E-03	
Bulk Lower Water Col (mg/L)	6.28E-07	1.01E-06	1.68E-06	2.52E-06	4.46E-06	
Inside the Vessel						
Fugacity (Pa)						
Water concentration (mg/L)	5.26E-07	9.92E-07	1.80E-06	2.84E-06	5.19E-06	
Suspended solids concentration (mg/kg)	2.00E-02	2.89E-02	4.44E-02	6.41E-02	1.09E-01	
Dissolved organic carbon (mg/kg)	9.64E-02	2.09E-01	4.06E-01	6.57E-01	1.23E+00	
Bulk Water Inside Vessel (mg/L)	2.58E-04	4.16E-04	6.89E-04	1.04E-03	1.83E-03	
Sediment Bed						
Fugacity (Pa)						
Pore Water concentration (mg/L)	1.28E-09	2.41E-09	4.39E-09	6.90E-09	1.26E-08	
Sediment concentration (mg/kg)	3.24E-06	4.68E-06	7.19E-06	1.04E-05	1.77E-05	

E3 Bivalve

Appendix E3. The effect on PCB concentrations in biota as function of increasing bivalve expsosure to interior vessel water.								Hazard Quotients	
			A. PRAM Defaults	B. 50%	C. 100%			default	50%
Bivalve Exposure to Interior Water			0.01	0.5	0.99				
Tissue Conc. (mg/kg-WW)			Total PCB	Total PCB	Total PCB			Dolphin-NOAEL*	Dolphin-NOAEL*
Pelagic Community								0.03165506	0.03165506
Phytoplankton (TL1)			1.67E-09	1.67E-09	1.67E-09			0.000	0.000
Zooplankton (TL-II)			7.72E-05	7.72E-05	7.72E-05			0.002	0.002
Planktivore (TL-III) herring			3.74E-04	3.74E-04	3.74E-04			0.012	0.012
Piscivore (TL-IV) jack			5.80E-04	5.80E-04	5.80E-04			0.018	0.018
Reef / Vessel Community									
Attached Algae			7.23E-06	7.23E-06	7.23E-06			0.000	0.000
Bivalve (TL-II) mussel			1.58E-04	2.78E-02	5.49E-02			0.005	0.878
Invertebrate Omnivore (TL-II) urchin			1.69E-02	5.33E-02	8.89E-02			0.535	1.683
Invertebrate Forager (TL-III) crab			3.62E-02	1.04E-01	1.71E-01			1.145	3.288
Vertebrate Forager (TL-III) triggerfish			6.55E-02	1.91E-01	3.15E-01			2.069	6.048
Predator (TL-IV) grouper			1.13E-01	3.13E-01	5.09E-01			3.564	9.889
Benthic Community									
Infaunal invert. (TL-II)			5.48E-05	5.48E-05	5.48E-05			0.002	0.002
Epifaunal invert. (TL-II)			1.51E-04	1.51E-04	1.51E-04			0.005	0.005
Forager (TL-III) lobster			3.45E-04	3.45E-04	3.45E-04			0.011	0.011
Predator (TL-IV) flounder			1.18E-03	1.18E-03	1.18E-03			0.037	0.037
	* Benchmarks were divided by an AF=10 to account for species-to-species differences in toxicity.								

Appendix E3. Cont.	Hazard Quotients							
	99%	99%	99%	99%	99%	99%	99%	99%
Bivalve Exposure to Interior Water								
Tissue Conc. (mg/kg-WW)	Dolphin-NOAEL*	Invert-NOED*	Cormor-NOAEL*	Gull-NOAEL*	Invert-LOED*	Fish-NOED*	Dolphin-LOAEL*	Fish-LOED*
Pelagic Community	0.03165506	0.06	0.08	0.083333	0.11	0.15	0.1582753	0.18
Phytoplankton (TL1)	0.000	0.000	0.000	0.000	0.0000	0.0000	0.0000	0.0000
Zooplankton (TL-II)	0.002	0.001	0.001	0.001	0.0007	0.0005	0.0005	0.0004
Planktivore (TL-III) herring	0.012	0.006	0.005	0.004	0.0034	0.0025	0.0024	0.0021
Piscivore (TL-IV) jack	0.018	0.010	0.007	0.007	0.0053	0.0039	0.0037	0.0032
Reef / Vessel Community								
Attached Algae	0.000	0.000	0.000	0.000	0.0001	0.0000	0.0000	0.0000
Bivalve (TL-II) mussel	1.734	0.915	0.686	0.659	0.4991	0.3660	0.3468	0.3050
Invertebrate Omnivore (TL-II) urchin	2.807	1.481	1.111	1.066	0.8079	0.5925	0.5615	0.4937
Invertebrate Forager (TL-III) crab	5.388	2.843	2.132	2.047	1.5505	1.1370	1.0776	0.9475
Vertebrate Forager (TL-III) triggerfish	9.947	5.248	3.936	3.779	2.8625	2.0992	1.9894	1.7493
Predator (TL-IV) grouper	16.088	8.488	6.366	6.111	4.6297	3.3951	3.2176	2.8293
Benthic Community								
Infaunal invert. (TL-II)	0.002	0.001	0.001	0.001	0.0005	0.0004	0.0003	0.0003
Epifaunal invert. (TL-II)	0.005	0.003	0.002	0.002	0.0014	0.0010	0.0010	0.0008
Forager (TL-III) lobster	0.011	0.006	0.004	0.004	0.0031	0.0023	0.0022	0.0019
Predator (TL-IV) flounder	0.037	0.020	0.015	0.014	0.0108	0.0079	0.0075	0.0066
	* Benchmarks were divided by an AF=10 to account for species-to-species differences in toxicity.							

Appendix E3. Cont.	Hazard Quotients								
	99%	99%	99%	99%	99%	99%	99%	99%	99%
Bivalve Exposure to Interior Water									
Tissue Conc. (mg/kg-WW)	Turtle-NOAEL*	Shark-NOAEL*	Shark-LOAEL*	TSV	Cormor-LOAEL*	Gull-LOAEL*	Bcv-Invert	Turtle-LOAEL*	Bcv-Fish
Pelagic Community	0.2178789	0.25196453	0.4065791	0.4368	0.8	0.833333	0.936	1.0893946	7.4463
Phytoplankton (TL1)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Zooplankton (TL-II)	0.0004	0.0003	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000
Planktivore (TL-III) herring	0.0017	0.0015	0.0009	0.0009	0.0005	0.0004	0.0004	0.0003	0.0001
Piscivore (TL-IV) jack	0.0027	0.0023	0.0014	0.0013	0.0007	0.0007	0.0006	0.0005	0.0001
Reef / Vessel Community									
Attached Algae	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bivalve (TL-II) mussel	0.2520	0.2179	0.1350	0.1257	0.0686	0.0659	0.0587	0.0504	0.0074
Invertebrate Omnivore (TL-II) urchin	0.4079	0.3527	0.2186	0.2035	0.1111	0.1066	0.0949	0.0816	0.0119
Invertebrate Forager (TL-III) crab	0.7828	0.6769	0.4195	0.3905	0.2132	0.2047	0.1822	0.1566	0.0229
Vertebrate Forager (TL-III) triggerfish	1.4452	1.2497	0.7744	0.7209	0.3936	0.3779	0.3364	0.2890	0.0423
Predator (TL-IV) grouper	2.3374	2.0212	1.2526	1.1659	0.6366	0.6111	0.5441	0.4675	0.0684
Benthic Community									
Infaunal invert. (TL-II)	0.0003	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
Epifaunal invert. (TL-II)	0.0007	0.0006	0.0004	0.0003	0.0002	0.0002	0.0002	0.0001	0.0000
Forager (TL-III) lobster	0.0016	0.0014	0.0008	0.0008	0.0004	0.0004	0.0004	0.0003	0.0000
Predator (TL-IV) flounder	0.0054	0.0047	0.0029	0.0027	0.0015	0.0014	0.0013	0.0011	0.0002
	* Benchmarks were divided by an AF=10 to account for species-to-species differences in toxicity.								