Artificial Reefing

Ex-ORISKANY Artificial Reef Project
Human Health Risk Assessment

SPAWAR
Systems Center
San Diego

January 2006
FINAL REPORT

PROGRAM EXECUTIVE OFFICE SHIPS

Ex-ORISKANY
Artificial Reef Project

HUMAN HEALTH
RISK ASSESSMENT

January 2006
FINAL REPORT

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ACRONYMS

ADD	average daily dose
AEC	Atlantic Environmental Consultants
AhR	aryl hydrocarbon
AT	averaging time
BAF	bioaccumulation factor
BAH	Booz Allen Hamilton
BCF	bioconcentration factor
BHI	bulkhead insulation
BW	body weight
CalEPA	California Environmental Protection Agency
CalTOX	CalEPA Multimedia Total Exposure Model for Hazardous Waste Sites
CFR	Code of Federal Regulations
CSF	cancer slope factor
CTE	central tendency exposure
DAD	dermally absorbed dose
DOC	dissolved organic carbon
ECMRD	Escambia County Marine Resources Division
ED	exposure duration
EF	exposure frequency
EPA	Environmental Protection Agency
EPC	exposure point concentration
FA	fraction absorbed
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FI	fraction ingested
FFWCC	Florida Fish and Wildlife Conservation Commission
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HQ	hazard quotient
IR	ingestion rate
IRIS	Integrated Risk Information System
LAARS	large area artificial reef site
LADD	lifetime average daily dose
LOAEL	lowest observed adverse effect level
LWC	lower water column
m	meters
MARAD	Maritime Administration
MCA	Menzie Cura & Associates, Inc.
mg/L	milligrams per Liter
MLLW	mean lower low water
NAVSEA	Naval Sea Systems Command
NCP	National Contingency Plan
NEHC	Navy Environmental Health Center

NLPCB	non-liquid polychlorinated biphenyls
NM	nautical miles
NOAA	National Oceanographic and Atmospheric Administration
OPPT	Office of Pollution Prevention and Toxics
PCB	polychlorinated biphenyls
PCDD	polychlorinated dibenzo-*p*-dioxin
PCDF	polychlorinated dibenzofuran
ppm	parts per million
PRAM	Prospective Risk Assessment Model
REEFEX	Reef Exercise (Sunken Vessels Used to Construct Artificial Reefs on the Continental Shelf of the US)
RfD	reference dose
RME	reasonable maximum exposure
SCEM	site conceptual exposure model
SERA	screening ecological risk assessment
SHHRA	Supplemental Human Health Risk Assessment
SPAWAR	Space and Naval Warfare
SSC-SD	Space and Naval Warfare Systems Center – San Diego
SUPSHIP	Supervisor of Shipbuilding, Conversion, and Repair
TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
TDM	Time Dynamic Model
TEF	toxic equivalency factor
TEQ	toxicity equivalence
TL	trophic level
TOC	total organic carbon
TSCA	Toxic Substances Control Act
TSS	total suspended solids
TWG	Technical Working Group
UCL	upper confidence limit
URS	URS Corporation
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
ZOI	zone of influence

EXECUTIVE SUMMARY

The results of the ex-ORISKANY human health risk assessment indicate that the cancer risks and noncancer hazards for adults and children are within U.S. Environmental Protection Agency (USEPA) acceptable criteria. Therefore, there are no significant risks associated with the ingestion of fish as a result of the sinking and use of the ex-ORISKANY as an artificial reef at Escambia East Large Area Artificial Reef Site off the coast of Pensacola, Florida.

The U.S. Navy prepared a decommissioned ESSEX class aircraft carrier, the ex-ORISKANY (CVA-34), for use as an artificial reef in shallow water approximately 22.5 nautical miles off the coast of Pensacola, Florida. Part of the preparations included the removal of polychlorinated biphenyls (PCBs) in accordance with the USEPA document *Draft National Guidance: Best Management Practices for Preparing Vessels Intended to Create Artificial Reefs* (USEPA, 2004a). The Navy removed all liquid PCBs and some solid materials containing PCBs at concentrations of 50 parts per million (ppm) or greater from the ex-ORISKANY, as recommended in the guidance. Solid materials, including electrical cable insulation, bulkhead insulation, paints, compressed fiber ventilation gaskets, and other rubber products, that contain PCBs at various concentrations remain onboard.

The Navy must receive a risk-based disposal approval from USEPA before sinking the vessel because PCBs will remain onboard at concentrations above 50 ppm in some materials. The approval requires that the Navy demonstrate that the remaining PCBs do not pose an unreasonable risk of injury to health or the environment. This risk assessment is part of the Navy's application for approval. It provides estimates of the risks to human health from exposure to the proposed ex-ORISKANY artificial reef.

PCBs from the sunken ex-ORISKANY might leach from the solid materials into the water and disperse over a large area. These PCBs may eventually accumulate in the tissue of fish living and feeding off the reef. There is a potential health risk to people who eat these fish. The risks vary depending on the amount of PCBs are in the fish, how much of their catch people eat, and how often they catch and eat fish from the reef.

This assessment assumed that recreational anglers will have the greatest potential for exposure to the PCBs left onboard the vessel because they are likely to catch and eat fish from the reef. It is also assumed that the children of these anglers eat some of their catch of fish. Thus, this assessment estimated the human health risks to these adult anglers and their children (a more sensitive population than the general adult population) from the consumption of reef fish caught from the ex-ORISKANYartifical reef. This assessment also evaluated potential exposures to divers who may be in contact with water during the time that PCB releases peak, and evaluated potential chronic effects to the fetus and nursing infants of exposed mothers.

Recognizing that exposure conditions at the reef might change over the course of time, this assessment evaluated subchronic exposures for fish ingestion over the two-year period immediately following sinking of the ship and chronic exposures for fish ingestion (typically 30 years) starting two years after the vessel is sunk. For each scenario, the amount of fish eaten (intake) was estimated using information obtained from recreational anglers who fish along the Gulf coast of Florida. The intakes were calculated following USEPA recommended approaches to derive reasonable maximum exposures (RMEs) and central tendency exposures (CTEs).

This assessment relied on two different computer models to predict PCB concentrations in water and fish at the future reef site for the different exposure times. The Time Dynamic Model (TDM) predicts short-term, time varying PCB concentrations in the water, sediment, and suspended solids inside the vessel, the lower water column surrounding the sunken ship, and in the upper water column above the reef and pycnocline expected to be present at the site during the first two years after sinking. These PCB concentrations are then used in the Prospective Risk Assessment Model (PRAM) food web module to estimate concentrations in fish and invertebrates and to calculate the risks from ingesting them.

During the initial two years, one assumption in TDM is that the amount of PCB release will peak and then slowly decrease, and that the water around the vessel will come to a steady-state concentration for PCBs. PRAM predicts PCB concentrations under this steady state in the environmental media and representative organisms that will live on or near the artificial reef. PRAM also calculates the potential human health risks associated with consuming fish from the reef site.

Based on these models, this risk assessment estimates cancer risk and noncancer hazards for adult anglers and their children who might eat fish from the reef. Cancer risks are calculated in terms of additional cases of cancer above what is normally expected to occur in a population over a 70-year lifetime. USEPA considers an increase in the range of one additional case in 1,000,000 people (expressed as 1E-6) up to one additional case in 10,000 people (1E-4) to be acceptable. Noncancer hazards are estimated by calculating a hazard quotient. A hazard quotient greater than 1 indicates a potential concern for noncancer health effects. Cancer risks and noncancer hazards for adults and children are summarized in Tables ES-1 and ES-2. The results show that short-term (subchronic) and long-term (chronic) exposures to PCBs from eating fish from the reef will not exceed harmful levels identified by USEPA. In addition, potential exposures to divers from dermal contact with water around the reef were found to be extremely low, and the evaluation of nursing infant exposures to PCBs from the mother's ingestion of fish caught at the proposed ex-ORISKANY reef site suggests that concomitant *in utero* exposures will not be greater than general background exposures.

Table ES-1

Adult and Child Fish Consumers: Cancer Risks and Subchronic Hazard Quotients Associated with Predicted Fish Tissue Concentrations for the ex-ORISKANY for the First Two Years Post Sinking

	Total PCBs	Hazard Quotient - Adult		Hazard Quotient - Child		Cancer Risk - Adult	
	(mg/kg, whole body wet weight fish tissue)	RME	CTE	RME	CTE	RME	CTE
USEPA Acceptable Level		**1.0**	**1.0**	**1.0**	**1.0**	**1E-06**	**1E-06**
0-60 meters from ship							
Benthic fish (flounder)	0.00043	0.0005	0.0002	0.0009	0.0004	4E-09	8E-10
Benthic shellfish (lobster)	0.00012	0.0002	0.00006	0.0002	0.0001	1E-09	2E-10
Pelagic fish (jack)	0.00019	0.0002	0.0001	0.0004	0.0002	2E-09	4E-10
Reef fish TL-IV (grouper)	0.045	0.06	0.02	0.1	0.04	4E-07	9E-08
Reef fish TL-III (triggerfish)	0.035	0.04	0.02	0.07	0.03	3E-07	7E-08
Reef shellfish (crab)	0.025	0.03	0.01	0.05	0.02	2E-07	5E-08
0-45 meters from ship							
Benthic fish (flounder)	0.00045	0.0006	0.0002	0.001	0.0004	4E-09	9E-10
Benthic shellfish (lobster)	0.00013	0.0002	0.00006	0.0003	0.0001	1E-09	2E-10
Pelagic fish (jack)	0.00020	0.0003	0.0001	0.0004	0.0002	2E-09	4E-10
Reef fish TL-IV (grouper)	0.045	0.06	0.02	0.1	0.04	4E-07	9E-08
Reef fish TL-III (triggerfish)	0.036	0.05	0.02	0.07	0.03	3E-07	7E-08
Reef shellfish (crab)	0.025	0.03	0.01	0.05	0.02	2E-07	5E-08
0-15 meters from ship							
Benthic fish (flounder)	0.00053	0.0007	0.0003	0.001	0.0005	5E-09	1E-09
Benthic shellfish (lobster)	0.00015	0.0002	0.00008	0.0003	0.0001	1E-09	3E-10
Pelagic fish (jack)	0.00023	0.0003	0.0001	0.0005	0.0002	2E-09	5E-10
Reef fish TL-IV (grouper)	0.046	0.06	0.02	0.1	0.04	4E-07	9E-08
Reef fish TL-III (triggerfish)	0.036	0.05	0.02	0.07	0.03	3E-07	7E-08
Reef shellfish (crab)	0.025	0.03	0.01	0.05	0.02	2E-07	5E-08

CTE – Central tendency exposure
RME – Reasonable maximum exposure
TL-III – Trophic Level III within the food web. Triggerfish is a representative fish species.
TL-IV – Trophic Level IV within the food web. Grouper is a representative fish species.

Table ES-2

Adult and Child Fish Consumers: Cancer Risks and Chronic Hazard Quotients Associated with Predicted Fish Tissue Concentrations for the ex-ORISKANY Under Steady State Conditions (Two Years Post Sinking to 32 Years Post Sinking)

	Total PCB (mg/kg, whole body wet weight fish tissue)	Hazard Quotient Adult		Hazard Quotient Adult + Child*		Hazard Quotient Child		Cancer Risk Adult		Cancer Risk Adult + Child*		Cancer Risk Child	
		RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
USEPA Acceptable Level		**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1E-06**	**1E-06**	**1E-06**	**1E-06**	**1E-06**	**1E-06**
ZOI = 2													
Benthic fish (flounder)	0.0012	0.005	0.005	0.004	0.002	0.006	0.002	6E-08	4E-09	7E-08	6E-09	2E-08	4E-09
Benthic shellfish (lobster)	0.00034	0.001	0.001	0.001	0.0007	0.002	0.0007	2E-08	1E-09	2E-08	2E-09	6E-09	1E-09
Pelagic fish (jack)	0.00058	0.002	0.002	0.002	0.001	0.003	0.001	3E-08	2E-09	4E-08	3E-09	1E-08	2E-09
Reef fish TL-IV (grouper)	0.11	0.4	0.4	0.4	0.2	0.6	0.2	6E-06	4E-07	7E-06	5E-07	2E-06	4E-07
Reef fish TL-III (triggerfish)	0.065	0.3	0.2	0.2	0.1	0.3	0.1	4E-06	2E-07	4E-06	3E-07	1E-06	2E-07
Reef shellfish (crab)	0.036	0.1	0.1	0.1	0.07	0.2	0.07	2E-06	1E-07	2E-06	2E-07	7E-07	1E-07
ZOI = 5													
Benthic fish (flounder)	0.00069	0.003	0.003	0.002	0.001	0.004	0.002	4E-08	2E-09	4E-08	3E-09	1E-08	3E-09
Benthic shellfish (lobster)	0.00020	0.001	0.001	0.0007	0.0005	0.001	0.0005	1E-08	6E-10	1E-08	1E-09	4E-09	7E-10
Pelagic fish (jack)	0.00034	0.001	0.001	0.001	0.0007	0.002	0.0007	2E-08	1E-09	2E-08	2E-09	6E-09	1E-09
Reef fish TL-IV (grouper)	0.11	0.4	0.4	0.4	0.2	0.6	0.2	6E-06	4E-07	7E-06	5E-07	2E-06	4E-07
Reef fish TL-III (triggerfish)	0.065	0.3	0.2	0.2	0.1	0.3	0.1	4E-06	2E-07	4E-06	3E-07	1E-06	2E-07
Reef shellfish (crab)	0.036	0.1	0.1	0.1	0.07	0.2	0.07	2E-06	1E-07	2E-06	2E-07	7E-07	1E-07

* Adult + Child includes 24 years exposure as an adult plus six years of exposure as a child

CTE – Central tendency exposure

RME – Reasonable maximum exposure

ZOI – Zone of influence. ZOIs 2 and 5 bound the predicted EPCs in fish tissue

TL-III – Trophic Level III within the food web. Triggerfish is a representative fish species.

TL-IV – Trophic Level IV within the food web is the top reef predator. Grouper is a representative fish species.

1. INTRODUCTION

1.1 BACKGROUND

1.1.1 A Short Description of the Planned Action and the ex-ORISKANY

The U.S. Navy is currently preparing to sink the ex-ORISKANY (CVA-34) to create an artificial reef in shallow water off the western coast of Pensacola, Florida (Figure 1-1) within the Escambia East Large Area Artificial Reef Site (LAARS) (Figure 1-2).

A risk-based disposal approval is required before sinking[1] under 40 Code of Federal Regulations (CFR) §761.62(c) because the ex-ORISKANY contains polychlorinated biphenyls (PCBs) in solid materials (e.g., electrical cable insulation, bulkhead insulation (BHI), paints, compressed fiber ventilation gaskets, and other rubber products) in concentrations greater than or equal to 50 parts per million (ppm). In consultation with the U.S. Environmental Protection Agency (USEPA) Office of Pollution Prevention and Toxics (OPPT), USEPA Region 4 is the approving authority for the Navy's request for risk-based PCB disposal approval for the ex-ORISKANY.

Appendix A presents a synopsis of the construction and operational history of this vessel. The ex-ORISKANY (CVA-34) has a displacement of 27,100 tons, a length of 888 feet, a hull width of 93 feet, and an extreme width of 147.5 feet, or an average beam of 120 feet. The depth of the water at the proposed site of sinking of the vessel is 212 feet, and if the vessel is sunk correctly, it should stand about 150 feet off the sea floor, with a maximum potential height of 157 feet if set on the sea floor in an upright position (FFWCC, 2004). It is anticipated that the vessel will sink some additional feet into the sand bottom sea floor (FFWCC, 2004).

[1] 40 CFR §761.62(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".

1.1.2 Historical Perspective

The Navy, through the Maritime Administration (MARAD), announced to coastal states in 2003 a solicitation to receive the former ESSEX class aircraft carrier, the ex-ORISKANY (CVA-34) for use as an artificial reef. Several states submitted applications to compete for the ex-ORISKANY, and the reef site was awarded to the State of Florida. Appendix B presents the Letter of Application submitted by the State of Florida's Fish and Wildlife Conservation Commission (FFWCC) and the Escambia County Marine Resources Division (ECMRD) to the Naval Sea Systems Command (NAVSEA) (FFWCC, 2004).

Previously, a multi-agency 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 sunk off the coast of South Carolina in 1987. The REEFEX Technical Working Group consisted of representatives from USEPA, U.S. Navy, South Carolina Department of Natural Resources (SCDNR), FFWCC, Florida Department of Environmental Protection (FDEP), Florida Department of Health (FDOH), and ECMRD. The technical approach and procedures used in this assessment are based, in part, on the findings developed by the REEFEX Technical Working Group.

Soon after the selection, the Navy began working with FFWCC and ECMRD to plan and prepare for sinking the ex-ORISKANY at the proposed deployment site at the East Escambia LAARS. In May 2004, the Navy and USEPA initiated technical discussions focused on providing science-based risk assessment results, which would enable Navy managers and USEPA regulators to make appropriate risk management decisions regarding the sinking of the ex-ORISKANY. In July 2004, the Navy submitted a draft Supplemental Human Health Risk Assessment (SHHRA) for the proposed ex-ORISKANY artificial reef to OPPT to seek risk-based disposal of PCBs under the regulatory provision of 40 CFR 761.62(c) (NEHC, 2004b). USEPA and the State of Florida reviewed the draft SHHRA document and the Technical Working Group[2] (TWG) held several teleconferences between August 2004 and January 2005, and meetings in August, September, and November, 2004 (USEPA and Florida, 2004).

The Navy submitted a Draft Final Human Health Risk Assessment (HHRA) in June 2005 and subsequently met with USEPA's Science Advisory Board (SAB) consultative panel in a public meeting held on August 1 and 2, 2005. The focus of the SAB consultation included leaching studies of the on-board PCB-containing materials and the fate and transport models known as the Time Dynamic Model (TDM) and the Prospective Risk Assessment Model (PRAM), which were

[2] The Technical Working Group is comprised of representatives from USEPA (Office of Pollution Prevention and Toxics, Office of Water, and Region 4), the State of Florida (Florida Fish and Wildlife Conservation Commission, the Escambia County Marine Resources Division, and other agencies), and the Navy and its subcontractors.

used to characterize the potential risk to human and ecological receptors using the artificial reef. In October 2005, the SAB posted individual panel member's comments and a summary of recommendations on USEPA's website. The Navy also received comments from USEPA Region 4. The Navy provided responses to both the USEPA Region 4 and SAB comments in November 2005. Subsequent issues for resolution were discussed in a conference call with the Navy and USEPA on December 6, 2005. The Navy submitted follow-up responses to USEPA on December 14, 2005, and the Navy and USEPA reached agreement on all outstanding issues. This report has been revised to address comments and questions provided by the SAB, OPPT, and EPA Region 4 (see Appendix J).

On January 10, 2006, USEPA held a public meeting in Pensacola, Florida to present the ex-ORISKANY artificial reef project. A fact sheet from the meeting is provided in Appendix I.

1.2 OBJECTIVES

The objective of this risk assessment is to assess whether PCBs that may be released during or after sinking of the ex-ORISKANY in the Escambia East LAARS has the potential to adversely impact human health from eating seafood caught at the reef. The results and conclusions from this assessment will be used to support risk management decisions about the potential beneficial reuse of the ex-ORISKANY as an artificial reef.

1.3 APPROACH

The quantitative risk assessment relies on two fate and transport models: PRAM (NEHC/SSC-SD, 2006a) and TDM (NEHC/SSC-SD, 2006b). These models perform the following functions:

- Incorporate empirically derived leach rates for PCBs from solid materials onboard the vessel (George *et al*., 2006)
- Estimate the release, fate, transport, bioconcentration, and bioaccumulation of PCBs leached from the vessel
- Calculate cancer risk and noncancer hazard from exposure to PCBs.

TDM simulates the release of PCBs for a two-year period immediately after sinking (NEHC/SSC-SD, 2006b). Short-term risks (zero to two years post sinking) were evaluated with TDM coupled to PRAM.

PRAM simulates the steady-state concentrations (at two years after sinking and later) 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). It calculates the long-term risks (two years to 32 years post sinking for this assessment) under steady-state conditions using site-specific exposure

assumptions.

This assessment uses the results of these models to quantify chronic and subchronic human health risks associated with the ingestion of various species of reef fish, and acute risks associated with exposures to PCBs in water during the period of highest PCB releases.

1.4 ORGANIZATION OF DOCUMENT

The assessment is organized into the following sections:

Executive Summary. Presents an overview of the project, risk assessment results, and risk conclusions.

Section 1. Introduction. This section presents information about the project history, the project objectives, the risk assessment approach, and document distribution and acknowledgement.

Section 2. Status of PCBs on Board the ex-ORISKANY. This section presents information on the PCB standards and Navy consultation with the State of Florida.

Section 3. Site Description. This section summarizes the types of species that recreational anglers or divers might catch at the reef.

Section 4. Predicting PCB Concentrations in Abiotic Media. This section summarizes the development of PRAM and TDM, their inputs and outputs to water and sediment (i.e., abiotic media), and the study of PCB leach rates.

Section 5. Predicting PCB Concentrations in Biotic Media with PRAM. This section summarizes PRAM modeling of PCB transfer from abiotic media into fish species expected to be consumed by recreational anglers, recreational divers, and children who share their catch.

Section 6. Exposure Assessment. The exposure assessment presents information on human activities that could result in exposure to PCBs released from the ex-ORISKANY reef; presents the Site Conceptual Exposure Model (SCEM); and discusses the potential exposure scenarios for recreational anglers, children who share their catch, and recreational divers.

Section 7. Toxicity Assessment. This section summarizes toxicity values used to quantify human cancer risk and noncancer hazard from exposure to PCBs originating from the ex-ORISKANY.

Section 8. Risk Characterization. This section integrates information from the exposure assessment and the toxicity assessment to quantify health risks to humans exposed to PCBs from the ex-ORISKANY reef site through consumption of fish.

Section 9. Uncertainty Analysis. The uncertainty analysis discusses the important factors contributing to uncertainty in the cancer risks and noncancer hazard quotients (HQs) presented in Section 8 and how each uncertainty influences the interpretation of the risk assessment results. It also includes a qualitative discussion of health risks that are not described in Section 8, including those associated with a recreational diver's acute exposures at the reef, exposure to dioxin-like PCB congeners in fish, and exposures both *in utero* and to nursing infants from the mother's consumption of fish.

Section 10. Conclusions. This section provides a summary of the risk assessment findings and presents the conclusions.

Section 11. References. This section provides the references for citations presented in this report.

1.5 DOCUMENT DISTRIBUTION

This document was initially prepared for Program Executive Office (PEO) Ships and the USEPA by the Navy Environmental Health Center (NEHC) with the assistance of URS. Subsequent iterations of the HHRA were provided by BAH with the assistance of MCA. The Navy project manager for REEFEX is SSC-SD. PEO Ships has approved the publication and distribution of this assessment. The document distribution list is comprised of individuals at USEPA Region 4, SSC-SD, and PMS-333. Additional electronic copies of this document may be obtained by contacting William (Bill) Wild, REEFEX Project Manager, SSC-SD, at bill.wild@navy.mil (email) or (619) 553-2781.

1.6 ACKNOWLEDGEMENT

The Navy staffing of this project is in accordance with Figure 1-3. The Navy is thankful for the contributions of the following individuals, whose involvement in this project was critical for timely completion of this document:

Craig Brown	USEPA Region 4
Dr. Ken Mitchell	USEPA Region 4
Laura Casey	USEPA Office of Pollution Prevention and Toxics
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2. STATUS OF PCBS ON BOARD THE EX-ORISKANY

Environmental preparation of the ex-ORISKANY followed the *Draft National Guidance: Best Management Practices for Preparing Vessels Intended to Create Artificial Reefs* (USEPA, 2004a). The PCB mitigation section of this guidance document recommends the following:

> Remove all solid material containing PCBs greater than or equal to (≥) 50 parts per million (ppm) unless a disposal permit has been granted under 40 CFR 761.62(c); remove all liquid materials containing PCBs. (USEPA, 2004a)

The guidance also discusses in detail the handling of liquid and non-liquid PCBs. Appendix C contains the excerpt of the guidance pertaining to PCB cleanup.

Soon after the State of Florida was selected as the site for sinking the ex-ORISKANY, and pursuant to the State of Florida Letter of Application to the Department of Transportation, Maritime Administration (Appendix B), the Navy began working with the FFWCC and the ECMRD to plan and prepare the vessel for sinking at the proposed deployment site at the Escambia East LAARS. The Navy and the State of Florida (Escambia County) have coordinated with each other on all phases of mitigation activities, including the removal of BHI materials and electrical cabling in the island structure above the flight deck. In addition, FFWCC, FDEP, and FDOH have provided input on diver safety issues to ensure safety within the island of the vessel.

3. SITE DESCRIPTION

3.1 LOCATION

According to the Navy's sink plan (USN, 2005), the ex-ORISKANY will be sunk at a depth of 212 feet within the Escambia East LAARS, approximately 22.5 nautical miles (nm) off the coast of Pensacola, Florida. Appendix E provides details regarding the selection of the Escambia East LAARS as an artificial reef site. The depth of the water at the proposed site of sinking of the vessel is 212 feet, and if the vessel is sunk according to plan, it should stand upright about 150 feet off the sea floor, with a maximum potential height of 157 feet (FFWCC, 2004). It is anticipated that the vessel will sink some additional feet into the sand bottom sea floor (FFWCC, 2004).

3.2 LOCAL ENVIRONMENTAL CONDITIONS

The accompanying ecological risk assessment (Johnson, *et al.*, 2006) provides a description of the physical, geological, and biological environment of the proposed area for sinking the vessel. In general, the bottom of the Escambia East LAARS consists of sand of varying depths over a limestone shelf, and has less than a five percent slope offshore. In the area of the proposed artificial reef site, the existing bottom is light brown sandy sediment with no observable limestone outcroppings.

The present biological environment of the proposed reef site is very limited due to the lack of substrate for community development (NAVSEA, 2004a). In general, the northeastern Gulf of Mexico region has minimal coverage with live bottom habitats, usually made up of soft corals and other reef species present on limestone outcroppings that cover approximately three percent of the sea floor. However, the hard bottom within the Escambia East LAARS is not well developed biologically, and outcroppings do not include tropical hard coral areas; the bottom is ephemeral in nature based on shifting sediments during storm events. 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.

3.3 TIME OF DEVELOPMENT OF REEF COMMUNITY

The reef community is the community of organisms that is expected to colonize the reef after the ex-ORISKANY sinks. It is expected to develop during the initial two years following sinking of the vessel. An assumption in PRAM is that the biological community at the reef develops over the initial two-year period after sinking of the vessel. The reef community is considered to be mature and stable after those first two years. There are at present no reef-associated organisms at the proposed reef deployment site, nor will there be at the time of sinking. However,

colonization of the vessel by reef organisms is likely to start almost immediately once the ship is sunk. The following discusses the rationale for assuming that the composition of the community at the reef, specifically the higher trophic fish and shellfish that are modeled in PRAM for potential human exposures, will mature sufficiently within the two-year period and be applicable to the assumptions in PRAM regarding the release of PCBs and transfer through the food web.

No studies are available on the development of colonization of artificial reefs created in the Gulf waters by large vessels such as the ex-ORISKANY. Publications by Bohnsack *et al.* (1994) and Walker et al. (2002) describe the colonization and development of small structured reefs in shallow nearshore waters off the southeast coast of Florida. Although the sizes and depths of those reefs are not at the same scale as the planned ex-ORISKANY reef, the publications are the most applicable peer reviewed articles describing artificial reefs in waters of the southeastern US.

Epibenthic biota such as algae, barnacles, crabs, and other invertebrates have been observed to colonize shallow water artificial reefs constructed from a variety of materials within a few weeks of immersion (Walker et al. 2002, Golani and Daimant 1999, Sherman *et al*. 1999, Clark and Edwards 1994). Colonization of artificial reefs by fish is also fairly rapid, occurring within weeks to two years after reef creation. For example, Bohnsack *et al.* (1994) reported that fish colonization of 16 concrete reefs of varying sizes in nearshore waters of southeastern Florida was very rapid, and within two years post-deployment, fish assemblages were abundant and diverse, with densities higher than at natural reefs in the area. Economically important species constituted 61% of the biomass. That study was supported by a more recent evaluation of several types of stone and concrete-based artificial reefs in nearshore waters of southeastern Florida, which documented increased fish abundance and richness compared to reference areas, including higher trophic sport fish such as groupers and snappers, within two years post-deployment of the reefs (Walker et al. 2002).

Other studies in southeastern Florida have also found rapid colonization of artificial reefs by fish assemblages. Cummings (1994) found that species diversity within the fish community reached equilibrium within 2.5 months at a shallow water artificial reef constructed of limestone boulder. Sherman *et al*. (1999) observed predatory fishes such as groupers, snappers, and jacks at small concrete reefs located in 23 feet to 70 feet of water prior to two years post-deployment. More biomass, greater fish species diversity, and more large fish were found at the reefs constructed in the deeper waters, up to 70 feet depth, compared to the shallower reefs.

Studies of artificial reefs in other marine waters have similarly found rapid fish recruitment. In the Mediterranean Sea, Coll *et al*. (1998) reported that the composition and abundance of fish species at concrete reefs constructed at 100 feet depth stabilized within two years of reef deployment. Clark and Edwards (1994) also found rapid colonization of artificial reefs by fish in

the Indian Ocean, with increased richness observed at 12 months of deployment. Golani and Diamant (1999) found that the number of fish species at artificial reefs in the Red Sea increased during the first seven months after deployment, and then leveled off for the remainder of the 2-year study. Species from a variety of trophic guilds were observed to be residents of the artificial reef within two years post-deployment, including predatory fishes such as groupers.

The above studies report that multiple fish species, including higher trophic sport fish, have been observed to colonize artificial reefs within a two-year time period, including off the coast of Florida. Ecological development of artificial reefs in marine environments has been noted to be difficult to predict, with some reefs observed to continually evolve over 13 to 20 years (Rilov and Benayahu, 2000; Svane and Petersen, 2001). Nonetheless, colonization of artificial reefs by fish species has been observed uniformly to be rapid, resulting in relatively high diversity and biomass within two years after reef deployment. The studies support the focus on reef development during the initial two-year period after vessel sinking as appropriate for evaluating the PCB uptake by fish from transient releases from the vessel. The post-two year time period is then considered to represent a sufficiently mature reef community for modeling the transfer of PCBs to fish and shellfish, such as grouper, trigger fish, jacks, flounder, lobster, and crabs, that would be consumed by humans under steady-state PCB releases and chronic exposure conditions.

3.4 EXPECTED RECREATIONAL SPECIES AT THE SITE

During the initial time period, only a few recreationally important fish and shellfish will colonize the reef. Exposure of the reef community to site-related contaminants may occur from water-borne contaminants and/or contaminated sediment, which may accumulate on the reef, and from contaminants that accumulate in the food chain. Ultimately, carnivorous fish and invertebrates on the reef will include species that recreational anglers catch and eat such as grunt, snapper, sea bass, grey triggerfish, lobster, and crabs that live on or near the bottom and are closely associated with the reef; as well as groupers, eels, and octopi that are pelagic but may be attracted to the reef to forage.

4. PREDICTING PCB CONCENTRATIONS IN ABIOTIC MEDIA

This section summarizes the models used to quantify PCB fate and transport, and abiotic media concentrations, in the marine environment at the proposed ex-ORISKANY artificial reef. The outputs of these models (i.e., predicted abiotic media concentrations of PCBs) are inputs to the food web module of PRAM (see Section 5). The models described in this section and Section 5 collectively provide exposure point concentrations (EPCs) for the assessment of human exposure to PCBs from the ex-ORISKANY (see Section 6).

4.1 LEACH RATE

A study that was conducted to determine the materials aboard the ex-ORISKANY and the amount of PCBs in these materials is included as Appendix D (Pape, 2004). PCB-containing materials include gaskets, rubber mounts and hangers, electrical cable insulation, BHI, and paints. TDM and PRAM used experimentally derived leach rates for each PCB homolog leaching from various PCB-containing materials taken from the ex-ORISKANY. These release rates are derived from leaching studies described in detail in George, *et al*. (2006) and NEHC/SSC-SD (2006a and 2006b). Figure 4-1 shows the leach rates incorporated into TDM to predict abiotic concentrations during the first two-year period following sinking of the ex-ORISKANY. These rates capture the time-varying nature of releases in the initial two-year period following sinking of the ship.

The final release rates used in PRAM are presented in Table 4-1. Leach rates are expressed on a PCB-homolog basis, normalized to the mass of material. Figure 4-2 shows the predicted releases from materials specifically from the ex-ORISKANY, obtained by multiplying the normalized average leach rate for that material by the estimated mass of material onboard the vessel. Note that the graphs in this figure are presented on a log scale. The top graph in Figure 4-2 provides the release rates by PCB homolog. The colors of each bar represent different materials. For example, pentachlorobiphenyl shows the highest overall release rate, primarily attributable to electrical cable. The bottom graph in Figure 4-2 shows the exact same information, but presented by material instead of PCB homolog. In this graph, each color represents a homolog group. For example, bulkhead insulation material shows the highest overall release rate of all the materials on-board the ex-ORISKANY, consisting primarily of monochlorobiphenyl, followed by tetrachlorobiphenyl and trichlorobiphenyl.

4.2 TIME DYNAMIC MODEL (TDM)

The TDM report (NEHC/SSC-SD, 2006b) describes the data output from TDM and its subsequent use in the PRAM biotic food web module. Output consists of the homolog and total

PCB concentrations calculated for air, water, dissolved organic carbon, suspended solids, and bedded sediments within the defined exposure zone. Figures C-1 to C-20 in Appendix C of the TDM documentation (NEHC/SSC-SD, 2006b) provides graphs of the predicted homolog concentrations and masses in the abiotic media over time. PCB concentrations in abiotic media from TDM that are used to evaluate exposures and risks in this assessment consist of predicted time averaged concentrations of total PCBs in water and other media for the zero- to 90-day initial release period and the 91- to 730-day period in the zero to 15 meter (m), zero to 45 m, and zero to 60 m distance intervals from the vessel (Tables 4-2 and 4-3). The abiotic data are utilized as input to the PRAM biotic module to predict tissue concentrations of PCBs in various fish and shellfish species. They are also used to estimate potential exposures to divers contacting PCBs in water on exposed skin during the initial 90 days after vessel sinking. Since PCB releases and TDM-modeled PCB concentrations in abiotic media vary over time during the initial two-year period after sinking, the predicted biotic tissue concentrations during that time reflect the varying PCB releases.

Biological colonization of the sunken vessel reef will also vary during the initial time period. The progressive food web model constructed to represent the artificial reef during the first two years after sinking (see Section 3.3) includes the assumed change in community structure and dynamics of the reef community (i.e., the changes in available food sources and dietary composition of food web consumers) during the initial period after the vessel is sunk. The time-variable dietary composition for representative organisms was used in PRAM to simulate the PCB exposures, via diet, that these organisms will experience during the initial post-sinking time period. It was assumed that dietary composition for reef-obligate forms such as lower trophic sessile filter feeders and invertebrate omnivores within the reef community do not change over time. These organisms are significant for PCB trophic transfers in the early stages of reef colonization due to their close association with the reef. Subsequent foragers and predators in the reef community are assumed to have progressive diets as the reef-obligate lower trophic species develop. Thus, the lower trophic species' colonization of the reef drives the subsequent dietary progression of foragers and predators under this reef development scenario.

The dietary progression used in PRAM to model exposures during the first two years after vessel sinking is based on a series of time intervals designed to reflect potential changes in the reef communities. The progressive food web starts at Day 1 after sinking (Day 1 is considered as starting at 12 hours post sinking, and continuing through the next 24 hours) and progressing through one week, two weeks, one month, six months, one year, and two years after vessel deployment. It is assumed that both the community structure and PCB release rates will have reached steady-state conditions at Day 730 (i.e., the two-year mark). The predicted PCB concentrations in fish and shellfish during these first two years are summarized in Table 4-4.

These data are used to evaluate potential subchronic risks to people who might eat fish and shellfish from the ex-ORISKANY artificial reef site.

4.3 PROSPECTIVE RISK ASSESSMENT MODEL (PRAM)

PRAM was developed under the direction of NEHC to facilitate the evaluation of the ex-ORISKANY and other decommissioned ex-Navy vessels as potential artificial reef building material. PRAM is designed to address the presence of residual PCBs onboard the vessel, potential transfer of these PCBs into environmental media after the initial release period, subsequent uptake by aquatic species associated with the reef, and potential risks from their consumption by recreational anglers under steady-state conditions. PRAM assesses incremental health risks associated with ingestion of fish impacted by PCB releases from a sunken vessel and does not include a determination of background risk associated with exposure to PCBs already present in the marine environment. PRAM consists of three constituent modules: a multimedia environmental chemical fate model, a biological uptake and bioaccumulation model, and a human health exposure and risk characterization model. These three modules are directly linked together within PRAM. Figure 4-3 presents a schematic of how these modules function together.

PRAM is a fugacity-based, steady-state model that predicts the fluxes of PCB homologs from the PCB-containing materials remaining on the sunken vessel, the partitioning into and among abiotic matrices in the marine environment, and the partitioning into biotic matrices in the marine environment.

PRAM is a box model in which the artificial reef and its associated environment are compartmentalized into boxes of water, sediment, and air. Interactions between these boxes are modeled under an assumption of thermodynamic steady state conditions. Most of the algorithms incorporated into PRAM are the same as those used in developing the Great Lakes Water Quality Initiative water quality criteria for PCBs (USEPA, 1995). A significant difference between the two models is that PRAM (1.4c) is a level-III fugacity model, and the Great Lakes used a level-II fugacity model. Release of PCBs from the material onboard the vessel and their flux into the reef environment drive the PRAM simulation. The key outputs from PRAM include: (1) whole-body tissue concentrations of total PCBs (based on the sum of the PCB homologs) in representative reef sport fish and invertebrates, representative bottom-dwelling (sediment-associated) sport fish and invertebrates, as well as open water sport fish within the zone of influence (ZOI) of the artificial reef; (2) cancer risks for people consuming these fish and/or invertebrates from the reef; and (3) noncancer HQs for people consuming these fish and/or invertebrates from the reef. Figure 4-3 presents the modules and how they are related in PRAM. Full details on the model are presented in NEHC/SSC-SD (2006a).

Following sinking of the ex-ORISKANY, the ship and shipboard materials will equilibrate with the surrounding seawater for a period of approximately two years. After the two-year period, leach rates are assumed constant, although they are expected to slowly decline. The normalized average leach rate data at the two-year time point were input to PRAM and used for predicting abiotic media concentration and chronic exposures to recreational anglers.

Tables 4-5 and 4-6 present the PRAM-predicted PCB concentrations in abiotic media for two assumed ZOIs (e.g., 2 and 5) around the ship that define the volume of water in which ship-related PCB concentrations are presumed to affect biota. These results were used as input concentrations for the food web modeling described in the next section. Figures 4-4 and 4-5 present these results graphically for each respective ZOI. Dissolved organic carbon (DOC) concentrations for the pentachlorobiphenyls show the highest concentrations. More than 98 percent of the PCBs released from the ex-ORISKANY advect from the system beyond the model boundary. The remaining 2 percent are largely bound to DOC within the interior of the vessel. The top graph in Figures 4-4 and 4-5 presents the distribution of PCB homologs throughout model compartments on a log scale. The bottom graph presents the same information on a linear scale. These figures show that the bulk of the PCBs that are not advected out of the model domain are found primarily in the interior of the vessel, and predicted concentrations do not change as a result of changes to the ZOI. However, predicted concentrations in the compartments exterior to the ship do change, but are much less than the concentrations in the vessel interior.

Section 9 discusses the uncertainties associated with the assumptions presented in this section.

5. PREDICTING PCB CONCENTRATIONS IN BIOTA WITH PRAM

As mentioned in Section 4.3 above, the biologic uptake and bioaccumulation module of PRAM mechanistically models the transfer of PCBs from abiotic media into biota. Both the TDM and PRAM abiotic media data are input into the PRAM biologic uptake module for predicting biotic tissue concentrations of PCBs. The PRAM biologic uptake module is built around an aquatic food web for marine ecosystems, and for the ex-ORISKANY, is populated by species that are appropriately representative of the local environment of the Gulf of Mexico waters. The food web component of the model is developed and presented in detail in the documentation of PRAM (NEHC/SSC-SD, 2006a). The food web model is comprised of three communities: the benthic, pelagic, and reef-associated communities. Each community is structured to account for uptake of PCBs through various trophic levels. Each trophic level is represented by a marine species that is characteristic of the local environment and would be of interest to recreational anglers and divers at the artificial reef site. Representative organisms for each community and trophic level are shown in Table 5-1.

The structure of the food web within which the released PCBs are transferred is treated as a closed system. That is, it is assumed that all of the organisms within the food web are resident and do not spend any time or obtain any food outside the influence of the sunken vessel. For sessile organisms and less mobile organisms associated with the reef structure and nearby sediment bed, this assumption is probably accurate. However, for mobile organisms such as fish, this is a highly conservative approach, as many fish are known to move from reef to reef and undergo seasonal and/or life-stage migrations. This is especially true for pelagic organisms, a major community modeled by PRAM, where the vast majority of species undergo large regional or oceanic movements over their lifetime.

The biologic uptake module of PRAM predicts whole body tissue concentrations of PCBs for all of the representative species for the food web model, as listed in Table 5-1. The predicted tissue concentrations in PRAM are for steady-state PCB releases, as assumed in PRAM for greater than the initial two-year period of reef development. Table 5-2 presents the tissue concentrations of PCBs for the representative species of the three communities, as predicted by PRAM for ZOI = 2. Table 5-3 presents the biota concentrations predicted by PRAM for ZOI = 5. These results are depicted graphically in Figures 5-1 and 5-2 for ZOI = 2 and ZOI = 5, respectively. Predicted biota concentrations are used as EPCs to assess chronic exposures due to the ingestion of PCBs in fish in this assessment, as described in Section 6. The PRAM-predicted biota concentrations that are used to evaluate subchronic exposures are derived from TDM output, as discussed in Section 4, and are also summarized in Section 6.

6. EXPOSURE ASSESSMENT

This section presents information on human activities that could result in the potential exposure to PCBs released from the ex-ORISKANY reef site. Exposures were estimated using various factors under multiple possible exposure scenarios. In general, exposures to PCBs released from the ex-ORISKANY were estimated for acute exposures to PCBs in water, and short-term subchronic and chronic exposures to PCBs in finfish that have accumulated PCBs through the food chain.

6.1 PROJECTED HUMAN UTILIZATION AND EXPOSURES AT THE ARTIFICIAL REEF

The eastern edge of the Escambia East LAARS, where the ex-ORISKANY is planned to be sunk, is expected to receive substantial recreational use (see Appendix B). As discussed in Section 3, the artificial reef is likely to increase biodiversity and productivity at the sunken vessel location, thus attracting higher trophic pelagic reef fish. The following are considered the two most likely human exposures to PCBs released from the ex-ORISKANY:

- Recreational fishing (private boats or charters)
- Diving/spearfishing.

Recreational fishing is expected to occur at the site once the artificial reef is deployed, by both private and charter boats. This activity presents a potential exposure of anglers to PCBs through the ingestion of sport fish caught from the reef.

Commercial net fishers are not expected to fish at the reef site, since it has been identified as an "obstruction" on nautical charts for over ten years, and trawl nets from commercial trawling would get entangled in the vessel's superstructure. In addition, although commercial hook-and-line fishing is plausible in the area (FFWCC, 2004), consumers of commercial catch will have a lower fraction of fish ingested from the artificial reef site than would the recreational angler, since they will consume fish caught commercially from a larger geographic region. For that reason, consumers of commercial catch will be exposed to lower amounts of PCBs from the site than consumers of catch from recreational anglers, thus risks to the commercial catch consumers are expected to be lower.

To identify potential diving and spearfishing utilization of the ex-ORISKANY reef, the FWC Division of Marine Fisheries Management Dive Assessment Team grouped activities into four

diving scenarios[3]. Several factors are likely to limit the amount of time an individual could spend diving the reef, particularly the depth of the reef and the amount of air a dive tank typically holds. The four different dive scenarios describe maximum daily exposure at the ship, assuming that individuals will dive 60 feet (where the top of the ex-ORISKANY's tower is located) or deeper. All scenarios assume a diver is using a standard 80 cubic inch aluminum tank and base the amount of his/her time underwater on the U.S. Navy Dive Table #3 – 1999 Unlimited/No Decompression Limit table[4]. That is, it is assumed that decompression will not be required before surfacing. The scenarios also assume that a second dive can be made in the same day, allowing for a recovery period at the surface before the second dive. The scenarios identified by the Dive Assessment Team are described in Table 6-1. For both recreational fishing and diving/spearfishing use of the site, potential health risks are evaluated for varying levels of exposure to site-related PCBs:

- Acute exposures – During the first 90 days after sinking the vessel, when PCB releases and, thus, PCB concentrations in environmental media are the highest (see Table 4-2).
- Subchronic exposures – During the first two years after sinking the vessel (see Table 4-3).
- Chronic exposures – Greater than two-year exposures to steady state PCB environmental media concentrations. The quantitation of PCBs in environmental media assumes a steady state release of PCBs from the sunken vessel and does not include terms to account for a diminishing mass of material over time.

Each of these exposure levels is described in more detail below, and each is quantified for health risks where data are available to quantify exposures and toxicity. Where data are not available to quantify exposures or toxicity, qualitative discussions of risk are presented. The exposure scenarios, and their parameterization and quantitation, are described more fully in the following subsections.

6.2 SITE CONCEPTUAL EXPOSURE MODEL

Potential human exposures to PCBs released from the ex-ORISKANY are visually depicted in the site conceptual exposure model (SCEM), presented in Figure 6-1. The SCEM illustrates the possible release pathways and transport of PCBs from the source locations to the points of exposure, as well as the routes of exposure to humans that may occur during activities at the ex-

[3] An evaluation of likely maximum diving conditions at the ex-ORISKANY reef site was conducted in a meeting held on January 7, 2005, between Jon Dodrill, FWC and members of the FWC Division of Marine Fisheries Management Dive Assessment Team, Bill Horn and Keith Mille.

[4] The NOAA No-Decompression Air Table lists identical maximum "no decompression limits" as the U.S. Navy Dive Table #3 – 1999 Unlimited/No Decompression Limit Table.

ORISKANY reef site. The SCEM consists of the following elements:

- PCB sources
- Release and transport
- Routes of exposure
- Human receptor populations of potential concern.

As the SCEM depicts, PCBs onboard the artificial reef can be released from the ship into the surrounding water, where they will subsequently bioconcentrate and bioaccumulate into reef fish and shellfish through the food-chain model. The fish and shellfish subsequently may be caught by recreational anglers and divers, and ingested under both subchronic and chronic exposures. The SCEM also presents the scenario of direct exposure by recreational divers to PCBs in water.

6.2.1 PCB Sources

The PCB sources consist of PCB-containing solid materials, including electric cable insulation, bulkhead insulation, paints, compressed fiber and rubber ventilation gaskets, and other rubber products (see Appendix D). PCB-containing materials are most likely to be found on vessels characterized by the following:

- Constructed before 1979
- Powered by boilers/turbines
- Provided repair and maintenance services such as surface tenders
- Had heavy electrical equipment such as rescue-salvage-towing vessels.

The PCB-containing materials on the ex-ORISKANY are considered the primary sources of PCBs to the environment at the artificial reef site. The final source term report for the ex-ORISKANY (Appendix D) provides details on the estimated masses for various PCB-containing bulk products.

6.2.2 Release and Transport

Results of the leach rate study (George *et al.*, 2006), summarized in Section 4.1, indicate that PCB releases from shipboard solid matrices differ widely depending on the material type, and that the releases are considered to be slow compared with PCBs unassociated with shipboard solid material (e.g., liquid PCBs). Leach rates for any given material were found to vary over orders of magnitude, and rates also varied several orders of magnitude for different materials.

In addition, PCB leaching from shipboard materials varied as a function of time. The output graphs provided in Appendix C of the TDM documentation (see Figures C-1 and C-4 for graphs of upper and lower water column concentrations (NEHC/SSC-SD, 2006b) clearly indicate that

total PCB concentrations in surrounding water are expected to be highest during the zero to 90-day period after sinking, as compared with the subsequent 91 to 730-day period (see also Tables 4-2 and 4-3). Releases of PCBs tend to approach steady state after the first 730 days (i.e., two years).

With leaching as the primary release mechanism, PCBs may be released into the water column and partition among environmental media, including settling and adsorbing onto sediment. Through the mechanical actions of burrowing worms, feeding on benthic macroinvertebrates by predators, and movements of underwater currents, secondary release mechanisms such as desorption and resuspension of PCBs from sediment may occur. PCBs in the water column and sediment can be taken up by lower trophic organisms and transported through the food chain to human food sources (e.g., finfish and shellfish).

6.2.3 Routes of Exposure

Uptake into marine biota is the primary route through which humans can be exposed to PCBs at the reef site (i.e., humans may be exposed to site-related PCBs through the ingestion of fish and shellfish caught from the site). Details on PCB bioconcentration and biomagnification in marine biota can be found in the PRAM documentation (NEHC/SSC-SD, 2006a) and Ecological Risk Assessment for the ex-ORISKANY (Johnston *et al*., 2006). A secondary route of potential human exposure at the sunken vessel reef is assumed to be direct skin contact by divers with PCBs in the water column. Exposures to PCBs via this route are minor because of the very low concentrations of PCBs that are predicted in the water column at the ex-ORISKANY reef site (see Section 9.5).

During the initial zero to 90-day period after vessel sinking, when releases of PCBs from shipboard residual materials are highest, the daily doses to divers will be higher than during later periods when PCB releases have reached lower steady state conditions. In other words, acute dermal exposures and associated health risks will be higher than subchronic and chronic dermal exposures and their associated risks. Thus, the evaluation of acute dermal exposures of divers during the zero to 90-day release period represents a conservative approach to evaluating the potential for health risks to divers from dermal exposure during later periods. The quantitation of potential risks related to the dermal route of exposure to PCBs in the water column are evaluated in Section 9.5.2.

Ingestion of seawater is not considered to be a complete exposure pathway given the diving requirements at the depth of the sunken vessel (more than 120 feet to flight deck). Considering the amount of time it would take for a diver to get down to such depths, and the potential imminent risk of drowning if the diver were to be ingesting water at this depth, incidental ingestion of seawater is considered to be an insignificant exposure pathway.

Divers are rarely expected to come in direct contact with sediment at the artificial reef site. Typical diving activities at the depth of the sunken vessel do not usually involve contact with sediment. As indicated in Section 6.1, the length of time a diver may be present at the sediment surface is limited by the depth to sediment (212 feet), and would typically last less than 20 minutes per dive. Also, with this depth and limited duration at the sediment surface, it is expected that direct contact with sediment for collection of shellfish or other items would be performed wearing gloves or using tools that would minimize direct sediment contact. In addition, because of the water temperature at the depth of the sunken vessel, divers would typically wear protective gear such as full wet suits including gloves. For these reasons, exposures to PCBs in sediment at the artificial reef site are expected to be much lower than exposures via other routes, and potential risks for this pathway are not further evaluated.

6.2.4 Human Receptor Populations of Potential Concern

Based on the anticipated future uses of the artificial reef site and the information provided on routes of exposures, the following human receptor populations were evaluated for potential exposures at the proposed ex-ORISKANY artificial reef:

- Recreational anglers who line fish for reef-associated fish are the population likely to have the greatest exposure potential at the proposed ex-ORISKANY site. This assessment assumes that members of the local community could fish this site, and that these individuals could be exposed to PCBs via ingestion of caught finfish on a long-term basis, consistent with the previous HHRA on sunken vessels (NEHC, 2004a).
  - Recreational anglers who troll or otherwise fish for pelagic species (e.g., amberjack) are assumed to have lower exposure than line-fishers. Fish caught by trolling are expected to have shorter residence times at the reef than species caught by line fishing, and thus have lower potential for uptake of reef-associated PCBs. For example, the greater amberjack, an expected pelagic species at the artificial reef, may move upwards of 124 miles in the Gulf of Mexico (Ingram and Patterson, 1999) and would be present at the reef only intermittently. Studies have shown that other pelagic species in the northern Gulf of Mexico tend to be seasonally present at artificial structures, with long periods of absence (Stanley and Wilson, 2003).
  - Children of recreational anglers who are likely to consume the catch. The recreational angler population also includes fetuses and nursing infants who may be exposed to PCBs through fish consumed by the mother.
  - Recreational divers are assumed to visit the ex-ORISKANY reef site on a regular basis. Because PCB-containing materials on board the ship are located within the ship, and the depth of the sunken vessel (more than 120 feet to flight deck) would limit the amount of time a diver could be present at the ship, direct contact with PCB-containing materials

within the vessel are unlikely to occur and is considered an incomplete exposure pathway. Dermal exposure to PCBs that may be released to the water column is a complete exposure pathway for divers, and is further evaluated. Spear-fishing and collection of shellfish is a possible activity of divers. However, time spent spearfishing at the artificial reef would be limited due to depth, as discussed in Section 6.1, and the spear-fisher is not likely to collect and consume as much fish over the 30 year period of exposure duration as that assumed for the line-fisher. Thus, the spear-fisher is considered to be a less-exposed individual than the line-fisher. Health risks are evaluated for consumption of finfish collected from the reef, and these risks will address any exposures that may be associated with shellfish consumption by spear-fishers. Also, as indicated in Section 6.2.3, because of the depth of sinking of the ex-ORISKANY, most divers would not spend appreciable time on the bottom; rather, most dive activities are expected to occur in the vicinity of the "island" (superstructure) of the ship (60 – 120 ft depth) where exposure to sediment is unlikely.

- Commercial net fishermen are not considered likely users of the ex-ORISKANY reef site, primarily because the structure of the vessel would damage or destroy any nets. Exposure of commercial net anglers to PCBs at the reef site is therefore not evaluated. Even if some commercial utilization were to occur, individuals eating their catch would be expected to be at lower risk than recreational anglers because commercial anglers would typically fish much larger areas than the areas assumed for the recreational angler and their fraction of catch from the vicinity of the ex-ORISKANY reef would be less than the fraction for recreational anglers.

Although recreational anglers have been identified as the population with the greatest exposure potential, because of distance from shore (approximately 22.5 nm), anglers of most concern would be those with large boats that could safely travel to the reef. Evidence from other neighboring reefs in the LAARS indicates that, although fishing is likely to be restricted to anglers with large boats, a number of individual boat owners and charters fish this area. Heavy utilization of the ex-ORISKANY reef site is expected, as suggested by the original requests for the reef construction (see Appendix B) and results of the angler surveys summarized in Appendix F.

In summary, the populations considered to have the highest potential exposure to PCBs are adults and children who may consume fish from the ex-ORISKANY artificial reef site. This population includes nursing infants exposed by consumption of breast milk and fetuses exposed while *in utero*, both associated with mothers who consume fish from the site.

6.2.5 Completed Exposure Pathways

The completed exposure pathways for humans consist of the ingestion of fish containing PCBs

released from the vessel materials, and to a lesser extent dermal contact with PCBs in water.

Acute and Subchronic Exposures - For short-term exposures that may occur within 90 days or two years (i.e., acute and subchronic exposures, respectively), time dynamic pathways are evaluated that quantify exposures before steady state conditions with PCB releases are reached. Short-term exposures consist of ingestion of fish by recreational anglers, and dermal contact with water by divers. Exposure pathways for both children and adults are complete for recreational angler exposures. Exposure pathways for adult divers are complete for dermal contact with surface water and fish ingestion; however, as explained in Section 6.2.4, fish ingestion by divers is considered an insignificant exposure pathway compared with recreational angler fish ingestion.

Chronic Exposures - For chronic exposures of human to PCBs via fish ingestion, exposures are evaluated for durations greater than two years, represented by steady-state exposure pathways. Chronic exposures consist of ingestion of fish by recreational anglers. Both child and adult exposures are complete for chronic recreational angler exposures, as are perinatal exposures through mothers who may be exposed via fish consumption.

6.2.6 Summary of Exposure Scenarios

Table 6-2 provides a summary of the exposure scenarios evaluated in this assessment and whether they were evaluated quantitatively or qualitatively. The following exposure scenarios were selected for evaluation in this assessment:

Adult recreational angler and child ingestion of fish - The ingestion of fish by recreational anglers was chosen as the scenario for quantitative evaluation, as it represents a reasonable worst-case scenario, addressing potential risks to local populations who would be expected to visit the reef on a regular basis, and who eat the fish they catch. In addition, risks associated with the ingestion of fish by children are evaluated because fish caught at the reef could be brought home and eaten by children (i.e., a more sensitive population than adults).

Under this scenario, both chronic and subchronic exposures and risks are evaluated. Subchronic exposures are evaluated for fish ingestion by an angler population over the two-year period immediately following sinking of the ship, as the sport fish and edible shellfish communities are becoming established at the artificial reef. Chronic exposures are evaluated for the durations after the initial two-year period of community establishment at the reef. Perinatal exposures through chronic exposures of mothers who may consume fish from the reef are evaluated qualitatively.

Potential acute exposures of children and adults from consumption of fish are evaluated qualitatively. The dermal contact pathway for anglers is assumed to be complete but is deemed

insignificant exposure, primarily due to the expected small amount of water contact but also because exposures from dermal contact by divers and the ingestion of fish pathway for anglers would have much higher exposures and risks.

Adult recreational diver dermal contact with water - Direct contact with water by recreational divers is a potential exposure pathway. Such an exposure would be highest during the first two years after sinking when predicted surface water concentrations are higher than those predicted two or more years after sinking. Because there are no acute PCB toxicity values for dermal exposure, the risk evaluation is performed qualitatively, and is based on the quantitative evaluation of ambient water concentrations of PCBs and the potential exposures through dermal uptake by recreational divers. Other routes of exposure for divers, such as consumption of fish and shellfish, inadvertent consumption of seawater, and dermal contact with sediment, are considered to present either negligible risks or risks substantially less than those associated with chronic fish consumption by anglers, as mentioned above.

6.2.7 Exposure Point Concentrations

Exposure point concentrations (EPCs) are those concentrations of chemicals in environmental media to which human receptors are exposed. Based on the SCEM, the EPCs for human exposures at the ex-ORISKANY artificial reef are the concentrations of PCBs in water and in the finfish that may be consumed by humans. Finfish and shellfish species that are expected at the artificial reef were identified in Section 3, and are included in the food web model for the reef described in Section 5. Because anglers and divers may preferentially target different species of sports fish, the following were considered appropriate representative species for human consumption from the reef site:

- Benthic fish (flounder)
- Benthic invertebrates (lobster)
- Pelagic fish (jack)
- Reef fish (grouper)
- Reef fish (triggerfish)
- Reef invertebrate (crab).

The representative species were selected to include sports fish and finfish as well as groups with greatest potential for PCB biouptake/bioaccumulation.

As mentioned in Sections 6.1 and 6.2.5, because of the time dynamic release of PCBs from residual materials on board the sunken vessel, EPCs are developed under scenarios of acute, subchronic, and chronic exposures to the respective environmental media. Concentrations of PCB homologs in abiotic and biotic media for these scenarios were developed in Sections 4 and 5, respectively, and summarized in Tables 4-2 through 4-6, and in Tables 5-2 and 5-3.

PCB EPCs were predicted for water and fish during acute and short-term exposures at three distances from the vessel (0-15 m, 0-45 m, and 0-60 m) and for water and fish under steady state conditions for two different ZOIs: 2 and 5. The ZOI defines the spatial volume of water around the sunken vessel that is modeled in the PRAM reef environment as a multiple of the vessel's physical dimensions.

Final EPCs for tissue and water that are used to quantify exposures and risks are shown in Table 6-3. Concentrations of PCBs are the sum of predicted PCB homolog group concentrations. EPCs for fish tissue are time-weighted average whole body concentrations predicted for each species. Note that because fish tissue concentrations of PCBs are expressed on a whole body, wet-weight basis, muscle tissue concentrations would be lower than the estimated whole body concentrations due to the presence of fat deposits in whole body tissue that sequester lipophilic chemicals such as PCBs. As such, use of whole body concentrations for estimating exposures to humans who consume the fish is a conservative measure that would likely overestimate actual exposures.

6.3 EXPOSURE PARAMETERS

A summary of the exposure parameters used to quantify subchronic and chronic exposures is provided in Table 6-4, and each parameter is described more detail below.

The key parameters used to evaluate acute and chronic exposures to environmental chemicals include the exposure frequency (EF), exposure duration (ED), and body weight (BW). For the fish ingestion pathway, key parameters also include the fish ingestion rate (IR) and fraction of fish ingested (FI) that come from the site. Most of the parameters used to quantify exposures of adult anglers and children are standard USEPA default values that are judged to be applicable to any reef site. However, the IR and FI parameters are regional and site-specific parameters. As described in more detail below, the IR terms are based on region-specific values provided by USEPA, and the FI terms are site-specific values based on angler surveys for the reef location.

The following describes the assumptions used to develop regional and site-specific exposure parameters for adult anglers and children who may be exposed to PCBs released from the ex-ORISKANY. The likely frequency and duration of exposure of recreational divers to the ex-ORISKANY reef is also developed below. Perinatal exposures of fetuses and nursing infants through maternal ingestion of fish are discussed in Section 9. Other exposure parameters for recreational anglers and divers, such as EF, ED, and BW are discussed at the end of this section.

6.3.1 Fish Ingestion Rate (IR) Terms

The adult fish ingestion rates (IR_a) are USEPA-recommended, consumer only rates for daily intake (g/day) of marine finfish in the Gulf region, as presented in Table 10-52 of the Exposure

Factors Handbook (USEPA, 1997a). The USEPA-recommended rates are higher for anglers in the Gulf region than for anglers in other U.S. regions. The RME ingestion rate is the 95th percentile value of 26.1 g/d, and the CTE is the mean value of 7.2 g/d. These rates were used to evaluate potential risks associated with ingestion by adults of fish caught at the ex-ORISKANY site.

Fish ingestion rates for children (IR_c) are not available in USEPA guidance for the Gulf region. Instead, the rates used in this risk assessment are based on scaling the Gulf region fish ingestion rate for adults, based on a comparison of national fish ingestion rates for adults and children. A scaling factor was derived as a ratio of an ingestion rate for children age one to five to an average adult ingestion rate, using national recreational fish ingestion rates in Table 10-61 of the Exposure Factors Handbook (USEPA, 1997a). These rates are mean fish intakes for individuals who eat fish and reside in households with recreational fish consumption. This scaling factor was then multiplied by the adult fish ingestion rates for the Gulf region, identified in the preceding paragraph, to arrive at child fish ingestion rates applicable to the Gulf region. Thus, IR_c is defined using the following equation:

$$IR_c = IR_a * A/B \qquad (1)$$

Where *A* and *B* represent the mean national recreational fish consumption rate for children and adults, respectively, without the consideration of their geographic location. The ratio of *A/B* is the scaling factor.

The child age one to five ingestion rate (*A*) in the Exposure Factors Handbook is 0.00563 kg/day. The adult ingestion rate (*B*) was derived as an average of five age groups (age groups 21 to 40, 40 to 60, 60 to 70, 71 to 80, and 80+), at 0.0158 kg/day. The scaling factor (*A/B*) of child rate to average adult rate is calculated to be 0.356 (0.00563 kg/day divided by 0.0158 kg/day). Applying the scaling factor to the adult fish ingestion rate for the Gulf region (IR_a) gives child fish ingestion rates (IR_c) for the RME of 0.0261 kg/day * 0.356 = 0.0093 kg/day, and the CTE of 0.0072 kg/day * 0.356 = 0.0026 kg/day.

The IR term for total fish is used to quantify the consumption of each species of fish in this assessment. This assumes that the total fish ingestion rate is applicable to each species of fish, rather than to the mixture of fish species that anglers are more likely to consume. Insufficient data are available to quantify the fraction each species contributes to the diet of anglers consuming fish from the future reef. Thus, the application of the total fish ingestion rate to the consumption of the single species with the highest predicted concentration of PCBs (e.g., “grouper” in Table 5-2) is a conservative approach to estimating exposures from fish consumption. For shellfish ingestion, divers are not likely to collect much shellfish given their brief time at a reef that will be approximately 200 feet below the water surface. Therefore, using

an ingestion rate for finfish will overestimate exposures to shellfish.

6.3.2 Fraction Ingested (FI) Terms

The ingestion rates provided in the Exposure Factors Handbook are based on the ingestion of marine finfish from all sources, not just a single reef. Thus, the fish ingestion rates identified above in Section 6.3.1 represent the total amount of marine fish that an angler is expected to eat. Because all of the fish that an angler eats is not expected to come from a single source (e.g., solely from an artificial reef), an FI term has been introduced into the risk equations to account for the fraction of total fish that will likely be ingested that originated from a single reef.

For the ex-ORISKANY, site-specific data on the fraction of total consumed fish that may come from the artificial reef site are not available since the vessel has not been sunk. In order to predict fishing and ingestion behavior at this future reef site, the State of Florida conducted a fish consumption survey among anglers that fish four artificial reefs currently located at the Florida LAARS. These reefs were chosen because they were thought likely to attract the same angler populations, and would likely mimic the ex-ORISKANY as far as attractiveness for fishing.

6.3.2.1Available Survey Data

The State of Florida conducted a fish consumption survey of anglers who fish the LAARS to predict the utilization of the ex-ORISKANY; methods are reported in Appendix F and results are provided in Appendix G. Four surrogate reefs were identified by ECMRD as appropriate surrogate fisheries for the ex-ORISKANY artificial reef site. In choosing the surrogate reefs, ECMRD recognized that none of the artificial reefs that are currently in the Escambia County Artificial Reef inventory are the size of the proposed ex-ORISKANY reef. Because a larger-profile reef can be anticipated to provide more fish habitat, and therefore potentially support greater fish harvests than any single smaller reef, a decision was made to survey four artificial reef sites within the LAARS, as opposed to just one site. ECMRD considered the inclusion of four reefs to be a conservative approach for the application of fish catch to the proposed ex-ORISKANY reef site. The four "surrogate" reefs[5] and the target fish species identified in the survey were thus considered to reflect region-specific reef conditions and reef-dwelling fish that are typically targeted by anglers of the Gulf Coast.

The ECMRD conducted 50 angler interviews between May 11 and May 16, 2004; subsequently, an additional 30 interviews were conducted over the Memorial Day weekend (May 28 to May

[5] These surrogate reefs are approximately the same distance from shore as the ex-ORISKANY reef site. The factor of distance from shore to reef is an important consideration because reefs that are located at large distances from shore would require a larger boat or vessel to reach the reef site from the standpoint of marine safety and this represents a specific fisher subpopulation.

31, 2004). The survey focused on identifying the fish caught from the four surrogate reefs and quantifying the number of meals of these fish that were consumed throughout the year 2003. Information from 77 of these 80 interviews was combined and used in the statistical evaluation to derive FI terms for this assessment[6]. Details of the procedures used to conduct the interviews are presented in Appendix F.

6.3.2.2Derivation of Site-Specific FI Term

Results of the statistical evaluation of the fish consumption survey data are presented in Appendix G. Based on this evaluation, FI terms of 0.17 (RME) and 0.25 (CTE) were derived for the ex-ORISKANY site.

The FI terms were derived as the fraction of total fish consumption that is attributable to the artificial reef, by dividing the annual average number of fish meals per year consumed by an angler at the four surrogate reefs off the Gulf Coast of Florida, as taken from the fish consumption survey, by the average annual number of fish meals consumed per person in the entire Gulf region. This latter value, the annual number of meals that anglers consume for the entire Gulf region, was derived from data in the Exposure Factors Handbook (USEPA, 1997a) by dividing the per person grams per day of fish ingested from the Gulf region (Table 10-52 of the Exposure Factors Handbook; USEPA, 1997a) by the grams per meal of fish multiplied by 365 days per year (see Section 10.10.1 of the Exposure Factors Handbook; USEPA, 1997a).

The RME is derived using the 95th percentile for the annual number of meals of fish consumed throughout the Gulf region, as taken from the Exposure Factors Handbook (USEPA, 1997a), and the CTE is based on the average number of annual meals of fish consumed throughout the Gulf region. The site-related annual number of meals of fish consumed, as determined from the survey of the four reefs off Florida, is the mid-point value of each of the survey respondents. Thus, the RME refers to individuals who consume fish from the Gulf region at the 95th percentile consumption rate (0.0261 kg/day) with a fraction of 0.17 coming from the reef site. The CTE refers to an individual who consumes fish from the Gulf region at the mean consumption rate (0.0072 kg/day) with a fraction of 0.25 coming from the reef site. The site-specific data used in the risk assessment show that less frequent anglers (CTE populations) tend to return to the same fishing location whereas the more frequent anglers (RME populations) fished in more areas and consumed fish caught in multiple areas, thereby reducing the FI for any one fishing location. As a result of the site-specific survey results, the RME FI is lower than the CTE FI.

[6] In addition to these face-to-face interviews, the State of Florida (FWCC, 2004) posted the fish consumption survey on their website and received 280 completed on-line survey responses in May 2004. Because of time constraints for developing the HHRA, data for these on-line responses were not incorporated into this analysis. However, this on-line survey is unlikely to represent a random sample of the underlying population but is more likely to represent avid anglers (i.e., those with enough interest in the topic to spend the time to fill out the survey questionnaire).

There is some uncertainty with the use of four surrogate reefs to predict the future fishing use of the ex-ORISKANY reef. However, the choice of surrogate sites is considered to be as representative as possible, and was based on the professional judgment of representatives of FFWCC and ECMRD.

6.3.3 Exposure Frequency (EF)

Exposure frequency refers to the number of days per year that an individual is exposed to site-related chemicals. For fish consumption, the ingestion rates presented in the Exposure Factors Handbook (USEPA, 1997a) are daily rates averaged over 365 days per year. This is an annual average daily ingestion rate and does not imply that a consumer is eating fish every day. This assumption is considered to be a conservative approach that should be protective for any individuals who do not fish the reef as frequently or over as long a duration. The exposure frequency assumed for divers is discussed in the following subsection.

6.3.4 Parameters for Short-Term Exposures for Recreational Divers

The predicted transient nature of PCB-releases at the ex-ORISKANY artificial reef site corresponds to short-term exposure periods for the receptors of concern. The term "transient release" refers to the release of PCBs under pre-steady state conditions. Based on results of the leach rate studies conducted by SPAWAR (George *et al.*, 2006), this period starts within 12 hours of sinking of the ship and extends for approximately two years. This transient release period can be subdivided into acute exposure periods (less than 90 days) and subchronic exposure periods (91 days to two years). During the first 90 days after vessel sinking, the primary human exposures to PCBs will be for recreational divers through direct skin contact with water while diving. Water PCB concentrations are at their maximum in the first few weeks after vessel sinking.

In addition, the distance intervals that define exposure areas closest to the ship are the appropriate ones to evaluate for short-term exposures; the distance intervals zero to 15 meters, zero to 45 meters, and zero to 60 meters away from the sunken vessel were chosen to represent the exposure areas of most concern for acute and subchronic human exposures.

The amount of time a diver will spend at the ex-ORISKANY reef site was discussed in Section 6.1. The maximum exposure under this analysis assumed that divers could be exposed to PCBs in water at the site for a daily total of 90 minutes. It was assumed that the ship would be sunk during the warmer summer months, and that divers would dive the reef two days per month.

Given the likely presence of a mild thermocline at this time of year, divers would probably wear protective gear instead of wearing swimsuits only. Thin gauge (2-3 millimeters thick) neoprene wet suits with booties, with or without gloves, and without hoods are typically worn in this type

of environment. Some restricted water circulation occurs against the skin inside the suit; however, most of this water enters the suit within the first few minutes of the dive on the way down (within the top 40 feet or so of the water column). Portions of the body covered by the suit, booties, gloves, and mask would be exposed to water originating from the upper water column as the wetsuit filled, and would receive very little, if any, exposure to water originating from the immediate vicinity of the ship. Thus the only body parts likely to be exposed to the lower water column (assuming an individual dives that deep) would be portions of the head and possibly the hands.

6.3.5 Exposure Duration for Child (ED_c) Exposures

Exposure duration (ED) refers to the number of years over which exposure occurs. It is assumed that the most exposed angler population consists of local residents, and that the ED for anglers reflects occupancy duration for residents.

For the chronic CTE and RME scenarios for child exposures, the standard default ED_c of six years was used, based on the assumption that the entire zero to six-year period for a child is spent at a single residence. For subchronic exposures under both CTE and RME scenarios, the ED_c is based on the release dynamics of PCBs from the residual materials onboard the sunken vessel, and is assumed to be the first two years after vessel sinking.

6.3.6 Exposure Duration for Adult (ED_a) Exposures

The adult exposure duration (ED_a) for chronic exposures is based on USEPA (1997a) recommendations on residential occupancy. The standard default value of 30 years for adults is used for the RME exposure. This value is the 90_{th} percentile value for time spent at a single residence on a national basis. Adults are also evaluated under RME for a 30-year exposure that assumes 24 years as an adult and six years as a child. For estimates of average (CTE) exposure, an ED_a of nine years was used based on the 50_{th} percentile value for time spent at a single residence. The adult CTE was also evaluated for a nine-year exposure that assumes three years as an adult and six years as a child. The potential risks to people who may consume fish for periods longer than 30 years from the ex-ORISKANY site are evaluated in Section 9.3.5.

For subchronic exposures, the ED_a is based on the release dynamics of PCBs from the residual materials onboard the sunken vessel, and is assumed to be two years for both RME and CTE.

6.3.7 Body Weights (BW)

The body weight term for children is assumed at 15 kg, and for adults at 70 kg (USEPA, 1989).

6.3.8 Averaging Time for Non-Carcinogens (ATnc)

The averaging time for non-carcinogens for both child and adult exposures is a dependent term, defined as ED x 365 days/year, per USEPA (1989) guidance.

6.3.9 Averaging Time for Carcinogens (ATc)

The averaging time for carcinogens is a fixed term, defined as 25,550 days, equal to a 70-year lifespan, as per USEPA (1989) guidance.

6.4 SUBCHRONIC AND CHRONIC AVERAGE DAILY DOSE ESTIMATES FOR ADULT AND CHILD FISH CONSUMERS

Average daily doses (ADDs) for individuals exposed to PCBs in fish were estimated by combining EPCs in Table 6-3 with exposure parameters described in Section 6.3 and summarized in Table 6.4. Two ADDs were calculated: an ADD for quantifying noncancer hazard and a lifetime ADD (LADD) for quantifying cancer risk.

6.4.1 Noncancer Evaluation

The ADD used to evaluate noncancer effects represents the chemical dose averaged over the duration of exposure. For both chronic and subchronic exposure evaluation, an ADD_c for a young child (Equation 2) and an ADD_a for an adult (Equation 3) were quantified separately. To evaluate exposures for a recreational angler who consumes fish for 30 years from childhood into adulthood, an $ADD_{a\&c}$ was calculated that combined exposures for the young child with adult exposures (Equation 4).

$$ADD_c = \frac{(C_f * IR_c * FI * EF * ED_c)}{(BW_c * AT_{nc_child})} \qquad (2)$$

$$ADD_a = \frac{(C_f * IR_a * FI * EF * ED_a)}{(BW_a * AT_{nc_adult})} \qquad (3)$$

$$ADD_{a\&c} = \frac{(C_f * FI * EF * \left(\frac{IR_c * ED_c}{BW_c} + \frac{IR_a * ED_a}{BW_a}\right)}{AT_{nc_child} + AT_{nc_adult}} \qquad (4)$$

where:

ADD_c	=	Average daily dose for child only (mg/kg-day)
ADD_a	=	Average daily dose for an adult only (mg/kg-day)
$ADD_{a\&c}$	=	Average daily dose for combined child and adult (mg/kg-day)
C_f	=	Chemical concentration in fish tissue (mg/kg) (calculated in PRAM)
IR_c	=	Fish ingestion rate in children (kg/day) (site-specific, daily average value)
IR_a	=	Fish ingestion rate in adults (kg/day) (site-specific, daily average value)
FI	=	Fraction of fish ingested (unitless) (site-specific value)
EF	=	Exposure frequency (days/year)
ED_c	=	Exposure duration for children (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight of a child (kg)
BW_a	=	Body weight of an adult (kg)
AT_{nc_child}	=	Averaging time for non-carcinogens, child (days)
AT_{nc_adult}	=	Averaging time for non-carcinogens, adult (days).

6.4.2 Cancer Evaluation

The LADD used to evaluate cancer effects represents the chemical dose averaged over a 70-year lifetime. In the chronic risk evaluation, a $LADD_c$ specific to a young child was calculated (Equation 5), a $LADD_a$ was calculated for adult only exposures (Equation 6), and an $LADD_{a\&c}$ was calculated for the young child combined with an adult was calculated to evaluate cancer risk for a recreational angler who consumes fish from childhood into adulthood (Equation 7). For the subchronic cancer risk evaluation, the intakes related to the ED of two years for the child and adult exposures were each averaged over a lifetime in the calculations of $LADD_c$ and $LADD_a$.

$$LADD_c = \frac{C_f * IR_c * FI * EF * ED_c}{BW_c * AT_c} \quad (5)$$

$$LADD_a = \frac{C_f * IR_a * FI * EF * ED_a}{BW_a * AT_c} \quad (6)$$

$$LADD_{a\&c} = \frac{C_f * EF * FI * \left(\frac{IR_c * ED_c}{BW_c} + \frac{IR_a * ED_a}{BW_a} \right)}{AT_c} \qquad (7)$$

where:

$LADD_c$ = Lifetime average daily dose for child only (mg/kg-day)

$LADD_a$ = Lifetime average daily dose for adult only (mg/kg-day)

$LADD_{a\&c}$ = Lifetime average daily dose for combined child and adult (mg/kg-day)

AT_c = Averaging time for carcinogens (days over lifetime).

7. TOXICITY ASSESSMENT FOR PCBS

The toxicity assessment identifies the toxicity values used in this assessment to quantify human cancer risk and noncancer hazard from exposure to PCBs originating from the ex-ORISKANY. In this assessment, PCBs were quantified as the sum of predicted PCB homolog group concentrations. A brief profile of PCB toxicity is provided in this section with the rationale for selection of toxicity values used in this assessment.

Toxicity values are combined with average daily doses of PCBs from fish consumption to calculate cancer risks and noncancer hazards in the risk characterization (Section 8). USEPA developed toxicity values for evaluating cancer risk and noncancer hazard from oral exposure to PCBs (USEPA, 2005a). The toxicity values for cancer evaluations are known as cancer slope factors (CSFs), whereas toxicity values for noncancer evaluations are known as reference doses (RfDs).

The CSF is an upper bound estimate, approximating a 95 percent confidence limit, on the increased cancer risk from a lifetime exposure to an agent (USEPA, 2005a). CSFs are used to calculate cancer risk from exposure to carcinogens by relating estimates of lifetime average chemical intake to the incremental probability of an individual developing cancer over a lifetime (USEPA, 2005b).

The chronic RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime (USEPA, 2005a).

7.1 TOXICITY VALUES USED IN THIS ASSESSMENT

Cancer and noncancer toxicity values published by USEPA were used in this risk assessment and are summarized in Table 7-1. Toxicity values obtained from the Integrated Risk Information System (IRIS), USEPA's database of consensus toxicity values (USEPA, 2005a), were used because these values have undergone extensive scientific peer review (USEPA, 2003a). No toxicity values are published in IRIS for evaluating the dioxin-like toxicity of PCB congeners. Selection of toxicity values for use in this assessment is consistent with USEPA's hierarchy for use of toxicity values (USEPA, 2003a):

Tier 1. Integrated Risk Information System (IRIS, http://www.epa.gov/iris).

Tier 2. Provisional Peer Reviewed Toxicity Values (PPRTVs) – The USEPA Office of Research and Development/National Center for Environmental Assessment (NCEA, http://www.epa.gov/ncea)/Superfund Health Risk Technical Support Center (STSC)

develops PPRTVs on a chemical-specific basis as requested by USEPA's Superfund program.

Tier 3. Other Toxicity Values – Includes additional USEPA and non-USEPA sources of toxicity information.

7.1.1 Toxicity Values for Evaluating Acute Exposures to PCBs

USEPA has not developed toxicity values for quantifying effects associated with acute exposures to PCBs in environmental media. Acute exposures are typically defined as those limited to less than one day up to two weeks. Acute lethal doses for animals have been published in literature, but these studies evaluated exposure at very high doses. The acute animal studies are not relevant to the lower concentrations predicted in this assessment for surface water and fish tissue. According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2000), the most commonly observed acute health effects in people exposed to large doses of PCBs are skin conditions such as acne and rashes. Studies of exposed workers have shown that long-term exposure to PCBs can result in changes in blood and urine chemistry that may indicate liver damage; however, the level of PCB exposures that typically occur in the general population are not likely to result in skin and liver effects (ATSDR, 2000). More typical general population exposures to PCBs involve dermal contact with and ingestion of PCB-contaminated environmental media such as soil and fish. Because of the lack of acute toxicity criteria that would be applicable to very short-term exposures at the artificial reef site, potential risks from exposures to PCBs in fish during the initial 90-day period after vessel sinking or to PCBs in water during short-term diving activities are evaluated qualitatively (see Sections 9.4 and 9.5).

7.1.2 Toxicity Values for Evaluating Subchronic Exposures to PCBs

The subchronic oral RfD for Aroclor 1254 of 5×10^{-5} mg/kg-d was used to estimate subchronic noncancer hazard for exposure durations between 91 days and two years (USEPA, 1997b). This value is a Tier 3 toxicity value in USEPA's toxicity value hierarchy (USEPA, 2003a).

CSFs of 2.0 $(\text{mg/kg-d})^{-1}$ and 1.0 $(\text{mg/kg-d})^{-1}$ were used to quantify RME and CTE cancer risks, respectively, as recommended in IRIS for food chain ingestion scenarios (USEPA, 2005a).

7.1.3 Toxicity Values for Evaluating Chronic Exposures to PCBs

Chronic toxicity values are evaluated for long-term exposures to PCBs.

7.1.3.1 PCBs

USEPA (2005a) provides oral RfDs for two PCB mixtures, Aroclor 1254 (RfD of $2x10^{-5}$ mg/kg-d) and Aroclor 1016 (RfD of $7x10^{-5}$ mg/kg-d). Review of data on the composition of PCB homologs predicted in water at the ex-ORISKANY site shows a closer similarity with the homolog makeup of Aroclor 1254 than with Aroclor 1016 (see Section 7.2). Therefore, the RfD for Aroclor 1254 RfD was used for both the RME and CTE scenarios.

CSFs of 2.0 $(mg/kg\text{-}d)^{-1}$ and 1.0 $(mg/kg\text{-}d)^{-1}$ were used to quantify RME and CTE cancer risks, respectively, as recommended for food chain ingestion scenarios (USEPA, 2005a).

7.1.3.2 Dioxin-like PCB Congeners

When dioxin-like PCB congener data are available, cancer risk from this subset of congeners in the PCB mixture can be evaluated using a toxicity equivalence (TEQ) approach that is described in Section 7.4.3 (USEPA, 1996; USEPA, 2000a). Given the lack of predicted congener concentrations in fish at the ex-ORISKANY reef, cancer risk from dioxin-like PCB congeners is addressed qualitatively in the Uncertainty Analysis (see Section 9.4.3).

USEPA has not developed a noncancer RfD for dioxin-like PCBs.

7.2 TOXICITY OF PCB MIXTURES

PCBs are synthetic organic chemicals consisting of 209 individual chlorinated biphenyl compounds, known as congeners. PCBs were produced as commercial mixtures of these congeners (e.g., Aroclors).

Following the release of commercial PCB mixtures into the environment, the original mixture may be altered as a result of environmental fate and transport processes such as partitioning, transformation, and bioaccumulation through the food chain. For example, environmental transport processes such as vaporization and dissolution do not act on all congeners equally, resulting in environmental concentrations of individual PCB congeners that may differ substantially from those present in the original commercial mixture. This process is known as weathering (Erickson, 2001; USEPA, 1996). Bioaccumulation through the food chain can result in altered patterns of the original congeners, and such alterations in composition may alter the toxicity of the mixture, making it more or less toxic than the commercial product.

Despite the fact that PCB mixtures in the environment might differ from Aroclors, most PCB toxicity studies have been performed using Aroclors, and toxicity data for multiple adverse effects, including cancer, are available for many commercial Aroclor mixtures (ATSDR, 2000;

Cogliano, 1998; USEPA, 2005a). For this reason, it is important to use toxicity information applicable to Aroclor mixtures that most closely resemble the PCB mixtures to which humans will be exposed in surface water and fish associated with the ex-ORISKANY reef site. The potential differences between Aroclors and environmental PCB mixtures is also the reason for evaluating the potential dioxin-like toxicity of PCB mixtures as described in Section 7.4.3.

The composition of PCB mixtures in solid materials remaining on the ex-ORISKANY have been compared to commercial Aroclors. This comparison revealed that PCBs in black rubber products resemble a mixture of Aroclor 1254 and Aroclor 1260; PCBs in bulkhead insulation and aluminized paint resemble a mixture of Aroclor 1254, Aroclor 1260, and Aroclor 1268; and PCBs in electrical cable resemble a mixture of Aroclor 1242, Aroclor 1254, and Aroclor 1260 (George, 2005). However, people are assumed to be exposed to PCBs that leach from these source materials into surface water and/or that bioaccumulate in fish. Figure 7-1 illustrates the composition of PCB homologs (in weight percent) predicted by PRAM (assuming a ZOI = 2 for the purpose of this illustration) for surface water and fish as well as the composition of PCB homologs (in weight percent) reported for several common Aroclor mixtures (ATSDR, 2000). Although the PCBs in solid material most closely matched Aroclors 1254, 1260, and 1268, the predicted surface water patterns and predicted fish tissue patterns most closely resemble Aroclor 1254; however, neither comparison indicates a perfect match. The similarity between predicted congener patterns in fish to Aroclor 1254 supports use of the Aroclor 1254 RfD to quantify noncancer hazard from fish consumption. Also, the PCB CSFs used to quantify cancer risk from fish consumption were derived from animal studies involving various Aroclor mixtures, including Aroclor 1254, and as such Aroclor 1254 values are considered appropriate for evaluating cancer risk from the consumption of fish from the reef site.

7.3 PCB CANCER TOXICOLOGY

This subsection briefly summarizes methods used to estimate cancer potency of PCBs and dioxin-like PCB congeners and explains why the CSFs identified in Section 7.2 were selected for use in this assessment.

7.3.1 Cancer Potency Evaluation

The CSF is used with exposure information to provide a conservative estimate of the likelihood that an individual will develop cancer as a result of lifetime exposure to a chemical. It is a plausible upper-bound estimate of carcinogenic potency used to calculate cancer risk from exposure to carcinogens by relating lifetime average contaminant intake to the incremental probability of an individual developing cancer over a lifetime. The oral CSFs used in this risk assessment are expressed as risk per unit dose (i.e., as units of incremental cancer risk per

milligram of contaminant per kilogram of body weight per day [mg/kg-d]$^{-1}$). Cancer potency is directly proportional to the CSF value; the larger the CSF, the greater the cancer potency of the compound.

As mentioned above, cancer risk was evaluated for PCBs using CSFs from USEPA's IRIS database (2005a). A CSF is not available on IRIS to quantify cancer risk from dioxin-like PCB congeners. Risk from dioxin-like PCB congeners is addressed qualitatively in the Uncertainty Analysis (see Section 9.4.3). Subsections 7.3.2 and 7.3.3 provide a discussion of some of the important toxicological issues associated with PCBs and dioxin-like PCB congeners.

7.3.2 Cancer Toxicity Criteria for PCBs

USEPA has classified PCBs as a B2 or probable human carcinogen based on liver tumors found in rats exposed to a range of commercial PCB mixtures, and on suggestive evidence from human studies, referred to as epidemiological studies (Safe, 1994; USEPA, 1996; USEPA, 2005a). To evaluate environmental mixtures, USEPA recommends an approach to assess cancer risk associated with exposure to PCBs that accounts for different PCB mixtures typically found in environmental media (USEPA, 2005a). Studies to date suggest that more highly chlorinated, less volatile congeners are associated with greater cancer risk. These congeners tend to persist in the environment in soil and sediment and to bioaccumulate and biomagnify in biota. More volatile, less chlorinated congeners are more likely to be metabolized and eliminated than highly chlorinated congeners. Based on knowledge of PCB partitioning in the environment, USEPA (2005a) recommends a suite of CSFs that are based on the exposure pathway as an indicator of the cancer potency of a PCB mixture, as summarized in Table 7-2 and described below.

To estimate risk from exposure to highly chlorinated congeners or exposure via pathways that tend to involve highly chlorinated congeners, USEPA (2005a) recommends using an upper-bound CSF of 2.0 per mg/kg-d and a central-estimate CSF of 1.0 per mg/kg-d. These CSFs are used for (1) food chain exposure; (2) sediment or soil ingestion; (3) dust or aerosol inhalation; (4) dermal exposure, if an absorption factor has been applied; (5) presence of dioxin-like, tumor-promoting, or persistent congeners; and (6) early-life exposure (all pathways and mixtures).

To estimate risk from exposure to more volatile PCB congener mixtures that are less persistent in the environment, USEPA (2005a) recommends using an upper-bound CSF of 0.4 per mg/kg-d and a central-estimate CSF of 0.3 per mg/kg-d. These CSFs are used for (1) ingestion of water-soluble congeners; (2) inhalation of evaporated congeners; and (3) dermal exposure, if no absorption factor has been applied.

If congener or isomer analyses verify that congeners with more than four chlorines comprise less

than 0.5 percent of total PCBs, USEPA (2005a) recommends use of an upper-bound CSF of 0.07 per mg/kg-d and a central-estimate CSF of 0.04 per mg/kg-d.

The fish consumption exposure pathway evaluated in this risk assessment meets the criteria for evaluating the exposure as a mixture of highly chlorinated PCBs because tetra-, penta-, hexa-, and heptachlorobiphenyls are the predominant homolog groups predicted in fish tissue (Figure 7-1). Thus, the high risk and persistent upper-bound CSF of 2.0 $(mg/kg\text{-}d)^{-1}$ and the central-estimate CSF of 1.0 $(mg/kg\text{-}d)^{-1}$ were incorporated into the RME and the CTE risk estimates, respectively.

7.3.3 Cancer Toxicity Criteria for Dioxin-Like PCBs

PCBs are commonly found as complex mixtures of congeners in environmental media and biological tissues. Twelve of these PCB congeners exhibit mammalian toxicity similar to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8,-TCDD, commonly referred to as dioxin), but with lower potencies. A TEQ approach was developed to estimate risk associated with these congeners (Van den Berg *et al*., 1998). The TEQ approach applies only to aryl hydrocarbon receptor (AhR)-mediated effects, assuming a model of dose additivity among congeners that bind to that receptor. PCB congeners included in the TEQ approach satisfy the following criteria:

- Structurally similar to dioxins and furans
- Bind to the AhR
- Elicit AhR-mediated biochemical and toxic responses
- Persist and accumulate in the food chain (Van den Berg *et al.*, 1998).

Binding to the AhR is an important criterion because most (if not all) biological effects of these congeners appear to be mediated by the AhR (Van den Berg *et al.*, 1998).

Each dioxin-like congener is assigned a toxic equivalency factor (TEF) to represent the fractional toxicity of the congener relative to 2,3,7,8-TCDD. Table 7-3 summarizes these TEFs, which were developed based on contaminant structure, persistence, resistance to metabolism, and toxicological action (Van den Berg *et al*., 1998). TEFs indicate an order-of-magnitude estimate of a congener's toxicity relative to 2,3,7,8-TCDD, and they are used to transform concentrations of individual congeners into equivalent concentrations of 2,3,7,8-TCDD.

The TEF of each congener present in the mixture is multiplied by the respective congener

concentration. The products are then summed to represent the toxic equivalent of 2,3,7,8-TCDD in the mixture, as determined by the equation:

$$TEQ = \sum_{i=1}^{12} (PCB_i \; x TEF_i) \qquad (8)$$

where:

TEQ	=	Toxicity equivalence concentration
PCB_i	=	Concentration of dioxin-like PCB congener i
TEF_i	=	Toxic equivalency factor for dioxin-like PCB congener i

Calculating cancer risks associated with dioxin-like TEQs from PCB congeners requires a CSF for oral carcinogenicity of 2,3,7,8-TCDD. No CSF is available for 2,3,7,8-TCDD from the IRIS database (USEPA, 2005a), USEPA's Tier 1 source of toxicity values. USEPA published a provisional dioxin CSF of 1.5E+05 $(mg/kg\text{-}d)^{-1}$ in its Health Effects Assessment Summary Table (HEAST) (USEPA, 1997b), which is a Tier 3 source of toxicity values in USEPA's hierarchy (USEPA, 2003a). This provisional CSF was derived from linearized multistage modeling of female liver cancer results from a two-year feeding study of Sprague Dawley rats (USEPA, 1985). USEPA's more recent dioxin reassessment provides a proposed CSF for oral carcinogenicity of 2,3,7,8-TCDD of 1E+06 $(mg/kg\text{-}d)^{-1}$ (USEPA, 2003b). However, the dioxin reassessment has not been formally released, and it is undergoing review by the National Academy of Sciences (NAS Project Identification Number: BEST-K-03-08-A). Cancer risk associated with dioxin-like PCB congeners is further evaluated qualitatively in Section 9.4.3.

7.4 NONCANCER HEALTH HAZARD

7.4.1 Evaluation of Noncancer Health Hazards

RfDs are used to characterize noncancer health hazards. USEPA (2005a) defines the RfD as:

> An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

It can be derived from a no observed adverse effect level (NOAEL), lowest observed adverse effect level (LOAEL), or benchmark dose, with uncertainty factors generally applied to reflect limitations of the data used.

RfDs can be based on adverse effects, such as gross or microscopic organ damage, and physiological effects (reproductive dysfunction, immunotoxicity, or biochemical effects [e.g., altered enzyme system]). Adverse effects are not likely at doses below RfDs. The level of concern for a particular contaminant does not increase linearly as the RfD is approached or exceeded, because these values are derived as threshold values. Therefore, comparing these values with exposure estimates provides an index of concern rather than a probability of an adverse effect occurring. RfDs are expressed as a dose in units of milligrams of contaminant per kilogram of body weight per day (mg/kg-d).

7.4.2 Noncancer Effects of PCBs

USEPA's IRIS database (USEPA, 2005a) provides oral RfDs for two commercial PCB mixtures, Aroclor 1016 and Aroclor 1254:

- RfD for Aroclor 1254 = 2E-05 mg/kg-d
- RfD for Aroclor 1016 = 7E-05 mg/kg-d.

As discussed in Section 7.2 and Section 7.3.2, the PCB mixture predicted in fish from the ex-ORISKANY reef more closely resembles Aroclor 1254 than Aroclor 1016; therefore, the RfD for Aroclor 1254 was used to quantify risk for the RME recreational angler scenario. The environmental mixture of PCBs predicted for surface water does not resemble Aroclor 1254 as much as the mixture predicted for fish, but it resembles Aroclor 1254 more closely than Aroclor 1016. The RfD for Aroclor 1254 is based on the LOAEL for impaired immune function, distorted growth of fingernails and toenails, and inflamed Meibomian (eyelid) glands in studies conducted on rhesus monkeys.

In addition to the skin, eye, and immune system effects that form the basis of the RfD for Aroclor 1254, experimental animal studies have shown reproductive and developmental effects and toxic effects to the liver, gastrointestinal system, blood, and endocrine system. In epidemiological studies, PCB exposure has been associated with (1) disruption of reproductive function, (2) neurobehavioral and developmental deficits in newborns (with *in utero* exposure) that continue at least through school age, (3) systemic effects such as (self-reported) liver disease and diabetes, (4) effects on the thyroid and thyroid hormone status, and (5) impaired immune function (ATSDR/USEPA, 1999; ATSDR, 2000).

7.4.3 Noncancer Effects of 2,3,7,8-TCDD TEQ

An RfD for dioxin-like compounds has not been developed. Further, USEPA (2003b) did not recommend an RfD for dioxin and related compounds because of the relatively high background

levels as compared to levels that might cause effects. Because an RfD has not been developed for dioxin-like compounds, the potential for noncancer hazards from exposure to dioxin-like PCB congeners is not quantitatively evaluated in this assessment.

8. RISK CHARACTERIZATION

This risk characterization integrates information from the exposure assessment and the toxicity assessment to quantify health risks to humans exposed to PCBs from the proposed ex-ORISKANY reef site through consumption of fish.

Cancer risks and noncancer health hazards were evaluated for the RME and CTE adult and child recreational angler scenarios. Results for subchronic exposure during the first two years after the sinking of the ex-ORISKANY are discussed in Section 8.1. Results for chronic exposure under steady state conditions are discussed in Section 8.2. As mentioned in Section 6.2, acute risks and risks to divers from exposures to PCBs in water are addressed in Section 9. Risks associated with *in utero* and nursing infant exposures through maternal fish consumption are also addressed in Section 9. All risk estimates account for the PCBs released from the ex-ORISKANY but do not consider background concentrations at the reef site that are not related to the ex-ORISKANY.

Cancer risks and noncancer HQs were estimated for the ingestion of several different types of reef-associated fish species because different fish species experience different exposure regimes, depending on the area of the water column that they predominantly reside in, and their diet preferences. The survey of anglers at artificial reefs in the Florida LAARS, described in Appendix F, points out that fish consumers eat a variety of species from the area, depending on their preferences and the availability of species over the course of a year. For this assessment, risks were estimated for consumption of multiple fish and shellfish species; however, the cancer risks and noncancer HQs correspond to ingestion of a single species rather than a mix of species. A single ingestion rate was used for all species, which was based on the total ingestion rate of all species of fish. In other words, the ingestion rate is not specific to any species and the risk estimates for any given species assume that an individual consumes only that species at the total fish ingestion rate. As a result, risks based on the consumption of the single species with the highest predicted tissue concentrations will encompass risks for people who eat a variety of species. The recreational angler may also incur cancer risk from the dioxin-like PCB congeners that accumulate in fish tissue. The cancer risk associated with these dioxin-like congeners is addressed qualitatively in Section 9.4.3.

8.1 NONCANCER HAZARD AND CANCER RISK EQUATIONS

8.1.1 Noncancer Hazard

Noncancer hazards are evaluated using the HQ, which is the ratio of the ADD to the chemical-specific RfD, are determined by the next equation:

$$HQ = \frac{ADD}{RfD} \qquad (9)$$

where:

HQ = Hazard quotient (unitless)

ADD = Average daily dose; estimated daily intake averaged over the exposure duration (mg/kg-d)

RfD = Chemical-specific reference dose (mg/kg-d).

Hazard quotients are based on the RfDs, which are threshold values, and HQs are not risk probabilities; the probability an adverse effect will occur does not usually increase linearly with higher HQs. An HQ less than one is interpreted as not presenting concern for the potential for noncancer effects. An HQ greater than one may indicate a potential adverse health effect from a chemical exposure, however, the magnitude of that potential is uncertain. HQs may be interpreted by considering the data that were used to derive the RfD, and the uncertainty and confidence that USEPA has in the RfD (USEPA, 2005a). Separate HQs are calculated for the child and adult because HQs for the child are typically higher than HQs for the adult for food consumption pathways where children often have higher food intake to body weight ratios. HQs are compared to USEPA's benchmark of 1 (NCP, 1990).

8.1.2 Cancer Risk

Excess lifetime cancer risk is calculated using the equation:

$$Risk = LADDxCSF \qquad (10)$$

Where:

Risk = Excess lifetime cancer risk, or the risk of developing cancer due to exposure above background cancer risk over the course of a 70-year (assumed) lifetime (unitless)

LADD = Lifetime average daily dose, estimated daily intake averaged over a 70-year lifetime (mg/kg-d)

CSF = Chemical-specific cancer slope factor $(mg/kg\text{-}day)^{-1}$.

Cancer risk is expressed as a lifetime excess cancer risk, over the course of a 70-year lifetime. This concept assumes that the risk of cancer from a given chemical is in "excess" of the background risk of developing cancer.

In assessing cancer risks due to chemical contamination, USEPA's National Contingency Plan (NCP) (USEPA 1990) establishes an excess cancer risk of one chance in one million (one in one million, expressed as 1E-06) as a "point of departure" for making decisions to manage the risks. Excess cumulative cancer risks lower than 1E-06 are not addressed by the NCP and are considered acceptable. Excess cumulative cancer risks between 1E-06 and 1E-04 may be considered acceptable, depending on whether there are ecological risks, site-specific factors such as the potential for exposure, and the level of uncertainty in the data that may lead to overestimation of risk estimates.

8.2 NONCANCER HAZARD AND CANCER RISK: SUBCHRONIC EXPOSURE

Anglers, their families, and divers who eat fish that they catch may consume fish that have accumulated PCBs released from the ex-ORISKANY during the first two years after sinking before steady state conditions are reached. Noncancer hazards and cancer risks were quantified for a child and adult consuming fish for this two-year period and results are summarized in Table 8-1. Noncancer HQs for the subchronic exposure do not exceed USEPA's benchmark of 1, and cancer risks do not exceed USEPA's acceptable risk range of 1E-06 to 1E-04.

HQs and cancer risks for subchronic exposures were calculated using fish EPCs that are time-weighted average whole body concentrations predicted for each species during the first two years after vessel sinking. The tissue concentrations calculated for each representative organism in the pelagic, reef, and benthic communities, for each specified time interval, are summarized in Table 6-3. The time-weighted averages were calculated by time-weighting the fish tissue concentrations calculated by the PRAM biotic food web module for each progressive time interval (i.e., Day 1, Days 2-7, Days 7-14, etc.) by the relative length of time that the food web was applicable during the two-year transient period.

For subchronic exposures, average fish tissue concentrations were calculated for the areas within the zero to 15 m, zero to 45 m, and zero to 60 m distance intervals from the ship. These distances roughly equate to the ZOIs of 2 and 5 that were used to predict fish tissue concentrations under steady state conditions that, in turn, were used to quantify risks from chronic exposure to PCBs in fish from the ex-ORISKANY site (see Section 8.3). The selection of the ZOIs is discussed in the PRAM documentation (NEHC/SSC-SD, 2006a).

As shown in Table 8-1, the highest estimated cancer risks and noncancer HQs for subchronic exposures were associated with consumption of TL-IV reef fish, represented by the grouper, followed by TL-III reef fish, represented by the triggerfish. None of the cancer risks exceed USEPA's risk range of 1E-06 to 1E-04 and none of the HQs exceed USEPA's benchmark of 1.

8.3 NONCANCER HAZARD AND CANCER RISK: CHRONIC EXPOSURE

Noncancer hazards and cancer risks were quantified for a child and for an adult consuming fish for 30 years, beginning two years after the sinking of the ex-ORISKANY when steady state conditions have been reached. Results are summarized in Table 8-2. Noncancer HQs do not exceed USEPA's benchmark of 1, and cancer risks do not exceed USEPA's acceptable risk range of 1E-06 to 1E-04.

HQs and cancer risks were calculated using whole body fish tissue EPCs estimated using ZOI assumptions of 2 and 5, as summarized in Table 6-3. The selection of these ZOIs is discussed in the PRAM documentation (NEHC/SSC-SD, 2006a). As shown in Table 8-2, the highest estimated cancer risks and noncancer HQs were associated with consumption of TL-IV reef fish, represented by the grouper, followed by TL-III reef fish, represented by the triggerfish. None of the cancer risks exceed USEPA's risk range of 1E-06 to 1E-04, and none of the HQs exceed USEPA's benchmark of 1.

8.4 RISK SUMMARY FOR FISH CONSUMERS

All subchronic and chronic noncancer HQs estimated for adults and children consuming fish contaminated with PCBs from the ex-ORISKANY are less than USEPA's benchmark of 1. All subchronic and chronic cancer risks estimated for these receptors are within or below USEPA's acceptable cancer risk range of 1E-06 to 1E-04. Evaluation of potential acute risks from recreational exposures at the proposed reef site, including ingestion of fish and dermal contact during diving, and ingestion of dioxin-like PCB congeners in fish are evaluated in Section 9.

9. UNCERTAINTY ANALYSIS

This section discusses important factors contributing to uncertainty in the cancer risks and noncancer HQs presented in Section 8 and how uncertainty influences interpretation of results. Uncertainty is inherent in any risk assessment because it is based on scientific judgment and assumptions, which are necessary due to the lack of full knowledge of scenarios and the true value of an input needed to calculate human health risk. For example, perfect knowledge about PCB assimilation efficiencies among fish species of interest is not available; therefore, the quantitative influence of uncertainty about this input is explored in this section. Cancer risk and noncancer HQs also are subject to variability in that all members of the exposed population do not have the same characteristics (e.g., body weight) and do not experience identical exposures (e.g., they may consume different species and some eat more fish than others). Variability is a population characteristic and typically cannot be reduced, only better understood.

One basic approach to account for uncertainty and variability simultaneously is the calculation of risks under both the RME and CTE. The RME is defined as the high-end exposure that is reasonably expected to occur for that exposure scenario, while the CTE is designed to represent exposure to an average scenario. This section supplements the CTE and RME analyses by describing sources of uncertainty in the abiotic modeling, biotic modeling, and human exposure and risk modeling. Note that descriptions of the TDM and PRAM modeling to which these uncertainty analyses apply are not presented in this report, but can be found in their respective documentation. Section 9.1 discusses uncertainties in the abiotic and biotic modeling as they may affect the risk estimates, and subsequent management of the risks, presented in Section 8.

Section 9.2 summarizes results of sensitivity analyses conducted during the development of PRAM (and described more fully in Section 2.3 of the PRAM documentation [NEHC/SSC-SD, 2006a]). A sensitivity analysis quantifies the influence that a change in a parameter has on the outcome (in this case, predicted risks) and can be helpful in identifying influential sources of uncertainty that can be reduced through further study or by defining variability more precisely. Several sensitivity analyses have been conducted on earlier versions of PRAM as well as the version used in this report (version 1.4c). It is cautioned that the sensitivity analyses were conducted on selected parameters one parameter at a time, except for K_{ow} and K_{oc} values, which co-vary as described later in this section. The sensitivity analyses cannot account for potential correlations and relationships among parameters (e.g., growth and uptake are both processes that depend on K_{ow} and temperature, and K_{ow} is temperature–dependent itself).

9.1 EXPOSURE CONCENTRATION MODELING

This subsection describes uncertainties associated with the PCB mass estimates onboard the

vessel, the PCB source leach rate estimates, predictions of PCB concentrations in abiotic media using TDM and PRAM, and predictions of PCB concentrations in biotic media using PRAM.

PRAM assumes steady-state conditions to solve for the distribution of PCBs within the reef components, including its surroundings and organisms associated with it. The environment within the prospective reef and surrounding area is highly dynamic and the assumption of thermodynamic steady-state conditions may not be truly accurate. Nevertheless, such an assumption is considered conservative, as the concentrations and distribution of PCBs at steady state predict the highest possible exposures.

9.1.1 Sources of Uncertainty in the Mass Estimates

This subsection describes uncertainties associated with the amount of PCB in the materials remaining onboard the ex-ORISKANY.

The concentrations of PCBs within certain materials onboard the ex-ORISKANY were found to be non-normally distributed. For some materials, there appears to be a bimodal distribution, where there is a group of samples with high PCB concentrations and another group with low or non-detect levels of PCBs. (The reason for this distribution is not known; a variety of reasons may be applicable, including different lots or suppliers). PRAM assumes that the calculated 95 percent UCL is representative of the amount of PCB in that material, and assumes that the PCB concentration within any specific source material onboard has a homogenous concentration. This may not be the case for the materials onboard the ex-ORISKANY, but is still considered a conservative assumption, as concentrations are unlikely to be uniformly higher than the 95 percent UCL.

The simulations performed for the ex-ORISKANY assume no degradation of the bound or released PCBs. This is considered a conservative assumption, especially for the less chlorinated homolog groups.

9.1.2 Sources of Uncertainty in the Leach Rate Estimates

This subsection describes uncertainties associated with source material leach rates.

Release behaviors of PCB homolog groups from PCB-containing solid materials onboard the ex-ORISKANY were quantified in a laboratory study that simulated shallow seawater leaching conditions (George *et al.*, 2006). Results from this study were used to develop regression models that describe leach rate as a function of time, from which leach rates were selected for use in PRAM. These regression models reveal that PCB releases decrease exponentially over time. PRAM incorporates the point in the curve representing the two-year point, although the leach

rate curves were still trending downward. Assuming that the leach rates continue to decrease after the two-year point, the two-year leach rates used in PRAM likely overestimate leaching for the 30-year exposure duration evaluated in this assessment. Regression models could not be developed for some homolog datasets that contained only one or two detected concentrations. In these cases, maximum measured leach rates were used in PRAM, which might also overestimate leaching during the exposure duration of interest.

Uncertainty associated with leachrate concentrations near analytical detection limits was avoided to the extent feasible by choosing appropriate sample preparation and analytical techniques and by testing materials containing relatively high concentrations of PCBs (i.e., greater than 500 mg/kg). Leach rate experiments were conducted at 25 degrees centigrade. A parallel set of experiments conducted at 4 degrees centigrade resulted in lower leach rates (George *et al.*, 2006). Thus, if surface water temperatures at the reef are less than 25 degrees centigrade, the PCB leach rates used in PRAM might overestimate leaching.

9.1.2.1 Biological Impacts on Leaching from PCB-Containing Materials

Leaching studies were conducted under abiotic conditions. The influence of biological organism degradation of the material onboard the ex-ORISKANY on the leaching of PCBs from the material is unknown. Potential biological impacts on leaching include a possible increase in leach rate due to biodegradation of shipboard solid materials and/or a possible decrease in leach rates due to biological growth over the materials. Both of these are very long-term processes; therefore, the leach rate study did not incorporate either of these processes into the experiments. There is no empirical evidence available indicating that the rate of PCB release will increase if shipboard solid materials biodegrade in the marine environment, nor is there any empirical evidence available indicating that leach rates are suppressed by biological fouling in marine environments. It is possible that both processes can occur and that the relative magnitudes of the competing effects cancel each other out.

9.1.2.2 Impact of Catastrophic Releases of PCBs

Empirical data are unavailable to evaluate whether a catastrophic event may affect short-term releases of PCBs from materials onboard the sunken vessel. A catastrophic event might include a sealed compartment rupture that would release PCBs to interior ship water or possibly directly to the external environment, relatively rapidly as compared with the slow release due to leaching. A catastrophic release would be expected to have minimal impact on chronic exposures of receptors to PCBs, since the release would occur over a very short time period, followed by transfer through the abiotic and biotic components of the reef site to the exposure media. Although moderate increases in acute exposures to the outer vessel water might occur due to

transient increases in water concentrations in the vessel interior, they are expected to be much below chronic exposures due to fish ingestion as further described in Section 9.5. In addition, exposures from fish ingestion due to any short-term increases in fish tissue concentrations following catastrophic releases would be expected to be negligible compared with the chronic exposures that are averaged over six years for children and 24 or 30 years for adults.

9.1.3 Sources of Uncertainty in TDM

The equilibrium partitioning equations in TDM require estimates of K_{oc}, fraction organic carbon, DOC, and transport across bins, which are driven primarily by water flow due to the current. The partitioning and environmental parameters used in TDM correspond to the values used in PRAM.

The values selected for TDM and PRAM for the fraction of organic carbon and DOC are typical for marine environments (see NEHC/SSC-SD, 2006a). It is not known what the actual fractions at the site of the proposed sinking are; thus, uncertainties are present in these values. However, the values used in the modeling were conservatively selected based on a consideration of what would be expected in the local marine environment. Uncertainty in partition coefficients can span an order of magnitude or more (Renner, 2000) and are discussed below in Section 9.1.4.5.

In both the TDM and PRAM models, PCBs are released only down-current from the ship, but the currents flow equally in all directions over time. As a result, PCB dispersal is assumed to be radially symmetric around the ship with the result that the PCB load predicted in TDM is distributed in all directions in each one-minute time step. If subsequent site-specific data suggest that currents and PCB dispersal are limited to particular directions, the model can be rerun with proportionally higher initial water concentrations, due to the smaller dispersal bin volumes.

9.1.4 Sources of Uncertainty in PRAM Module 1 (Abiotic Media)

Sources of uncertainty in the abiotic module of PRAM include the ZOI, air and water current, the environmental parameters used to describe the partitioning behavior of the PCBs (e.g., K_{ow}, K_{oc}, and user-defined inputs such as total organic carbon [TOC] in sediment), and specific coefficients from the fugacity equations. Each of these is discussed in the following subsections.

9.1.4.1 Zone of Influence (ZOI)

The ZOI definition is likely the most subjective parameter input for PRAM because the ZOI establishes limits within which PCB concentrations are presumed to influence biotic uptake. ZOIs adopted for use in PRAM were based on considerations of the dietary and habitation preferences of the various reef-associated fish species. Dr. John Conner, working in conjunction

with the Navy and USEPA as part of the TWG, developed an approach to the ZOI and provided recommendations for appropriate ZOI multiplier values for the ex-ORISKANY (see Appendix K). The impact of varying the ZOI on PCB concentrations is displayed in Figure 9-1. The horizontal or x-axis represents the ZOI, which increases from a minimum value of 1. The vertical or y-axis represents the ratio of the PCB concentration in the lower water column (LWC) at the given ZOI value divided by the maximum PCB concentration in the LWC that occurs when the ZOI = 1. The ratio represents the fractional amount of the original PCB concentration remaining as the ZOI increases. Subtracting the ratio from 1 provides the fractional amount that the original PCB concentration has decreased as the ZOI increases. The applicable percentages can be determined by multiplying the respective fractions by 100.

As displayed in the graph, most of the reduction in PCB concentrations occurs when the ZOI expands from 1 to 10, then the rate of PCB concentration reduction diminishes significantly as the ZOI increases to 100. The graph shows that once the ZOI multiplier exceeds a value of 6, the relative change in PCB concentration predicted in the environmental medium becomes insignificant. The greatest change in PCB concentration estimates occurs between ZOI multipliers from 1 to 6. As the ZOI expands, the resulting PCB concentrations in the various columns decline because the mass entering the system from the source (the vessel) remains constant while the volume of the elliptical cylinder increases. At a ZOI = 1.5, the resulting ratio compared to a ZOI of 1 is approximately 0.76, which indicates that the original PCB concentration has decreased by about 24 percent when the base of the ZOI has been expanded by just 50 percent. When the ZOI = 3, the ratio is close to 0.50, showing that approximately 50 percent of the original PCB concentration is reduced by expanding the base of the ZOI to encompass three times the maximum horizontal area of the vessel.

However, for those fish species (e.g., the reef community) that derive the bulk of their exposure from the interior of the vessel, changes in ZOI are less significant. For example, for the reef fish TL-IV predator, predicted concentrations are virtually indistinguishable between ZOI = 2 and ZOI = 5. This is because they derive the bulk of their body burden from exposure to water in the interior of the vessel, which does not change with changes in ZOI.

9.1.4.2 Air and Water Current

The overall average wind current for the area associated with the ex-ORISKANY reef site is reported to be 7.4 knots or 8.5 miles per hour (FWCC, 2004). The value used in PRAM is based on buoy data for the area and represents a reasonable, long-term average value. Although there may be uncertainty in this value, over the longer term it is likely to be representative of expected flow conditions.

9.1.4.3 Diffusion Coefficient in the Fugacity Model

Four models of transfer velocity across the seawater-air interface were evaluated for PRAM. The California Environmental Protection Agency (CalEPA) Multimedia Total Exposure Model for Hazardous Waste Sites (CalTOX) model (UCD and LLNL, 1994) as well as the CemoS Model (Baumgarten *et al*., 1996) use an empirical approach to estimate D/Δ based on the laboratory results of Southworth (1979). However, the data used by Southworth (1979) were specific to a large freshwater river (see Trapp and Harland, 1995). The approach suggested for open ocean is that of Liss and Slater (1974), which is specific to the air-ocean interface. Liss and Slater (1974) determined that the average transfer velocity (i.e., the combination of diffusion velocity and turbulence) for water across the seawater-air interface was 30 m/hour.

In developing inputs for PRAM, two other methods in addition to the Southworth and Liss and Slater methods were evaluated and compared to field observations by Trapp and Harland (1995): that of Mackay and Yeun (1983), which was developed for lake environments; and the method presented as the Langbein–Durum method (Trapp and Harland, 1995) for a river backwater situation. For comparison purposes, in the papers of Mackay (Mackay *et al*., 1985; Mackay and Paterson, 1991) a mass transport coefficient (U) of 3 m/hour (72 m/day) for the airside U coefficient and 0.03 m/hour (0.72 m/day) for the waterside U coefficient were used in modeling the hexachlorobiphenyl homolog. According to Mackay and Paterson (1991), these values were selected based on best professional judgment without any further justification.

Trapp and Harland (1995) evaluated the aforementioned four estimation methods for a large river and a ship channel. Although neither situation is similar to the open ocean application anticipated for PRAM, the relative performances of the models are useful here. The Liss and Slater method overestimated the observed transport velocities for both situations (Trapp and Hartland, 1995). Both the Southworth and Langbein–Durum methods significantly underestimated the velocities for the ship channel scenario but were accurate predictors of the river scenario. The Mackay and Yeun method significantly underestimated the transport velocity for the river scenario and significantly overestimated the velocity for the ship channel (Trapp and Hartland, 1995). The lone method for oceans (Liss and Slater, 1974) appears to produce non-conservative results based on the limited attempt by Trapp and Harland (1995) to validate the model. Although Trapp and Harland (1995) pointed out that, “it is unlikely that one universal empirical model is applicable to all cases and consequently no exact simulation can be expected,” a conservative algorithm was deduced for use in PRAM, based on the Southworth method. The Southworth method was consistently conservative or accurate in the validation scenarios reported by Trapp and Hartland, although overly conservative under certain situations of very low current speeds (Trapp and Hartland, 1995).

Based on the apparent conservatism associated with the Southworth method and the precedence for its use within CemoS and CalTOX, the method has been adopted for use within PRAM. One possibly significant uncertainty for the application of this approach is that the method was derived with chemicals with Henry's Law constants between 1 and 100 Pascals, whereas some of the more chlorinated PCB homolog series have much higher Henry's Law constants. The potential quantitative impact on predicted concentrations and risks is unknown.

9.1.4.4 Sediment-Water Boundary Layer

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

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

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

$$\Delta_{43}[m] = 318 \quad D_S^{0.683} \tag{11}$$

There is some uncertainty associated with this approach because model results are used as inputs to a subsequent modeling scheme and the applicability of predicted soil results for sediment may

not be valid. The appropriateness of this approach within PRAM is unclear, as it would suggest that the diffusion path length varies for each PCB homolog series. As a result of this uncertainty, and given the additional uncertainties associated with the use of a soil-based model result, the CalTOX model was rejected for this purpose. The approach used by Mackay *et al.* (1985) and many others, where the diffusion path length or boundary thickness for sediment is set as half of the active sediment layer, is used within PRAM. The quantitative influence this choice has on predicted concentrations and risks is not clear.

9.1.4.5 Partition Coefficients

There is considerable uncertainty associated with the use of partition coefficients under environmental conditions (Renner, 2000). Differences in the ways in which partition coefficients are measured or derived contribute to the range of values observed from the literature for the same congener or PCB mixture. In addition, partitioning is weakly dependent on temperature, which accounts for some of the differences observed across studies.

Seth *et al.* (1999) conclude that variability in the composition of organic matter present in soils and sediments, and the experimental difficulties and constraints in developing organic carbon partition coefficients (K_{oc}), explain the wide variability that is observed. These authors recommend that K_{oc} estimates based on observed relationships to the hydrophobicity parameter K_{ow} are preferable and provide a functional relationship of $K_{oc} = 0.35 * K_{ow}$ with an uncertainty bound of 2.5 times (e.g., the lower bound of $K_{oc} = 0.14 * K_{ow}$ and the upper bound is $K_{oc} = 0.89 * K_{ow}$). This provides some indication of the level of uncertainty in K_{oc} values.

Partitioning coefficients for dissolved organic carbon (K_{doc}) show similar variability under actual environmental conditions. Burkhard (2000) compiled data from 70 references and explored numerous functional relationships between K_{doc} and K_{ow} and found a predictive relationship of $K_{doc} = 0.08\ K_{ow}$ with five percent confidence limits of a factor of 20 in either direction. It is assumed that these large uncertainties are attributable, at least in some part, to the variability in structure and composition of DOC in sediments, soils, and surface waters. This variability is not accounted for by the hydrophobicity parameter. The author observed ranges of K_{doc} values approaching two orders of magnitude for a given chemical.

9.1.5 Sources of Uncertainty in PRAM Module 2 (Aquatic Food Web)

9.1.5.1 Assumptions of Fish Exposure

The aquatic food web portion of PRAM is parameterized to represent expected exposures of aquatic organisms that are assumed to spend their entire lifespan at the modeled reef. However, some reef-associated fish such as the red snapper have a wide home range or spawn in areas

away from the reefs and would likely spend at least some portion of their lifespan outside the modeled reef. Other reef fish reside on the reef only as adults or might have migrated to the reef as a result of natural events such as high-energy storms. If fish spend part of their lifetime away from the reef and with less exposures to PCBs, their body burdens would be expected to be less than that modeled in PRAM. On the other hand, if fish spend part of their lifetime in other locations that have sources of PCBs, their actual PCB tissue concentrations could be higher than modeled by PRAM. As mentioned in Section 4.3, PRAM does not account for background exposures to PCBs that may be in the marine environment.

9.1.5.2 Parameter Uncertainty - Assimilation Efficiency

The assimilation efficiency (α) used in the governing equation (Equation 99 in NEHC/SSC-SD, 2006a) is specific to the chemical being assimilated and is not necessarily directly related to the assimilation efficiency of foodstuffs[7] (e.g., see Gobas *et al.,* 1988; Endicott *et al.,* 1991; Connolly, 1991; and Fisk *et al.,* 1998). These authors have developed relationships between a K_{ow} and the assimilation of the chemical across the gastrointestinal tract. Based on data collected by Gobas *et al.* (1988) for various hydrophobic organic compounds, the following non-linear regression was developed (Equation 2 in Gobas *et al.,* 1988):

$$1/\alpha = 5.3\times10^{-8} K_{ow} + 2.3 \qquad (12)$$

where:

α = assimilation efficiency across gastrointestinal tract (fraction)

K_{ow} = octanol-to-water partition coefficient [Liters/kg]

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

$$\alpha = 37.9 - 11.216 \log_{10} K_{ow} + 0.8409(\log_{10} K_{ow})^2 \qquad (13)$$

For chemicals with a $\log_{10}K_{ow}$ greater than 6.6, Endicott *et al*. (1991) found that α was equal to

[7] Matrix effects associated with the assimilation of chemicals have been identified, but the process of actually crossing the gastrointestinal tract is believed to be most associated with lipophilicity (see Spacie and Hamelink, 1995; Kleinow and Goodrich, 1992).

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

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

$$\log_{10} \alpha = -1.8 + \log_{10} Kow - (0.08 \log_{10} Kow^2) \qquad (14)$$

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

It is clear that the methods and results described above are very different. It is notable that the efficiencies reported by Fisk *et al.* (1998) were specific to dietary exposures only, while many of the studies used by Endicott *et al.* (1991) relied on field observations. Figure 9 in the PRAM documentation (NEHC/SSC-SD, 2006a) presents these estimation regressions across a range of K_{ow}s. The significant difference that lies within the $\log_{10}K_{ow}$ range from 5 to 7 was based on observed values. This range encompasses the majority of the bioaccumulative PCBs modeled in PRAM. Thus, use of the parabolic equation of Fisk *et al.* (1998) in PRAM contains uncertainty, but is based on an analysis of diet-specific data sets designed to evaluate assimilation uptake.

9.2 SENSITIVITY ANALYSIS OF PRAM INPUT PARAMETERS

Sensitivity analyses of PRAM for both the abiotic and biotic portions of the model are described in the PRAM documentation (NEHC/SSC-SD, 2006a) and summarized below for those parameters that affect health risk estimates. Sensitivity analyses were conducted by changing one parameter at a time and evaluating the difference in predicted risk as compared to the "baseline" run (ZOI = 2 with parameters set as described in this document). These showed that changes in the ZOI have by far the greatest impact on predicted risk in terms of changes in the abiotic modeling of Module 1. Factors of 2 changes in K_{oc} and K_{ow} lead to approximately a factor of 4 change in predicted risks. Generally, increases in K_{ow} lead to increases in risk, although these are somewhat offset by concomitant increases in K_{oc} (under the assumption that K_{oc} and K_{ow} are related as shown by Seth *et al.*, 1999; Karickhoff, 1981). Increases in K_{oc} lead

to decreases in predicted risks and a redistribution of material in the abiotic module. In general, higher K_{oc} leads to greater partitioning to the organic fraction in particles and sediment. Changes in TOC show very little impact in terms of risk. Decreasing TOC to 0.5 percent from one percent leads to virtually the same predicted risks. This is because the sediment pathway is not a dominant exposure pathway.

The sensitivity analysis for the biological uptake component of PRAM focused on five specific parameters as described in greater detail in the PRAM documentation (NEHC/SSC-SD, 2006a):

- Octanol to water partition coefficient, K_{ow}
- Respiration rate regression parameter, $\beta 2$
- Depuration rate, Ke
- Growth rate, G
- Assimilation efficiency, α.

The octanol-to-water partition coefficient (K_{ow}) was identified as having major impacts on the PRAM-calculated cancer risks/HQs during sensitivity analyses of the earlier versions of PRAM. The respiration rate was investigated because it directly influences the degree to which aquatic organisms take up PCB constituents from other than dietary sources. The depuration rate and the growth rate were selected for sensitivity analyses because of their significant impact on the bioconcentration factor (BCF). Similarly, the assimilation efficiency was chosen for sensitivity analysis due to its influence on the bioaccumulation factor (BAF). Figures 9-2 and 9-3 shows the predicted HQs for the CTE child (Figure 9-2) and the RME child (Figure 9-3) based on changes in these individual parameters. The sensitivity analyses are described in detail in Section 2.3 of the PRAM documentation (NEHC/SSC-SD, 2006a).

In general, the procedure in the sensitivity analysis consisted of multiplying the value for each of the parameters in the bulleted list by 0.5 and 2.0 (except for assimilation efficiency, for which the values were multiplied by 0.5 and 0.25). The PRAM documentation provides the corresponding decrease and/or increase in predicted cancer risk, or HQ, on a percentage basis. Figures 9-2 and 9-3 present the results of the highest increases; decreases are not shown.

Decreasing the K_{ow} values to half the base case values reduced the resulting PCB cancer risks/HQs by seven percent to 43 percent. Doubling the K_{ow} values from the base case increased the resulting PCB cancer risks/HQs by two percent to 43 percent. Considering that the higher trophic levels (TL-IV) tend to consume the lower trophic levels (TL-III), particularly within a specific community of biota (benthic, pelagic, or reef), the percent differences in risks stemming from variations in the K_{ow} values generally are larger in the higher trophic species.

Reducing the respiration coefficient (β2) values to half the base case values decreased the resulting PCB cancer risks/HQs by 20 percent to 58 percent. Doubling the β2 values from the base case increased the resulting PCB cancer risks/HQs by 25 percent to 149 percent.

Decreasing the depuration rates (Ke) to half the base case values increased the resulting PCB cancer risks/HQs by 17 percent to 76 percent. Doubling the Ke values from the base case decreased the resulting PCB cancer risks/HQs by 20 percent to 52 percent.

Decreasing the aquatic organism growth rates (G) to half the base case values increased the resulting PCB cancer risks/HQs by 124 percent to 526 percent. Doubling the G values from the base case decreased the resulting PCB cancer risks/HQs by 57 percent to 78 percent.

Decreasing the assimilation efficiencies (α) to half the base case values for the species represented decreased the resulting PCB cancer risks/HQs by 30 percent to 69 percent. Decreasing the α values to 25 percent of the base case decreased the resulting PCB cancer risks/HQs by 44 percent to 85 percent.

There is considerable uncertainty in the specific partition coefficients associated with each of the homologs. These are important in both the abiotic and biotic components of the model. An alternative PRAM run was conducted to demonstrate the combined influence of K_{ow} and K_{oc} in particular. Using the ZOI = 2 results as the baseline case, the 95 percent UCL of the individual congener K_{ow} for a homolog group (as presented in Appendix B of the PRAM documentation) was used as input to PRAM. It was further assumed that K_{oc} is approximately 0.35 times K_{ow}, consistent with Seth *et al.*, (1999) and similar to Karickhoff (1981). This results in a redistribution of contaminants within the abiotic modeling zone. However, since no other parameters were changed, including water flow (e.g., current), the bulk of the PCBs released from the ship are still advected out of the system. What remains is redistributed as shown in Figure 9-4. The interior of the vessel still dominates in terms of exposure concentrations (e.g., the vessel interior water drives reef fish exposures), but whereas the bulk of the material was DOC-bound previously, under the scenario of co-varying K_{ow} and K_{oc} there is a greater concentration of suspended solids (although it is still very low). This is shown in the bottom graph of Figure 9-4. The top graph shows the exact same information, but on a log scale. From the top graph it is possible to determine how the PCB homologs are redistributed in the compartments exterior to the ship. Predicted fish tissue concentrations of PCBs are shown in Figure 9-5. Concentrations in reef fish tissue decrease slightly under this scenario as compared to the baseline ZOI = 2 run. Predicted noncancer HQs and cancer risks are still below levels of concern. For example, under the baseline case ZOI = 2, the predicted HQ for the RME child consuming TL-IV reef fish was 0.6, and under the co-varying K_{ow} and K_{oc} scenario the HQ decreases to 0.3.

9.3 SOURCES OF UNCERTAINTY IN THE EXPOSURE ASSESSMENT

In addition to the sources of uncertainty in the abiotic and biotic modeling modules of PRAM, there are also inherent uncertainties associated with the parameters in the risk characterization module of PRAM that are used to evaluate subchronic and chronic exposures. The key parameters for the fish ingestion pathway include the fish ingestion rate, fraction of fish ingested that are from the reef, duration of exposure, and fish tissue concentrations of PCBs. Each of these parameters is discussed in more detail in the following subsections. In addition, the potential for adverse health effects from acute exposures through fish consumption are discussed. The toxicity values used in the assessment to quantify cancer risk and noncancer hazard, although based on science, also contribute to the uncertainties in characterizing risk at a site. Uncertainties in the toxicity values are discussed in Section 9.4.

9.3.1 Fish Ingestion Rate (IR) Term

The RME and CTE fish IRs were developed under the assumption that the rates could be applied to the ingestion of a single species of fish or shellfish. In other words, species-specific IRs were not assumed, and the total fish IRs are not adjusted to account for the possible consumption of multiple species of fish. Regionally derived fish IRs tend to be highly uncertain when applied to specific sites. The rates used in this assessment were not developed for the ex-ORISKANY artificial reef site, and the application of the total fish IR terms to each species of fish is a conservative assumption that likely overestimates risks. In other words, if anglers catch and eat a variety of species from the reef, PRAM output for consumption of TL-IV fish would overestimate associated health risks.

9.3.2 Fraction of Fish Ingested (FI) Term

The FI term was derived from a survey of anglers who fished reefs off the coast of Florida. Four existing artificial reefs off the coast of Florida in the Gulf of Mexico were assumed to be most representative of the proposed ex-ORISKANY artificial reef site, also planned to be sunk in the same general area. Because of the large size of the ex-ORISKANY vessel, it was assumed that the environmental conditions and amount of fish collected from the existing four smaller reefs would serve as the best surrogate of reef conditions in the Gulf in the vicinity of the proposed site. The species of fish caught and the total number of meals of fish consumed from those surrogate reef sites over the course of a year were considered representative of the species and number of meals of fish that might be consumed from the ex-ORISKANY site.

The amounts of fish caught at the surrogate sites were determined by a survey of 80 anglers who fished the four reefs at some time during 2003. The survey was conducted over a few days, and

respondents were asked to recall how many total meals of fish they consumed over the course of the year that they fished the reefs, and how many of those meals were of fish caught from the surrogate reefs. The amount of error in the recall of these individuals for a one-year period adds an unknown amount of uncertainty to the final estimates of meal consumption. The amount of fish meals reported to be consumed from the reefs for the year ranged from 1.5 to 20 per individual. Although this range is fairly wide, the mean and 95th percentile values for the fraction of meals consumed from the reefs (0.17 and 0.25, respectively) compared to total consumption estimated for all the Gulf waters over the year (20.4 and 29.2 meals/year for the mean and 95th percentile, at 129 and 326 g/meal, respectively) appear to be reasonable.

9.3.3 Fish Tissue Concentrations

Fish tissue concentrations of PCBs are predicted for uncooked whole body wet weight. Actual exposures of fish consumers are much more likely to muscle tissue (i.e., fillets of fish), which may have lower concentrations of PCBs due to the lower amount of fat in muscle tissue, than to whole body, as was found in fish samples collected from an artificial reef site in the South Atlantic (Johnston *et al.*, 2005a). In general, PCBs will partition to the fat layer beneath the skin of fish, which results in higher PCB concentrations in whole body fish (i.e., with the skins on) than in fish fillets without skins. The consumption of fish without skins would result in lower risks from PCB exposures than consumption of fish fillets with the skin on. Thus, PRAM, which models PCB concentrations into whole body fish tissue with the skins on, results in conservative estimates of health risks from fish consumption. In addition, exposures would most likely be to fish that have been prepared (e.g., perhaps the skin and head are removed) and cooked. PCB concentrations can be reduced as much as 25 percent as a result of these processes (Moya *et al.*, 1998; Wilson *et al.*, 1998; USEPA, 2000b). The use of whole body fish tissue concentrations of PCBs, which have not been adjusted for cooking removal of PCBs in fat, is a conservative approach to estimating the EPC and subsequent risks to consumers of fish from the ex-ORISKANY reef site.

9.3.4 Short-Term Exposures of Anglers via Consumption of Finfish

Adult anglers and children may be exposed to PCBs via consumption of finfish caught during the initial few weeks after vessel sinking when PCB releases from residuals onboard the vessel are predicted to be the highest, and during the first two years when the releases are still higher than under long-term steady-state conditions. Although releases of PCBs are highest during those time periods, the TDM-predicted fish tissue concentrations of PCBs for periods less than two years are actually lower than during longer exposure periods (i.e., more than two years). Table 4-4 presents the predicted fish tissue concentrations of PCBs for various time periods, including the first day, weeks, month, six months, one year, and two years. The timing of peak

concentrations of PCBs in tissues varies with the species; for some species it occurs within the first month, for others it does not occur until two years. Nevertheless, tissue concentrations during all time periods up to two years are less than the PRAM predictions for steady state conditions greater than two years.

The lower modeled fish tissue concentrations of PCBs predicted during the first two years of release (despite higher water concentrations) are due to the progressive biological colonization of the reef and availability of food resources that occurs during the first two years after sinking. As described in Section 4.2.1, a dietary progression is used in PRAM to model exposures of the reef community during the first two years after vessel sinking. The progressive diet is based on a series of time intervals thought to reflect changes with colonization in the reef community during those first two years. The immature colonization during those first two years places some limits on the food resources for higher trophic organisms, though not all food sources are assumed to be limited (e.g., contributions to the food web from reef-obligate forms such as sessile filter feeders and invertebrate omnivores are assumed not to change over time; these organisms are significant for PCB trophic transfers in the early stages of reef colonization due to their close proximity to the reef). It is assumed that the reef community structure and PCB release rates change during the first two years, and that both will have reached a steady-state condition at the two-year mark, as discussed in the TDM documentation (NEHC/SSC-SD, 2006b).

Assuming the same fish ingestion rate for all species regardless of the timing of their consumption, this comparison of tissue concentrations under short-term and steady-state conditions indicates that the amount of ingested PCBs in fish from the reef site on a daily basis for short-term exposure (i.e., during the first two weeks and over the first two years) would be less than the daily ingestion rate under chronic exposures. For acute and subchronic exposures (i.e., at two weeks and two years, respectively), based on the lower tissue concentrations and similar toxicity of PCBs, it can be inferred that the potential risks to human health would also be less than the risk estimates for chronic exposures.

9.3.5 Exposure Duration (ED)

The exposure duration assumed for chronic exposures to PCBs via ingestion of fish was 30 years. This value is recommended by USEPA (1997a) guidance for the RME as the 90th percentile of the number of years that the U.S. population resides in a single residence. The value is designed to be applicable to the evaluation of residential exposures to chemical contamination of properties. However, the value does not account for the possibility that although people may change residential locations, they may still continue to fish from the same reef location. The value could underestimate exposures to those people who may fish the ex-ORISKANY artificial reef site for more than 30 years, even though they may not live in the same

location during that time. If a value greater than 30 years is assumed for the duration exposure, the cancer risks associated with the consumption of fish caught at the reef would increase proportionately (note that noncancer HQs would remain the same). If the value for the exposure duration were assumed to be 45 years instead of 30 years, the RME cancer risk estimate for the consumption of grouper (i.e., the trophic level IV fish) from the artificial reef would be 1E-05.

In addition, the assumption of a 30-year exposure period assumes that the angler will not change his/her fishing preferences over the entire 30 year period, and will repeatedly fish the ex-ORISKANY artificial reef during this entire 30 year period at the fraction assumed for the reef. For those individuals who change their fishing habits over the 30-year exposure period, the risk estimates would be overestimated.

9.4 TOXICITY ASSESSMENT

The toxicity values used in this risk assessment were the most current values published by USEPA (1997b, 2005a). The following subsections provide a brief discussion of some of the principal uncertainties related to the toxicity of these contaminants.

9.4.1 PCB Cancer Slope Factors (CSFs)

The PCB CSFs are based on animal studies using commercial mixtures. For PCBs, USEPA has developed both upper-bound and central estimates CSFs. The upper-bound and central estimate CSFs differ by only a factor of two. There are many uncertainties associated with the use of animal studies to predict cancer risk in humans, both qualitatively and quantitatively through the CSF. Qualitatively, PCBs have been classified as probable human carcinogens (former USEPA category B2), based on clear evidence of carcinogenicity in animal experiments and suggestive studies in human populations. Quantitatively, major sources of uncertainty in the application of experimental information to human exposure are the extrapolation of animal studies to human populations, the extrapolation of the high experimental doses to the lower doses from environmental exposures, extrapolation to less than lifetime doses (including the impact of early life exposures), and extrapolation of results from commercial mixtures to environmental mixtures. The first three uncertainties are common to the derivation of many CSFs derived by USEPA, and the extrapolation from commercial to environmental mixtures is specific to mixtures such as PCBs.

9.4.2 PCB Reference Doses (RfDs)

The RfD for PCBs used in the RME evaluation is based on immunological effects observed in rhesus monkeys exposed to Aroclor 1254. An uncertainty factor of 300, which accounts for

sensitive members of the population and for extrapolating from animal data to human data, is incorporated into the RfD. Without application of this uncertainty factor, one would calculate lower HQs. USEPA is currently reviewing new studies on noncancer effects of PCBs as part of the ongoing IRIS review process. These studies report possible associations between developmental and neurotoxic effects in children from pre-natal or post-natal exposures to PCBs and were not available at the time that the RfD used in this assessment was developed.

Major sources of uncertainty associated with the PCB RfDs include:

- The selection of uncertainty factors in the derivation of the RfDs, including the length of the study, the critical effect, the quality of the data set, and the variability of human population, including sensitive subpopulations.
- The assumption that the critical effects in animal studies are the critical effects in humans.
- The assumption that the dose metric of ADD is applicable to bioaccumulative compounds. Toxicity changes resulting from alterations in PCB mixtures ("weathering") following release to the environment.

In addition to uncertainties in the chronic RfD, there is additional uncertainty associated with toxic effects that may result from shorter exposure durations. The critical period of exposure for developmental effects associated with *in utero* exposure may be days or weeks instead of the long-term exposure assessed in this report. USEPA has not established toxicity values for the evaluation of such acute (short-term) exposures; therefore, acute risks that may be associated with perinatal exposures to PCBs are not evaluated quantitatively in this assessment (see Sections 9.6 and 9.7), but acute risks to divers are evaluated semi-quantitatively in Section 9.5.

9.4.3 Cancer Risk from Dioxin-like Congeners in Fish Tissue

Cancer risk from dioxin-like PCB congeners can be evaluated using the TEQ approach described in Section 7.4.3. Given the lack of predicted dioxin-like PCB congener concentrations for fish at the ex-ORISKANY, cancer risk from dioxin-like PCB congeners is discussed qualitatively in this subsection.

Uncertainties associated with the TEQ approach have been discussed in the scientific literature and in the context of USEPA's Dioxin Reassessment (USEPA, 2003b), although some of the uncertainty associated with application of the TEQ approach has been reduced to some extent with recent NTP studies (2004a, 2004b, 2004c, and 2004d). The TEQ approach requires a CSF for 2,3,7,8-TCDD, but none is available on IRIS (USEPA, 2005a). A preliminary draft

document (USEPA, 2003b) presents USEPA's scientific reassessment of the health risks resulting from exposure to 2,3,7,8-TCDD and other dioxin-like compounds as well as a proposed CSF. But this document has not been finalized pending an ongoing NAS review (NAS Project Identification Number: BEST-K-03-08-A) to ensure that the risk estimates contained in the draft are scientifically robust and that there is a clear delineation of all associated uncertainties. Therefore, given the uncertainties in the TEQ approach for dioxin-like PCBs and the status of the ongoing review by USEPA, cancer risks associated with dioxin-like PCB congeners are not quantified.

TDM and PRAM models were not parameterized to quantify fish tissue concentrations and human health risk for fish consumers from dioxin-like PCB congeners. To some extent, risk from these congeners is accounted for, given their presence in the Aroclor test materials used in studies that form the basis of the PCB CSFs. However, risk might be overestimated or underestimated using CSFs based on toxicological studies of Aroclors alone, depending on how the PCB mixture weathers and is bioaccumulated by fish. Risks might be underestimated if dioxin-like PCB congeners are present in reef fish tissue in proportions greater than those in the Aroclor test material. However, the most potent dioxin-like PCB congener, PCB-126, was never detected in leachrate from PCB-containing solid materials examined in the leach rate study (George *et al.*, 2006), suggesting that the major dioxin-like PCB congener would not be present in fish tissue at the ex-ORISKANY site in proportions greater than those in the Aroclor test material. This finding also suggests that the method of assessing health risks using Aroclor toxicity data, as done with PRAM, would be sufficiently protective of the health of people who consume fish from the reef site.

9.5 ASSESSMENT OF ACUTE DERMAL RISKS FOR THE RECREATIONAL DIVER

As presented in Table 6-1, recreational divers may be exposed to PCBs in surface water during short periods of diving activities. Since releases of PCBs from residual materials are highest during the first 90 days after vessel sinking (see Tables 4-5, 4-6, and 6-3), acute risks from direct contact with PCBs in water is a potential exposure pathway of concern during that time period. Because concentrations of PCBs in water are highest during the zero- to 90-day period, the daily doses to divers will be higher during that initial time period than during later periods when PCB releases have reached lower steady state conditions. Thus, the evaluation of dermal exposures of divers during the zero- to 90-day release period represents a conservative approach to evaluating the potential for health risks from PCBs released to water; i.e., subchronic and chronic dermal exposures and associated health risks will be lower than during the initial acute episode.

Because there are no acute PCB toxicity values for use in assessing risks from dermal exposure,

risks from dermal contact with PCBs while diving at the reef are evaluated qualitatively. Recent USEPA guidance on dermal risk assessment (USEPA, 2004b) is used in a screening evaluation in the following subsections where potential acute doses from water concentrations during the zero- to 90-day period are compared with doses from fish ingestion under chronic exposures. Specifically, the calculated dermally absorbed dose (DAD) of PCBs from water was compared with the dose from oral intake of PCBs via the fish ingestion route. The analysis demonstrates that estimated acute exposures to PCBs at the artificial reef site during the zero- to 90-day period are substantially lower than chronic exposures to PCBs from fish ingestion during steady-state conditions of PCB releases.

9.5.1 Exposure Data

The data used for assessing short-term risks were average PCB concentrations predicted by TDM for various abiotic matrices. Site-specific PCB homolog and total PCB concentrations were calculated for ten environmental matrices:

- Water above the pycnocline (upper water column)
- Total suspended solids (TSS) in the upper water column
- DOC in the upper water column
- Water below the pycnocline (lower water column)
- TSS in the lower water column
- DOC in the lower water column
- Sediment
- Internal vessel water
- Internal vessel TSS
- Internal vessel DOC.

The modeled abiotic media concentrations of PCBs are dependent on a number of site-specific variables, including PCB source concentrations and mass of PCB source materials, material-specific and time-dependent leach rates of PCB homologs, physical properties of the reef and reef environment, and the modeled domains that are defined as specific time-distance intervals (e.g., elapsed times from sinking, and distances from the sunken vessel). For acute exposures, the time interval was assumed at zero to 90 days, and the distance intervals were assumed to be the areas closest to the vessel: zero to 15 meters, zero to 45 meters, and zero to 60 meters away from the sunken vessel, with exposures occurring below the pycnocline.

The TDM output for average PCB concentrations in the abiotic matrices for the zero- to 90-day period and for distance intervals zero to 15 m, zero to 45 m, and zero to 60 m away from the sunken vessel is provided in Table 4-4. Table 6-3 provided the predicted concentrations in abiotic media for the zero- to 90-day period, for the distance intervals of zero to 15 m, zero to 45 m, and zero to 60 m away from the sunken vessel, in units of mg/L for water and mg/kg for solids. For the upper water column (water above the pycnocline), the PCB water concentrations range from 3 to 6 x 10^{-14} mg/L and from 3 to 4 x 10^{-9} mg/L in the lower water column. The results indicate that PCB concentrations in the lower water column within the first 90 days after vessel sinking will be at their maximum in the distance interval zero to 15 m from the sunken vessel, whereas the PCB concentrations in the upper water column will be at their maximum in the distance interval zero to 60 m from the sunken vessel.

Note that the maximum predicted levels in matrices above the pycnocline are below the limits of detection using isotope dilution high-resolution gas chromatography/mass spectrometry (USEPA Method 1668A, USEPA, 1999), at a detection limit of 10E-6 micrograms per liter (µg/L) for water. Some concentrations in matrices below the pycnocline (i.e., for internal ship compartment matrices) are at or above the limits of detection.

9.5.2 Preliminary Quantitation of Dermal Exposures

As discussed in Section 6, exposures evaluated for the recreational diver scenario consist of short-term exposures to PCBs in the water column that are released from the sunken vessel within the first 90 days after sinking.

In Section 6.1, various scenarios were identified to represent likely recreational diving activities at the artificial reef site. The top of the vessel will be at least 15 m (50 feet) below the water surface, and the bulk of the vessel, where most of the PCBs reside, will be more than 50 m (165 feet) below the surface. Because of this depth and the limited air supply needed for deep dives, the amount of time a diver could spend in the water will be limited. It was assumed that the ship would be sunk during the warmer summer months, and that the scenario of highest potential exposure to PCBs from the ex-ORISKANY consisted of a limited dive time, approximately 90 minutes per day for two days per month (i.e., about three hours per month or less, depending on depth of dive). Portions of the body covered by the suit, booties, gloves, and mask would be exposed to water originating from the upper water column as the wetsuit filled, and would receive very little, if any, exposure to water originating from the immediate vicinity of the ship. Thus, the only body parts likely to be exposed to the lower water column (assuming that an individual dives that deep) would be portions of the head and possibly the hands.

TDM estimates that the average PCB water concentrations during the zero- to 90-day release

period are in the low picograms per Liter (pg/L) concentration range (3 to 6 x 10^{-14} mg/L in the upper water column and 3 to 4 x 10^{-9} mg/L in the lower water column, depending on distance from the vessel, Table 6-3).

From this information, an estimate of possible absorption of PCBs across the exposed skin and consequent dose to a recreational diver can be determined. Recent USEPA guidance on dermal risk assessment (USEPA, 2004b) has consolidated recommendations in the original dermal guidance documents and in the Exposure Factors Handbook (USEPA, 1997a). The recent guidance provides screening tables and Excel® spreadsheets that can be used to calculate absorbed doses for a number of organic chemicals, including two PCBs: 4-chlorobiphenyl and hexachlorobiphenyl.

The Excel® screening table spreadsheet for organics described in Appendix B of the recent USEPA (2004b) guidance was used to calculate the dermal absorbed dose of the two PCBs, using the predicted dermal permeability coefficients (K_p). The chemical concentration of total PCBs for the lower water compartment at the zero to 15 m interval from the vessel (4 x 10^{-9} mg/L), which was the highest predicted water concentration from the TDM modeling (see Table 6-3), was used for each of the two PCBs to calculate the DAD term.

The mathematical model for quantifying dermal absorption in USEPA (2004b) is a two-compartment distributed model that describes the absorption of chemicals from water through the skin as a function of both the thickness of the stratum corneum and the event duration (t_{event}). The absorption process when the chemical is only in the stratum corneum is non-steady state and is a function of t_{event} once steady state is reached. One fundamental assumption of this model is that absorption continues long after the exposure has ended; i.e., the final absorbed dose (DA_{event}) is estimated to be the total dose dissolved in the skin at the end of the exposure.

For highly lipophilic chemicals or for chemicals that are not highly lipophilic but exhibit a long lag time (τ_{event}), some of the chemical dissolved into skin may be lost due to desquamation during that absorption period. A fraction absorbed (FA) term is included in the evaluation of DA_{event} to account for this loss of chemical due to desquamation. Only chemicals with log K_{ow} > 3.5 or chemicals with t_{event}> 10 hours (at any log K_{ow}) would be affected by this loss. The FA terms for the two PCBs used in the model (4-chlorobiphenyl and hexachlorobiphenyl), each with a log K_{ow} value > 3.5, were 60 and 50 percent, respectively.

The DADs for the two PCBs were calculated using equation 3.1 in Appendix A of USEPA (2004b), and the doses absorbed per event (DA_{event}) were calculated using equation 3.2 in Appendix A of USEPA (2004b) and the USEPA Excel® spreadsheets. The following input

parameters were used:

- Skin surface area (SA) available for contact = 1933 cm^2, average of 50th percentile of male and female values (see Tables 6.2 and 6.3 of USEPA, 1997a).
- Event frequency (EF) = 2 events/30 days (i.e., 2 per month)
- Time event (t_{event}) = 1.5 hours per event (90 minutes maximum dive time per day)
- Exposure frequency (EF) = 90 days per year
- Exposure duration (ED) = 1 year
- Body weight = 70 kg
- Averaging time = 25,550 days (365 days for 70 years).

With the assumption that each PCB was at the highest modeled concentration of 4E-09 mg/L in the lower water compartment (below pycnocline) for the initial 90-day period, the DADs were estimated at 8.5E-14 mg/kg-day and 6.4E-14 mg/kg-day for 4-chlorobiphenyl and hexachlorobiphenyl, respectively. The DA_{event} was calculated using the predicted K_p for the PCBs, which is a key parameter driver in the DA_{event} calculation. USEPA (2004b) points out that the K_{ow} and MW values for these PCBs are outside the "Effective Prediction Domain" (EPD) of the data used to generate K_p values, so the screening model can only be considered a preliminary estimate of the K_p, and hence of the modeled dermal absorption.

9.5.3 Comparison with PCB Exposures from Fish Ingestion

The DADs for the two example PCBs that were modeled for two dives per month under the acute exposure scenario can be compared with the highest dose estimated for exposures to PCBs released from the sunken vessel, which is associated with chronic exposures from daily ingestion of fish caught at the vessel. The dose estimated for consumption of grouper from the ZOI of 2 presents the highest risk in Appendix H from the PRAM modeling of chronic exposures (NEHC/SSC-SD, 2006a). The daily dose from ingestion of grouper by an adult over the course of 30 years, including the six years of ingestion as a child, is estimated at 3E-06 mg of PCB/kg body weight per day (at 0.11 mg/kg fish tissue and the exposure parameters described in Section 6.4). In comparison, the DAD of PCBs from water exposure while diving within zero to 15 meters of the vessel during the initial zero- to 90-day PCB release period is estimated at 1E-13 mg/kg-day (i.e., the sum of the two modeled doses). This comparison shows that the acute dermal exposure is many orders of magnitude below the dose associated with the highest fish consumption exposure.

This screening analysis demonstrates that doses from dermal uptake of PCBs in water during acute exposures would be minimal compared to the doses associated with chronic exposures to PCBs via fish ingestion by anglers. Because of the lack of toxicity criteria for acute exposures to PCBs, similar conclusions about health risks cannot be definitive; however, the large differences in doses between the acute and chronic exposure scenarios (by many orders of magnitude) strongly infer that health risks from dermal absorption of PCBs would similarly be much lower than those associated with chronic exposures from fish ingestion.

9.5.4 Uncertainties in the Dermal Exposure Analysis

Uncertainties associated with the evaluation of doses and potential health risks from dermal exposure to PCBs while diving include:

- Predicted water concentrations. The modeled data are average concentrations for total PCBs and are based on TDM, which has inherent uncertainties (see Section 4 and NEHC/SSC-SD, 2006b).

- Frequency, duration, and exposure area. The duration of diving at the sunken vessel within the first 90 days is estimated to be low, considering the information on depth and standard diving practices as presented in Table 6.1. Although curiosity may drive additional dives above the number assumed in this evaluation, the vessel will not have been sufficiently colonized during the first 90 days after sinking to provide biological resources that are attractive to divers. Moreover, divers would likely move from one ZOI to another, although the evaluation conservatively assumed that they would spend all of their time within zero to 15 m of the vessel, below the pycnocline where PCB concentrations would be the highest.

- Dermal contact with PCB-containing bulk products such as paints on the vessel. Direct contact with PCB-containing solids is not evaluated, primarily because most of the diving exposure is expected to be limited to outside the vessel, due to safety concerns associated with diving at the depth of the vessel interior. In addition, while PCBs are present in paint and other solid materials in the vessel interior, they are not likely to be freely available. Thus, the impact of this pathway is considered insignificant.

- The degree of uptake upon dermal contact with water containing PCBs. The modeling of PCB uptake from water uses parameters such as permeability coefficients that are outside the range of the model are highly uncertain. The model provides dermal absorption parameterization only for two PCBs, which are assumed to represent the total PCBs that are predicted in water by TDM. In addition, for those divers who coat their skin with oily

protectants as thermal insulation or against toxins in biota, the impact of the protectants on dermal uptake of PCBs in water is unknown.

Although there are numerous uncertainties in the above evaluation of the potential for health risks from dermal absorption of PCBs while diving at the ex-ORISKANY reef site, the conservative assumptions in the evaluation are considered to be sufficient to infer a lack of potential health risks from such exposures.

9.6 EFFECTS OF IN UTERO AND PERINATAL EXPOSURES

As mentioned in Section 7, PCBs have been implicated in reproductive and developmental effects to infants from *in utero* exposures. PCBs may also affect infants through breast feeding, and an evaluation of the potential exposures of breast-feeding infants from the proposed ex-ORISKANY artificial reef site is presented in the following Section 9.7. USEPA guidance documents do not provide a procedure for estimating potential risks to the developing fetus that may result from the mother's ingestion of PCB-contaminated fish, nor are toxicity criteria or exposure estimation methods advised.

USEPA (2005d) recently conducted a review of the literature on PCB effects resulting from early life exposures as part of a risk assessment of fish consumption for the Housatonic River, Rest-of-River Superfund Site. The following information is taken primarily from that review, and original citations are provided as cited in USEPA (2005d), and supplemented with information from some more recent reports. It is a summary that is not intended to be a comprehensive review of the topic.

Epidemiological studies of the effects of early life exposures have been conducted over the last 20 years with cohorts of children of mothers who had occupational, accidental, or environmental exposure to PCBs. The following summary focuses on studies where the PCBs are due to environmental exposures, primarily in fish-eating populations. The findings of most of these studies were summarized earlier in a joint report prepared by ATSDR and USEPA (ATSDR/USEPA, 1999) as well as in the Toxicological Profile for PCBs (ATSDR, 2000). The above reviews strongly infer that *in utero* and perinatal exposures to PCBs, including from the consumption of contaminated fish, can result in developmental effects on the fetus and nursing infant. However, the evaluation of nursing infant exposures to PCBs from mother's ingestion of fish caught at the proposed ex-ORISKANY reef site (see the following subsection) suggests that concomitant *in utero* exposures would only be slightly above background exposures.

9.6.1 Neurological Effects

Schantz *et al.* (2003, as cited in USEPA 2005d) reviewed recent studies regarding PCBs as

mediators of neurobehavioral outcomes in children. In these studies, maternal PCB exposures ranged from "background" concentrations of PCBs, to elevated concentrations of PCBs as a result of fish consumption or other food chain exposures, to ingestion of high concentrations of PCBs (and polychlorinated dibenzofuran [PCDFs]) via cooking with PCB-contaminated rice oil. Studies of children living in Holland, Germany, Taiwan, the Faroe Islands, and the United States (Michigan and New York) have reported negative associations between prenatal PCB exposure and measures of cognitive functioning in infancy or childhood (Chen *et al.*, 1992; Jacobson and Jacobson, 1996; Darvill *et al.*, 2000; Patandin *et al.*, 1999; Walkowiak *et al.*, 2001; Winneke *et al.*, 1998; Budtz-Jorgensen *et al.*, 1999; Grandjean *et al.*, 2001; Vreugdenhil *et al.*, 2002a; Stewart *et al.*, 2003a, b; as cited in USEPA 2005d). Only one epidemiologic study, which was conducted in North Carolina, did not report an association between PCB exposure and cognitive function (Gladen and Rogan, 1991, as cited in USEPA 2005d). However, a study that compared the PCB concentrations in serum across these study cohorts (except the Taiwanese) showed that the North Carolina cohort had the lowest PCB serum concentrations (Longnecker *et al.*, 2003, as cited in USEPA 2005d).

Many of the earlier epidemiology studies, published in the 1990s and earlier, showing associations between exposures to PCBs *in utero* and effects on infants or children have been criticized for a variety of reasons. Swanson *et al.* (1995, as cited in Exponent, 2000) identified flaws in most of the Great Lakes and North Carolina studies, including biased subject selection, low or unreported response rates, and poor exposure estimates. Seegal (1999, as cited in Exponent, 2000) suggested that the reported cognitive deficits in children exposed to fish-borne contaminants from the Great Lakes may be due to chemicals other than PCBs, including methylmercury and pesticides.

However, several studies and a USEPA review (USEPA, 2002) published since the ATSDR (2000) summary have examined the relationship between prenatal PCB exposure and child performance on neuropsychological tests of attention and information processing. The results, as summarized below, are consistent with those summarized by the earlier ATSDR (2000) report.

In western Michigan, Jacobson and Jacobson (1996, 2003, as cited in USEPA 2005d) conducted a prospective, longitudinal study of children whose mothers consumed Lake Michigan fish. Prenatal exposures were quantified based on PCB concentrations in umbilical cord serum, maternal serum, and milk. At age 11, the children were tested with a battery of 15 neuropsychological tests. Prenatal PCB exposure was associated with greater impulsivity, poorer concentration, and poorer verbal, pictorial, and auditory working memory. There was no evidence of visual-spatial deficit or increased hyperactivity. Adverse effects were more significant in children who had not been breastfed, which USEPA (2005d) suggests is indicative that breast feeding of an infant can overcome cognitive and motor delays associated with

prenatal PCB exposure.

In a study involving 212 children enrolled in the Oswego Newborn and Infant Development Project, cognitive development in preschool children prenatally exposed to PCBs and methylmercury was examined (Stewart *et al.*, 2003a, as cited in USEPA 2005d). The children in this study were assessed at 38 months of age, followed by reassessment at 54 months of age. Concentrations of the most persistent and highly chlorinated PCB congeners in umbilical cord blood were statistically significant predictors of small but measurable deficits in performance at 38 months of age in the highest exposure group (>0.09 ng/g highly chlorinated PCBs in cord blood). No effects were observed at 54 months of age, leading the authors to suggest that functional recovery may occur (Stewart *et al.*, 2003a).

In the same Oswego cohort, Stewart *et al.* (2003b, as cited in USEPA 2005d) reported the association between prenatal exposure to cord blood PCBs, the corpus callosum, and response inhibition in children who were 4.5 years old. Response inhibition is a behavioral process that is adversely affected by PCBs in animal models and is frequently impaired in children with neurological conditions.

Schantz *et al.* (2003, as cited in USEPA 2005d) concluded that the weight of evidence for PCB effects on neurodevelopment is growing, but that the role of specific congeners or classes of congeners has not been elucidated. Some continuing studies involving congener-specific analyses (Korrick *et al.*, 2000, as cited in USEPA 2005d) might be helpful in defining congener-specific roles in mediating neurotoxic effects.

In an earlier review of epidemiological studies of neurobehavioral effects, Rice (2001, as cited in USEPA 2005d) concluded that the studies show a consistent relationship between PCB exposure and suboptimal neurological status during infancy, and cognitive effects associated with *in utero* exposure. Rice (2001, as cited in USEPA 2005d) further concluded that it was not possible to identify specific congeners associated with these effects, but also that TEQ (from dioxin-like PCBs, poly-chlorinated dibenzo-*p*-dioxin [PCDDs], and PCDFs) was not particularly predictive for neurotoxic outcomes.

One set of investigators studied whether there was an effect of how recently a mother ate fish from Lake Michigan (never, stopped years before pregnancy, stopped when learned pregnant, ate throughout pregnancy) on several measures of infant neurobehavior (Darvill *et al.*, 1997, as summarized in ATSDR/USEPA, 1999). After controlling for a number of variables, there was a significant effect of the recency of Lake Michigan fish consumption on infant behavior measured at 24 months.

Shubat (1990, cited in ATSDR/USEPA, 1999) estimated the PCB intake (assuming exposure only from fish ingestion) for the women in the Lake Michigan fish eater study conducted in the 1980s by Jacobson *et al.* These studies reported an association between maternal exposure to PCBs and certain subtle neurobehavioral effects still present in children 11 years of age. For the women (average weight = 62 kg) who were evaluated, the estimated average daily PCB dosage associated with adverse effects was 0.49 µg PCBs/kg-d. A similar intake value (0.45 µg PCB/kg-d) was associated with neurobehavioral deficits in a subsequent study of children of women consuming Lake Michigan fish (Lonky *et al.*, 1996; calculation in ATSDR/USEPA, 1999). Similar PCB doses are associated with adverse neurobehavioral effects in studies with monkeys (ATSDR/USEPA, 1999).

Schantz and Widholm (2001, as cited in USEPA 2005d) reviewed animal studies regarding neurobehavioral effects and gestational and lactational exposures to dioxin-like PCB congeners and nondioxin-like PCB congeners. Prenatal and combined prenatal and postnatal exposure to dioxin-like PCB congeners appeared to be associated with increased locomotor activity, although this effect was dependent on the species, timing of exposure, and laboratory assessment procedures. Postnatal exposure to dioxin-like PCB congeners resulted in decreased activity levels followed by failure to habituate.

Studies of Dutch children have suggested that the neurotoxicity of prenatal PCB exposure could persist into school age children, possibly resulting in subtle cognitive and motor developmental delays (Vreugdenhil *et al.*, 2002a, as cited in USEPA 2005d).

A study of mental and motor development of Japanese children of mothers of the general population found no significant association between the PCB TEQ levels in mother's blood and mental or motor development of six-month offspring (Nakajima *et al*., 2005). There were significant negative associations with the levels of some isomers of dioxins and mental and motor development. However, PCB concentrations in blood of the mothers were only one-quarter to one-fifth the concentrations in studies where correlations were observed. As a result of the findings of neurobehavioral studies in humans, researchers have begun to investigate the area(s) of the brain and the mechanisms damaged by PCBs. Specifically, USEPA (2005d) reports that animal and cell culture models have been used to examine the effects of PCBs on the cerebellum and hippocampus, including biochemical endpoints (protein kinase C, caspase-3, ryanodine receptor, intracellular calcium levels) in these regions of the brain. These studies have used different PCB congeners and commercial mixtures (Aroclor 1254, non-ortho PCB congeners, or ortho-PCB congeners), thus complicating analysis of the data. However, recent work strongly suggests that apoptosis (cell death) is induced by PCBs in neuronal cells, and specifically that ortho-substituted congeners, but not coplanar PCBs, kill neurons. In a recent study using a model of human neural cells, researchers report that specific PCB congeners can

mimic triiodothyronine action on neural cell differentiation, providing support for PCB interference with hormone-modulated cell differentiation in neural tissue (Fritsche *et al*., 2005).

9.6.2 Immunotoxicity

Longnecker (2001, as cited in USEPA 2005d) reviewed immune system effects of PCBs and concluded that effects on T cells might be related with AhR binding because T cell levels were associated with prenatal TEQ exposure concentrations. However, no conclusions were drawn regarding clinical implications of this immune system effect.

Prenatal exposure to PCBs and dioxins is associated with changes in the T-cell lymphocyte population in young children (Weisglas-Kuperus *et al.*, 1995, as cited in USEPA 2005d). Weisglas-Kuperus *et al.* (2000, as cited in USEPA 2005d) studied whether such changes persist into later childhood for children with background PCB and dioxin exposures and whether these exposures are associated with the prevalence of infectious or allergic diseases and changes in immune response. The authors concluded that perinatal background exposure to PCBs and dioxins might be associated with a greater susceptibility to infectious diseases. This conclusion is reinforced by a more recent report (Weisglas-Kuperus *et al.*, 2003), in which a higher postnatal PCB exposure (through breast milk) was associated with a higher prevalence of recurrent middle ear infections and a higher prenatal PCB exposure was associated with shortness of breath with wheeze.

9.6.3 Endocrine Effects

Multiple animal studies have shown that exposure to PCBs *in utero* and/or during early development can deplete levels of circulating thyroid hormones in the fetus or neonate, which may give rise to a hypothyroid state during development. Because thyroid hormones are now recognized as important to the normal development of the brain, any PCB-associated disruption of thyroid hormone status may become manifest as adverse neurodevelopmental/neurobehavioral effects (ATSDR, 2000). It has also been suggested that interference with endocrine systems, particularly the thyroid, could be one possible explanation for PCB-induced psychomotor delay observed in several cohort studies (Winneke *et al.* 2002). The suggestion is supported with the finding that PCB congeners in isolated cell systems can mimic triiodothyronine action on neural cell differentiation (Fritsche *et al*., 2005).

Recent epidemiological studies investigating the impacts of PCB exposures on the thyroid system have found decreased thyroxine and thyroid stimulating hormone (TSH) associated with non-ortho PCBs in the placentas of pregnant women in the general population of Taiwan (Wang *et al.*, 2005). The authors suggest that alterations in thyroxine and TSH feedback to the

hypothalamus can result from *in utero* exposure to PCBs. Another recent study, of the general population of Quebec, Canada, with lower exposures to organochlorine compounds than reported in previous studies, found a negative correlation between maternal total triiodothyronine levels and three non-coplanar congeners (PCB-138, PCB-153, and PCB-180) measured in cord blood, without any other changes in thyroid status (Takser *et al*., 2005). The study provides further evidence that at low levels of exposure, persistent environmental contaminants can interfere with thyroid status during pregnancy.

Lamb *et al.* (2005) recently examined prenatal exposure to specific PCB congeners and effects on offspring growth over a 17 year period. Study subjects were part of the ongoing National Collaborative Perinatal Project. Maternal blood levels of ortho-substituted PCBs were associated with reduced weight through age 17 among girls, but not boys. Tri-ortho-substituted PCBs were marginally associated with increased height in boys. Although limited by sample size (150 children), the results suggest that prenatal exposure to PCBs may impact growth, especially in girls, and that ortho-substitution is an important determinant of its affect on growth.

Prenatal exposure to PCBs, dioxins, and other organochlorine compounds could result in steroid hormone imbalances (Vreugdenhil *et al.*, 2002b, as cited in USEPA 2005d). These hormones are involved in development of the central nervous system, influencing reproductive and non-reproductive behaviors that show sex differences. Vreudgenhil *et al.* (2002b) reported an association between prenatal exposure to PCBs and dioxins and play behavior in young children. Specifically, prenatal PCB exposure was related to less masculinized play in boys and more masculinized play in girls, and prenatal dioxin exposure was related to more feminized behavior in boys and girls. These apparent hormone imbalances were not associated with postnatal PCB and dioxin exposure from breastfeeding.

9.7 BREAST MILK PATHWAY (NURSING INFANT EXPOSURE)

In Section 8 of this document, adult and child risks are quantified for exposures to PCBs through the ingestion of fish caught at the ex-ORISKANY artificial reef site. However, risks to nursing infants that may result from exposures to PCBs in breast milk from the mother's consumption of fish from the site were not quantified. Potential adverse developmental, immunological, and neurological effects to the nursing infant may be associated with exposure to PCBs in breast milk, as suggested from epidemiology studies on perinatal exposures described in the previous subsection. However, USEPA (2003b) points out in their reassessment of dioxin risks that the potential risks from exposure to PCBs in breast milk should be balanced against the benefits of breastfeeding, which has been associated with higher cognitive ability and positive outcomes in infants.

Because of the high uncertainty in using chronic toxicity criteria to quantify risks to nursing infants exposed to PCBs in breast milk over a relatively short duration, USEPA (2005c) recommends that the evaluation of the breast milk pathway consist of estimating the exposures of nursing infants to PCBs in breast milk and comparing those exposures with exposures to PCBs in breast milk in the general population. The approach and specific methodology for evaluating PCB exposures of infants is described in USEPA (2005c), and is consistent with the exposure analysis described by CalEPA (2003). Much of the following discussion on PCBs in breast milk and effects on nursing infants comes from a recent risk assessment of a PCB-contaminated river site sponsored by USEPA (2005d).

9.7.1 General Approach and Methodology

USEPA (2005c) recommends that the breast milk exposure pathway be evaluated by comparing predicted breast milk PCB concentrations due to exposures to the site with those measured in breast milk from the general population. A child's body burden of PCBs can largely be the result of exposures to PCBs in mother's breast milk during nursing as an infant (Patandin *et al.,* 1999b). Concentrations of PCBs in a mother's body and in breast milk decline during the course of breast feeding, which could indicate transfer of PCBs to the nursing infant.

Levels of PCBs in breast milk are determined by the long-term consumption of PCBs by the mother rather than by dietary intake of PCBs during pregnancy and lactation (Huisman *et al.,* 1995; Pluim *et al.,* 1994). This is due to the slow elimination from the human body, measured in years, which results in the accumulation of PCBs in a mother's body over time. Thus, the transfer of PCBs to breast milk reflects past intakes by the mother over many years. PCB concentrations in breast milk reflect the maternal body burden, and depend on many factors, including the following: maternal exposure levels, maternal age (which is an indicator of exposure duration), number of children who have been breast fed, duration of breast feeding, and length of time between children, as summarized in USEPA (2005d). PCBs accumulate in lipids of breast milk, which is approximately three percent to five percent lipid in humans (USEPA 2005d).

The methodology and parameters for predicting concentrations of PCBs in human breast milk from exposures of mothers to PCBs in fish from the artificial reef site are described in the following subsection, and are based on the fish tissue concentrations of PCBs predicted by PRAM. PCB data from studies of human breast milk from populations most likely to be similar to fish consumers are summarized in the subsequent subsection. The predicted PCB concentrations in breast milk of mothers consuming fish from the ex-ORISKANY reef site are then compared with background concentrations of PCBs in human breast milk. There is considerable variability and uncertainty associated with the prediction of PCB concentrations in

breast milk and the selection of background concentrations with which to compare them. These uncertainties are also discussed.

9.7.2 Calculating PCB Concentrations in Human Breast Milk

USEPA provides guidance for estimating concentrations of dioxins and dioxin-like PCBs in breast milk in the *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Final* (USEPA, 2005c). The methodology was updated from earlier guidance documents (USEPA 1994, 1998a), and is consistent with the method recommended by CalEPA (2003). The methodology in these guidance documents was applied to the evaluation of total PCBs in the site-specific risk assessment sponsored by USEPA (2005d), with modification of the concentration units and conversion factors from the application to dioxins to facilitate the evaluation of PCB concentration data in breast milk.

The general equation in USEPA (2005c) for estimating PCB concentrations in breast milk fat is:

$$C_{milkfat} = \frac{ADD * h * f_1}{0.693 * f_2} \qquad (15)$$

where:

Variable	Description	Units	Value
$C_{milk\ fat}$	Concentration of PCBs in milk fat	mg PCB/kg milk fat	Calculated
ADD	Average maternal intake of PCBs for adult scenario	mg PCB/kg body weight-day	Equation 16
h	Half-life of PCBs in adults	Days	2,190 This value is equal to a half-life of six years as estimated by USEPA (2005c). CalEPA (2003) assumes a half-life of four years for PCBs.
f_1	Fraction of ingested PCBs that is stored in fat	Unitless	0.9 (USEPA 2005c)
f_2	Fraction of mother's weight that is fat	kg fat/kg body weight	0.3 (USEPA 2005c)
0.693	Natural log of 2		

The average daily dose (ADD) to determine maternal intake of PCBs is based on the exposures estimated for the adult consumption of fish, and further described in the following subsection. The values for f_1 and f_2 were suggested in earlier USEPA guidance documents (USEPA, 1994, 1998a, 1998b). The inclusion of a half-life (*h*) term for total PCBs in adult tissue was selected for PCB congeners in USEPA (2005d), and is described in a subsequent subsection below.

9.7.2.1Maternal Intake of PCBs

The maternal intake of total PCBs (i.e., the ADD term) is used in Equation 15 above to estimate the breast milk concentration as a result of ingestion of fish from the ex-ORISKANY artificial reef site. The equation for calculating average daily maternal intake of PCBs from fish consumption is the same as the equation used to estimate adult intake of PCBs from fish consumption for noncancer hazards in Section 6:

$$ADD_a = \frac{(C_f * IRa * FI * EF * ED_a)}{(BW_a * AT)} \qquad (16)$$

where:

Variable	Description	Units	Value	
			RME	CTE
ADDa	Average daily dose for an adult	mg/kg-day	Calculated	
C_f	Chemical concentration in fish tissue	mg/kg wet weight	0.10 (Grouper, Table 6-3)	
IR_a	Fish ingestion rate for adults	kg/day	0.0261 (RME, Table 6-4)	0.007 (CTE, Table 6-4)
FI	Fraction of fish ingested	Unitless	0.17 (RME, Table 6-4)	0.2500 (CTE, Table 6-4)
EF	Exposure frequency	days/year	365	365
ED_a	Exposure duration for adults	years	30 (RME, Table 6-4)	3 (CTE, Table 6-2)
BW_a	Body weight of an adult	kg	70	70
AT	Averaging time	days	10,950	1,095

The maternal intake (ADD) calculations are performed for both the RME and CTE scenarios, as described in Section 6.3. The concentration term (C_f) is the output from PRAM for the steady-state conditions at the reef within the ZOI of 2 (Table 6-3); exposures are calculated for the consumption of each of the marine organisms that are modeled in PRAM. Use of the concentration term for any one fish species assumes that the female adult consumes only that species from the reef site at the ingestion rate assumed for fish consumption. The ingestion rate (IR) and fraction ingested (FI) terms are from the adult exposure scenarios in Table 6-4. As described in Section 6, the IR term is taken from USEPA guidance on total fish consumption for the Gulf coast, and the FI term is derived from a regional fish consumption survey.

The nursing infant exposure analysis described in USEPA (2005d) includes a cooking loss term that accounts for the loss of PCBs from fat in the fish during cooking. The cooking loss term lowers the concentration of PCBs in consumable fish tissue by 25 percent, based on a review of numerous studies. However, to remain consistent with the procedures used in Sections 6 and 8 to estimate exposures and health risks to the adult consumers of fish, the cooking loss term is omitted from the calculation of PCB intake.

The calculated concentrations of PCBs in breast milk associated with fish consumption from the artificial reef are presented below following the determination of background concentrations of PCBs in breast milk.

9.7.2.2 Half-Life of PCBs in Tissue

Because the determination of PCB levels in breast milk is based on accumulated body burden following chronic intake from fish ingestion, a term to estimate the loss or turnover of PCBs in the body is included in the calculations of breast milk levels. USEPA (2005d) selected a half-life of six years for PCBs in human adult tissue based on a review of the scientific literature. Data on the half lives of PCB mixtures and congeners were critically reviewed by ATSDR (2000) in its Toxicological Profile for PCBs. Because many of the studies were found to have serious limitations, such as inadequate analytical methodology (e.g., co-elution of congeners, high limits of detection), short times between sampling, and congener concentrations reflecting steady-state conditions in which a loss could not be measured, USEPA (2005d) compiled a subset of the available data on PCB half lives based on serum concentrations in humans and primates. The subset of data was selected to account for the higher percent of body fat in women and to provide better estimates of elimination rate.

The compiled data showed that, even for a single congener, a wide range of half-life values have been reported. This range likely reflects uncertainty due to possible continued exposure to PCBs in the study population and non-equilibrium distribution of PCBs in tissues, in addition to the variability associated with differences in physiology, metabolism, and excretion. Based on the range of serum half-lives, USEPA (2005d) selected a central tendency half-life of 6 years to calculate the concentrations of PCB congeners in breast milk, which is used in Equation 15 above. Note that the half-life of four years for PCBs recommended by CalEPA (2003) would reflect more rapid loss of PCBs from adult tissue, and consequently result in lower calculated concentrations in breast milk than using the value of six years.

The use of a half-life in the calculation is based on an assumption that a steady state has been achieved for PCB concentrations in the mother's tissue. This assumption requires that the ED of the mother be longer than the half-life of PCBs, or the model will overestimate breast milk

concentrations. This condition is met using the ED of 30 years of fish consumption and six years for the half-life of PCBs in the body. In addition, the model assumes that more than six years of the exposure must occur prior to breast feeding.

9.7.3 Breast Milk Concentrations Measured in the General Population

As indicated above, evaluation of the breast milk pathway consists of a comparison of calculated concentrations of PCBs in breast milk associated with consumption of fish from the artificial reef with background concentrations for the general population. USEPA (2005d) summarized the data on PCBs in breast milk from 16 study populations to arrive at a general population background level. The summarized data support a decreasing trend in PCB concentrations in breast milk and in human serum from the early 1980s through the late 1990s.

USEPA (2005c, 2005d) focuses on background concentrations of PCB congeners in breast milk of the general population rather than total PCBs, since the procedure for evaluating the breast milk pathway is based on PCB congeners. Hence, USEPA has not recommended a background concentration for total PCBs in breast milk. However, a background concentration of total PCBs in human breast milk can be derived from the study results summarized in USEPA (2005d). Four of the 16 studies summarized in USEPA (2005d) report data for total PCBs in breast milk in addition to PCB congeners. The results of the four studies are very similar, and are summarized in the following paragraphs. The average PCB concentration in human breast milk from the four studies is 0.32 mg/kg lipid. Although the concentrations of different individual PCB congeners vary within a single study and across studies, the total PCBs reported by each of the four studies are very similar.

Korrick and Altschul (1998) surveyed intrauterine PCB exposure in infants from the New Bedford area. The New Bedford Harbor and estuary were highly contaminated with PCBs by effluents from a local electronics industry. Fishing was banned in the harbor and estuary in 1979. Breast milk was collected from 122 area residents from 1993 to 1997 at approximately two weeks postpartum and analyzed for PCB congeners. The mean concentration of total PCBs of all participants was 0.32 mg/kg lipid. Total PCBs were reported as the sum of 49 congeners.

Greizerstein *et al.* (1999) obtained blood and breast milk samples from seven women participating in the New York State Angler Study. PCB congeners were analyzed using high resolution GC/ECD. Total PCBs were calculated as the sum of the congeners measured above their detection limits. The results were reported for each woman, along with details such as the number of fish meals consumed per year, whether or not it was her first child, the time postpartum that the sample was obtained, and the body mass index. Three of the women were nursing their first baby, and the samples were collected two months postpartum. These three

women were also low fish consumers and did not report occupational exposure to PCBs. Samples from these three women were considered to represent background, with the average total PCB concentration at 0.27 mg/kg lipid.

During two studies in 1992 and 1997, Noren and Meironyte (2000) obtained breast milk samples from healthy native Swedish mothers living in the Stockholm area within the first three months of delivery. Between 55 and 75 percent of the women were nursing their first infant. Samples from 20 women were pooled in 1992 and samples from 40 women were pooled in 1997. Average total PCBs in the 1992 study were 0.38 mg/kg lipid, and from the 1997 study were 0.32 mg/kg lipid.

Because the resultant average total PCB concentrations that were reported in the four studies were so similar, no attempt was made to determine whether a specific study design or population would be more appropriate than any other for determining the general population background concentration of PCBs in breast milk. The average and standard deviation of the four studies results in a general population background concentration of 0.32 ± 0.04 mg/kg lipid.

9.7.4 Comparison of Predicted Breast Milk Concentrations with Anticipated Background Concentrations

Tables 9-1 and 9-2 summarize the calculations of predicted incremental, or additional, concentrations of PCBs in human breast milk due to maternal exposures to fish from the ex-ORISKANY reef site. The predicted concentrations are compared to background concentrations of PCBs as an average of values from four studies presented in USEPA (2005d). Results are presented for the RME exposures in Table 9-1 and the CTE exposures in Table 9-2. These two tables list the EPC in fish tissue that is used in the calculation, the predicted PCB concentrations in milk fat, the average background concentration, and the ratio of the predicted incremental concentration in breast milk with anticipated background.

The analysis indicates that both high-end and central tendency patterns of fish consumption from the ex-ORISKANY artificial reef site are not expected to result in concentrations of PCBs in breast milk greater than general background levels. The highest predicted concentration of PCBs in breast milk (associated with the consumption of grouper under the RME scenario) is less than 20 percent of the average general background concentration in breast milk. This scenario assumes that the mother consumes only grouper from the site for 30 years, at the reasonably conservative ingestion rate and frequency of the RME scenario.

The prediction of PCB concentrations in breast milk from consumption of fish was based on tissue concentrations in grouper that reside within 15 m of the sunken vessel (i.e., within ZOI =

2). The predicted concentrations of PCBs are lower in other fish species, particularly lower trophic species such as jack. They do not change substantially in fish modeled for exposures in different ZOIs, since higher trophic level fish tissue concentrations are not driven by distance from the vessel. The consumption of lower trophic fish, with lower tissue concentrations of PCBs, would result in proportionately lower predicted concentrations of PCBs in breast milk.

Several other uncertainties are associated with modeling exposures to PCBs in breast milk. The uncertainties associated with the ADD parameters are discussed in detail in other parts of Section 9. The half-life of elimination of PCBs from the body selected for the calculation was a central tendency estimate of six years. The data for individual congeners as summarized by USEPA (2005d) ranged from one year to infinity. The use of a half-life of 12 years would have doubled the predicted PCB concentrations in breast milk. However, because the model assumes that a steady-state concentration of PCBs has been achieved, the full doubling might not be observed if women consumed fish for less than 10 to 20 years prior to nursing. Use of a shorter half-life, such as recommended by CalEPA (2003), would have decreased the predicted breast milk concentrations (e.g., the use of a four-year half-life would have lowered the predicted breast milk concentrations to two-thirds of predicted levels). The half-life that was selected for PCBs in the mother is therefore considered to be sufficiently conservative.

The background concentrations in breast milk that provide the point of comparison were based on samples collected in New Bedford, MA, in 1993-1997; New York in 1991-1993; and in Stockholm, Sweden, in 1992 and 1997. PCB background concentrations in breast milk have been decreasing, and USEPA (2005d) reports that the data from Kalantzi *et al.* (2004) suggest that the concentrations in 2003 in the United Kingdom may be half what they were in 1993. This trend is also likely to be the case in the United States, based on reported reductions of PCBs in serum, which, like breast milk concentrations, reflects whole body burdens. Correcting for a trend of decreasing PCB concentrations in breast milk since the time of the four background studies would have led to larger predicted increases in PCB in breast milk due to consumption of contaminated fish.

10. CONCLUSIONS

The primary focus of this assessment was to assess the potential for future risks to human health from exposure to PCBs that may be released from the ex-ORISKANY if it were used to create an artificial reef at the Escambia East LAARS. PCBs contained on ships are regulated as PCB Bulk Product Waste under 40 CFR §761.62(c), and a risk-based disposal permit from USEPA is required prior to sinking. Thus, PCBs are the sole focus of the risk-based disposal approval and this risk assessment.

The risk assessment quantitatively estimated health risks based on the residual PCB levels in solid materials contained on board the ex-ORISKANY and was conducted in a series of steps. First, the TDM and PRAM applied the empirical leach rate data to simulate environmental conditions at the reef site for a two-year period from the time of sinking until the reef is fully developed (zero to two years, using TDM) and near steady-state conditions (at two years after sinking and later, using PRAM). Second, the outputs from these models are incorporated into the food chain bioaccumulation model in PRAM and collectively provide EPCs for the assessment of human exposure to PCBs. Third, the exposure assessment determined that recreational anglers are considered to be the population with the greatest potential for exposure. The potentially complete exposure pathways include the consumption of finfish and caught at the reef site by recreational anglers and divers, and exposures of divers to water at the sunken vessel. Because it is likely that the fish caught at the reef could be brought home and eaten by children (i.e., a more sensitive population than the general adult population), the risk associated with a child's ingestion of reef fish was also evaluated. Fourth, the toxicity assessment identified the appropriate cancer and noncancer toxicity values for subchronic and chronic exposure conditions. Finally, toxicity values are combined with ADDs of PCBs from fish consumption to calculate cancer risks and noncancer hazards as part of the risk characterization.

Cancer risks were compared to the USEPA cancer risk range identified in the NCP (USEPA, 1990) of approximately one in 1,000,000 (expressed as 1E-06, equivalent to 1×10^{-6}) to one in 10,000 (expressed as 1E-04, equivalent to 1×10^{-4}) over a 70-year lifetime. Hazard quotients were compared to USEPA's benchmark of 1.

Results of this quantitative risk evaluation indicate that the highest cancer risks and noncancer hazard quotients were associated with the consumption of grouper, which represents trophic level IV fish, followed by triggerfish, which represents trophic level III fish. However, none of the predicted RME and CTE cancer risks and noncancer hazard quotients for adults and children under subchronic or chronic exposure conditions exceeded USEPA's acceptable risk range for carcinogens or noncancer benchmark. Specifically, the highest adult RME cancer risks under subchronic and chronic exposure conditions is 4E-07 and 7E-06, respectively, for consumption

of trophic level IV reef fish. The highest noncancer HQs for a child under subchronic and chronic exposure conditions are 0.1 and 0.6, respectively, also for consumption of trophic level IV reef fish.

These results indicate that the cancer risks and HQs calculated for the recreational angler adult and child ingestion of all reef fish species are considered acceptable relative to USEPA criteria during the first two years post sinking and at steady-state conditions (two years after sinking). Results of this risk assessment suggest that there are no significant risks associated with the ingestion of fish contaminated with PCBs as a result of the sinking and use of the ex-ORISKANY as an artificial reef at Escambia East LAARS. In addition, potential exposures to divers from dermal contact with water around the reef were found to be extremely low, and the evaluation of nursing infant exposures to PCBs from the mother's ingestion of fish caught at the proposed ex-ORISKANY reef site suggests that concomitant *in utero* exposures will not be greater than general background exposures.

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Table 4-1

Summary of Analysis of PCB Release Rate (Leach Rate) Data for Materials Found Onboard Ex-US Navy Vessels (Adapted from R. George, *et. al.* , 2006)

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

Table 4-1

Summary of Analysis of PCB Release Rate (Leach Rate) Data for Materials Found Onboard Ex-US Navy Vessels (Adapted from R. George, *et. al.* , 2006)

Bulkhead Insulation										
PCB = 0.044%										
Maximum Rate	0	8209	8259	158137	286990	53159	34568	0	0	0
Median Rate	0	0.0	2091	53427	95598	17305	0	0	0	0
Maximum Occurs -	---	14-days	7-days	21-days	21-days	69-days	1-day	---	---	---
No. Detections	0	8	16	16	16	15	6	0	0	0
No. Non-detections	17	9	1	1	1	2	11	17	17	17
Regression Analysis										
ln(Intercept)	---	1.16E+01	1.00E+01	1.38E+01	1.46E+01	1.45E+01	9.97E+00	---	---	---
Slope	---	-1.51E+00	-4.85E-01	-5.89E-01	-6.21E-01	-8.69E-01	-4.24E-01	---	---	---
alpha	---	8.18E-04	4.14E-07	2.63E-05	6.54E-04	1.37E-03	2.43E-02	---	---	---
r2	---	0.8646	0.8593	0.8117	0.6672	0.6976	0.7568	---	---	---
rate at 2-years	---	5.36	944	20704	37917	6762	1303	---	---	---
Rate used for the PRAM	0	5.36	944	20704	37917	6762	1303	0	0	0

Rubber Material (also used for ventilation gaskets)*										
PCB = 0.16%										
Maximum Rate	184	1267	239	922	638	0	167503	0	0	0
Median Rate	57.1	43.5	82.9	284	248	0	0	0	0	0
Maximum Occurs -	7-days	14-days	14-days	14-days	69-days	---	<1 day	---	---	---
No. Detections	12	14	14	14	14	0	4	0	0	0
No. Non-detections	4	2	2	2	2	16	12	16	16	16
Regression Analysis										
ln(Intercept)	5.81E+00	7.09E+00	5.99E+00	8.50E+00	1.07E+01	---	7.40E+00	---	---	---
Slope	-3.17E-01	-6.55E-01	-2.97E-01	-5.36E-01	-9.95E-01	---	-8.78E-01	---	---	---
alpha	2.88E-08	7.83E-02	4.98E-02	2.22E-05	4.47E-03	---	7.51E-03	---	---	---
r2	0.9591	0.2552	0.3063	0.8007	0.6567	---	0.9850	---	---	---
rate at 2-years	41.4	NS	56.6	144	63.1	---	5.04	---	---	---
Rate used for the PRAM	41.4	1267	56.6	144	63.1	0	5.04	0	0	0

*Note: Rubber material includes materials found onboard all Navy vessels. Only black rubber is found on the ex-ORISKANY

where:

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

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

Table 4-2

Predicted Average Total PCB Concentrations in Abiotic Media During the Period 0 to 90 Days After Sinking (from TDM)

Time Period = 0 to 90 days after sinking

Distance from Sunken Vessel	0 to 15 meters	0 to 45 meters	0 to 60 meters
UWC water concentration (mg/L)	3.24E-14	5.30E-14	6.08E-14
UWC Suspended solids concentration (mg/kg)	5.59E-10	9.15E-10	1.05E-09
UWC Dissolved organic carbon (mg/kg)	3.73E-09	6.10E-09	7.01E-09
LWC water concentration (mg/L)	3.69E-09	3.18E-09	2.99E-09
LWC Suspended solids concentration (mg/kg)	6.39E-05	5.51E-05	5.17E-05
LWC Dissolved organic carbon (mg/kg)	4.26E-04	3.67E-04	3.45E-04
Sediment concentration (mg/kg)	4.46E-06	3.84E-06	3.61E-06
IVW concentration (mg/L)	2.87E-06	NA	NA
IVW Suspended solids concentration (mg/kg)	4.97E-02	NA	NA
IVW Dissolved organic carbon (mg/kg)	3.31E-01	NA	NA

where: UWC = Upper Water Column; LWC = Lower Water Column; IVW = Interior Vessel Water

Table 4-3

Predicted Average Total PCB Concentrations in Abiotic Media During the Period 91 to 730 Days (2 years) After Sinking (from TDM)

Time Period = 91 to 730 days after sinking

Distance from Sunken Vessel	0 to 15 meters	0 to 45 meters	0 to 60 meters
UWC water concentration (mg/L)	1.24E-14	2.02E-14	2.32E-14
UWC Suspended solids concentration (mg/kg)	2.49E-10	4.07E-10	4.68E-10
UWC Dissolved organic carbon (mg/kg)	1.66E-09	2.72E-09	3.12E-09
LWC water concentration (mg/L)	1.38E-09	1.19E-09	1.12E-09
LWC Suspended solids concentration (mg/kg)	2.75E-05	2.37E-05	2.22E-05
LWC Dissolved organic carbon (mg/kg)	1.83E-04	1.58E-04	1.48E-04
Sediment concentration (mg/kg)	3.94E-06	3.40E-06	3.19E-06
IVW concentration (mg/L)	1.08E-06	NA	NA
IVW Suspended solids concentration (mg/kg)	2.14E-02	NA	NA
IVW Dissolved organic carbon (mg/kg)	1.42E-01	NA	NA

where: UWC = Upper Water Column; LWC = Lower Water Column; IVW = Interior Vessel Water

Table 4-4

Predicted Time-Weighted Average Total PCB Concentrations in Biota During the Initial Two-Year Period (from TDM)

Biotic Compartment		0-15 meters	0-45 meters	0-60 meters
			(mg/kg-ww)	
Pelagic Community				
Phytoplankton (TL1)	algae	2.45E-11	4.01E-11	4.60E-11
Zooplankton (TL-II)	copepods	2.87E-05	2.47E-05	2.32E-05
Planktivore (TL-III)	herring	0.00016	0.00013	0.00013
Piscivore (TL-IV)	jack	0.00023	0.00020	0.00019
Reef / Vessel Community				
Attached Algae	algae	2.75E-06	2.37E-06	2.23E-06
Sessile filter feeder (TL-II)	bivalves (w/o shell)	5.96E-05	5.14E-05	4.82E-05
Invertebrate Omnivore (TL-II)	urchin	0.014	0.014	0.014
Invertebrate Forager (TL-III)	crab	0.025	0.025	0.025
Vertebrate Forager (TL-III)	triggerfish	0.036	0.036	0.035
Predator (TL-IV)	grouper	0.046	0.045	0.045
Benthic Community				
Infaunal invert. (TL-II)	polychaete	2.11E-05	1.82E-05	1.70E-05
Epifaunal invert. (TL-II)	nematode	6.00E-05	5.17E-05	4.86E-05
Forager (TL-III)	lobster	0.00015	0.00013	0.00012
Predator (TL-IV)	flounder	0.00053	0.00045	0.00043

Values are weighted averages for all time intervals from 1 day to 2 years.

Table 4-5

Results of Abiotic Modeling from PRAM for ZOI = 2

Air	**Mono**	**Di**	**Tri**	**Tetra**	**Penta**	**Hexa**	**Hepta**	**Octa**	**Nona**	**Deca**	**Total PCB**
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	5.85E-16
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	6.68E-17
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	2.98E-13
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	1.02E-12
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	1.33E-08
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	1.78E-07
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	4.45E-09
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	4.39E-09
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	1.08E-04
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	9.88E-04
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	1.83E-06
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	1.80E-06
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	4.44E-02
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	4.06E-01
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	4.45E-09
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	4.39E-09
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	7.19E-06

Table 4-6

Results of Abiotic Modeling from PRAM for ZOI = 5

Air	**Mono**	**Di**	**Tri**	**Tetra**	**Penta**	**Hexa**	**Hepta**	**Octa**	**Nona**	**Deca**	**Total PCB**
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	8.47E-16
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	9.68E-17
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	2.73E-13
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	9.32E-13
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	1.22E-08
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	1.63E-07
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	2.59E-09
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	2.55E-09
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	6.27E-05
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	5.74E-04
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	1.83E-06
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	1.80E-06
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	4.44E-02
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	4.06E-01
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	2.59E-09
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	2.55E-09
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	4.18E-06

Table 5-1
Food Web Structure and Representative Species

Community	Characteristic Organisms	Representative Species
Pelagic Community	Open water organisms that obtain the majority of their food in open water	
Phytoplankton (TL-I)	Free-floating algae	Algae
Zooplankton (TL-II)	Small organisms that graze on free-floating algae	Copepods
Planktivore (TL-III)	Organisms (mostly fish) that prey primarily on zooplankton	Herring
Piscivore (TL-IV)	Organisms (mostly fish) that prey upon fish	Jack
Reef / Vessel Community	Reef-associated organisms that obtain the majority of their food from the reef	
Attached algae (TL-I)	Attached algae	Algae
Sessile filter feeder (TL-II)	Non-moving organisms attached to the sunken vessel that filter small organisms and suspended particles from the water column	Bivalves (w/o shell)
Grazing / foraging omnivore (TL-II)	Mobile invertebrates that feed on attached algae and other invertebrates	Urchin
Invertebrate forager (TL-III)	Mobile (walking/crawling) invertebrates that prey upon planktivores, filter feeders, and attached algae	Crab
Vertebrate forager (TL-III)	Fish that prey predominantly on the reef epifaunal organisms such as the filter feeders and invertebrate foragers	Triggerfish
Predator (TL-IV)	Organisms that prey upon fish and invertebrates associated with the reef	Grouper
Benthic Community	Sediment-associated organisms that obtain most of their food from the benthic environment	
Infaunal invertebrate (TL-II)	Macroinvertebrates (i.e., larger than 0.5 mm) that live and feed within the sediment bed	Polychaete
Epifaunal invertebrate (TL-II)	Certain amphipods, echinoderms	Nematode
Forager (TL-III)	Crustaceans such as crabs and lobsters	Lobster
Predator (TL-IV)	Flounder, flatfish, skates, rays, sea basses	Flounder

TL = Trophic level

Table 5-2
Predicted Biota Concentrations from PRAM for ZOI = 2

ZOI = 2		Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total PCBs
Pelagic Community												
Phytoplankton (TL1)	algae	1.5E-14	4.0E-10	3.2E-11	5.2E-10	6.8E-10	2.7E-11	1.1E-11	0.0E+00	5.0E-15	1.8E-17	1.7E-09
Zooplankton (TL-II)	copepods	3.8E-10	1.4E-05	1.4E-06	2.7E-05	2.7E-05	3.9E-06	3.4E-06	0.0E+00	1.7E-08	2.5E-09	7.7E-05
Planktivore (TL-III)	herring	1.2E-10	1.6E-05	2.9E-06	1.1E-04	1.9E-04	3.0E-05	2.6E-05	0.0E+00	8.6E-08	4.5E-09	3.7E-04
Piscivore (TL-IV)	jack	3.0E-11	2.8E-06	7.8E-07	6.3E-05	3.4E-04	9.0E-05	8.8E-05	0.0E+00	2.6E-07	5.6E-09	5.8E-04
Reef / Vessel Community												
Attached Algae	algae	5.3E-11	1.4E-06	1.2E-07	2.0E-06	3.2E-06	3.1E-07	1.9E-07	0.0E+00	4.4E-10	2.0E-11	7.2E-06
Sessile filter feeder (TL-II)	bivalves	9.3E-10	3.1E-05	3.1E-06	5.8E-05	5.7E-05	5.0E-06	3.6E-06	0.0E+00	1.2E-08	1.3E-09	1.6E-04
Invertebrate Omnivore (TL-II)	urchin	1.5E-08	1.2E-03	1.7E-04	5.6E-03	9.0E-03	6.4E-04	3.4E-04	0.0E+00	2.3E-07	3.2E-09	1.7E-02
Invertebrate Forager (TL-III)	crab	5.2E-08	2.1E-03	3.2E-04	1.1E-02	2.1E-02	1.6E-03	9.0E-04	0.0E+00	9.9E-07	6.5E-08	3.6E-02
Vertebrate Forager (TL-III)	triggerfish	1.4E-08	9.9E-04	2.1E-04	1.3E-02	4.5E-02	4.5E-03	2.6E-03	0.0E+00	3.0E-06	9.7E-08	6.5E-02
Predator (TL-IV)	grouper	7.8E-09	5.1E-04	1.2E-04	1.1E-02	8.1E-02	1.2E-02	8.0E-03	0.0E+00	8.6E-06	1.9E-07	1.1E-01
Benthic Community												
Infaunal invert. (TL-II)	polychaete	2.5E-10	9.9E-06	1.0E-06	2.0E-05	2.0E-05	1.9E-06	1.4E-06	0.0E+00	3.8E-09	2.7E-10	5.5E-05
Epifaunal invert. (TL-II)	nematode	3.5E-10	2.1E-05	2.5E-06	5.6E-05	6.1E-05	5.9E-06	4.3E-06	0.0E+00	1.1E-08	6.0E-10	1.5E-04
Forager (TL-III)	lobster	4.5E-10	2.5E-05	3.8E-06	1.2E-04	1.7E-04	1.6E-05	1.1E-05	0.0E+00	1.8E-08	4.0E-10	3.4E-04
Predator (TL-IV)	flounder	9.3E-11	1.5E-05	4.1E-06	2.5E-04	7.6E-04	9.1E-05	6.4E-05	0.0E+00	8.3E-08	1.2E-09	1.2E-03

Table 5-3
Predicted Biota Concentrations from PRAM for ZOI = 5

ZOI = 5		Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total PCBs
Pelagic Community												
Phytoplankton (TL1)	algae	1.4E-14	3.7E-10	2.9E-11	4.8E-10	6.3E-10	2.5E-11	1.0E-11	0.0E+00	4.6E-15	1.7E-17	1.5E-09
Zooplankton (TL-II)	copepods	2.2E-10	8.3E-06	8.4E-07	1.6E-05	1.6E-05	2.2E-06	2.0E-06	0.0E+00	1.0E-08	1.5E-09	4.5E-05
Planktivore (TL-III)	herring	6.7E-11	9.3E-06	1.7E-06	6.2E-05	1.1E-04	1.7E-05	1.5E-05	0.0E+00	5.0E-08	2.6E-09	2.2E-04
Piscivore (TL-IV)	jack	1.8E-11	1.6E-06	4.5E-07	3.6E-05	1.9E-04	5.2E-05	5.1E-05	0.0E+00	1.5E-07	3.3E-09	3.4E-04
Reef / Vessel Community												
Attached Algae	algae	3.1E-11	8.3E-07	7.0E-08	1.2E-06	1.8E-06	1.8E-07	1.1E-07	0.0E+00	2.5E-10	1.1E-11	4.2E-06
Sessile filter feeder (TL-II)	bivalves	5.4E-10	1.8E-05	1.8E-06	3.4E-05	3.3E-05	2.9E-06	2.1E-06	0.0E+00	6.7E-09	7.3E-10	9.2E-05
Invertebrate Omnivore (TL-II)	urchin	1.5E-08	1.2E-03	1.7E-04	5.5E-03	8.9E-03	6.3E-04	3.3E-04	0.0E+00	2.2E-07	2.7E-09	1.7E-02
Invertebrate Forager (TL-III)	crab	5.2E-08	2.1E-03	3.2E-04	1.1E-02	2.0E-02	1.6E-03	8.8E-04	0.0E+00	9.7E-07	6.4E-08	3.6E-02
Vertebrate Forager (TL-III)	triggerfish	1.4E-08	9.9E-04	2.1E-04	1.2E-02	4.4E-02	4.4E-03	2.6E-03	0.0E+00	2.9E-06	9.6E-08	6.5E-02
Predator (TL-IV)	grouper	7.8E-09	5.1E-04	1.2E-04	1.0E-02	8.0E-02	1.2E-02	7.8E-03	0.0E+00	8.4E-06	1.9E-07	1.1E-01
Benthic Community												
Infaunal invert. (TL-II)	polychaete	1.5E-10	5.7E-06	6.0E-07	1.2E-05	1.2E-05	1.1E-06	7.9E-07	0.0E+00	2.2E-09	1.6E-10	3.2E-05
Epifaunal invert. (TL-II)	nematode	2.0E-10	1.2E-05	1.4E-06	3.2E-05	3.6E-05	3.4E-06	2.5E-06	0.0E+00	6.3E-09	3.5E-10	8.7E-05
Forager (TL-III)	lobster	2.6E-10	1.5E-05	2.2E-06	6.7E-05	1.0E-04	9.4E-06	6.4E-06	0.0E+00	1.0E-08	2.3E-10	2.0E-04
Predator (TL-IV)	flounder	5.4E-11	8.9E-06	2.4E-06	1.5E-04	4.4E-04	5.3E-05	3.7E-05	0.0E+00	4.8E-08	7.1E-10	6.9E-04

Table 6-1

Scenarios for Potential Diving and Spearfishing Utilization

Scenario	Surface Recovery Time* (hours)	First Dive		Second Dive		Daily Total (minutes)
		Depth (ft.)	Time (mins.)	Depth (ft.)	Time (mins.)	
1[a]	2.5	60	60	60	30	90
2[b]	1.5	80	40	60	24	64
3[c]	2	100	25	60	30	55
4[d]	1	120	20	90	12	32

* Surface recovery time is amount of time required (based on nitrogen buildup in the bloodstream) for a diver to wait in order to conduct a second sequential dive

Notes

[a] Using compressed air, diver will make two dives to the top of the tower

[b] Using compressed air, diver will dive a little deeper to explore other parts of the tower

[c] Using compressed air, diver will dive deeper to explore other parts of the tower

[d] Using the mixed gas Nitrox (32% oxygen), diver approaches flight deck of the ship

Table 6-2

Summary of Exposure Scenarios Evaluated Quantitatively and Qualitatively in this Assessment

		Subchronic exposure [1]		Chronic exposure [2]	
Receptor Population	**Acute Exposure [1]**	**RME**	**CTE**	**RME**	**CTE**
Recreational Fisher					
Adult	qualitative	quantitative	quantitative	quantitative	quantitative
Child	qualitative	quantitative	quantitative	quantitative	quantitative
Adult + child	qualitative	quantitative	quantitative	quantitative	quantitative
Infant (fetus and nursing infant)	qualitative	qualitative	qualitative	qualitative	qualitative
Diver					
Adult	qualitative	qualitative	qualitative	qualitative	qualitative

Notes

[1] Acute and subchronic exposure evaluations were based on three sets of fish and water EPCs predicted from three assumed exposure areas: (1) 0-15 meters from ship; (2) 0-45 meters from ship; and (3) 0-60 meters from ship. These three expsoure areas bound the zones of influence of 2 and 5 used in the chronic exposure evaluation.

[2] Chronic exposure evaluations were based on two sets of fish EPCs predicted by PRAM from two assumed zones of influence: 2 and 5.

Table 6-3

Predicted Exposure Point Concentrations (EPCs) of Total PCBs

Biotic Compartment (mg/kg wet wt)	**PRAM (>2 years)[1]**		**TDM[2](0-2 years)**		
	ZOI = 2	**ZOI = 5**	**0-15 meters**	**0-45 meters**	**0-60 meters**
Benthic fish (flounder)	0.0012	0.00069	0.00053	0.00045	0.00043
Benthic shellfish (lobster)	0.00034	0.00020	0.00015	0.00013	0.00012
Pelagic fish (jack)	0.00058	0.00034	0.00023	0.00020	0.00019
Reef fish TL-IV (grouper)	0.11	0.11	0.046	0.045	0.045
Reef fish TL-III (triggerfish)	0.065	0.065	0.036	0.036	0.035
Reef shellfish (crab)	0.036	0.036	0.025	0.025	0.025
Abiotic (Water) Compartment (mg/L)			**TDM[3](0-90 days)**		
Upper Water Column	NE	NE	3.20E-14	5.30E-14	6.10E-14
Lower Water Column	NE	NE	3.70E-09	3.20E-09	3.00E-09

ZOI = Zone of influence; ZOIs 2 and 5 bound the predicted EPCs in fish tissue.
NE = not evaluated; risks for exposures to water were not evaluated under subcronic or chronic conditions, since concentrations under acute conditions (0-90 days) posed the highest exposures (see Section 9.3).

[1] Biotic EPCs from PRAM (see Tables 5-2 and 5-3) were used for the evalaution of risks under steady state conditions, >2 years.

[2] Biotic EPCs from TDM (see Table 4-4) were used for the evaluation of risks under subchronic exposures, 0-2 years.

[3] Abiotic EPCs for water from TDM (see Tables 4-5 and 4-6) were used for a qualitative evaluation of risks under acute exposures, 0-90 days.

Note: Acute and subchronic exposure evaluations were based on three sets for fish EPCs predicted from three assumed exposure areas in the TDM: (1) 0-15 meters from ship; (2) 0-45 meters from ship; and (3) 0-60 meters from ship. These three exposure areas bound the ZOI of 2 and 5 used in the chronic exposure evaluation using PRAM output.

Table 6-4

Parameters for Human Exposures

Parameter	Adult				Child			
	Subchronic		Chronic		Subchronic		Chronic	
	RME	CTE	RME[1]	CTE	RME	CTE	RME	CTE
Ingestion Rate (kg/day)	0.026	0.007	0.026	0.007	0.009	0.003	0.009	0.003
Fractional Intake (unitless)	0.17	0.25	0.17	0.25	0.17	0.25	0.17	0.25
Exposure Frequency (days/year)	365	365	365	365	365	365	365	365
Exposure Duration (years) [2]	2	2	24	3	2	2	6	6
Body Weight (kg)	70	70	70	70	15	15	15	15
Averaging Time Non Cancer (days)	730	730	8,760	1,095	730	730	2,190	2,190
Averaging Time Cancer (days)	25,550	25,550	25,550	25,550	25,550	25,550	25,550	25,550

[1] Chronic health risks to adults under RME are the sum of adult plus child risks, for a total exposure duration of 30 years, and under CTE for a total exposure duration of 9 years.

[2] The exposure duration for adult only scenario for RME is 30 years and for CTE is 9 years

Table 7-1

Toxicity Values Used in this Assessment[1]

Chemical of Potential Concern	Exposure Period	Oral Reference Dose (RfD)		Oral Cancer Slope Factor (CSF)	
		RfD (mg/kg-d)	Reference	CSF $(mg/kg\text{-}d)^{-1}$	Reference
Total PCBs (Sum of homologues)	Acute (from immediately post-sinking to 90 days post-sinking[2])	----------	No toxicity value ----------	Not quantified because cancer risk for acute exposure period would be less than cancer risk for other exposure periods.	
	Subchronic RME (first 2 years post-sinking)	5E-05	Aroclor 1254; HEAST, 1997	2	upper bound - high risk and persistence; IRIS, 2005
	Subchronic CTE (first 2 years post-sinking)	5E-05	Aroclor 1254; HEAST, 1997	1	central estimate - high risk and persistence; IRIS, 2005
	Chronic RME (30 years; year 2 to year 32 post-sinking)	2E-05	Aroclor 1254; IRIS, 2005a	2	upper bound - high risk and persistence; IRIS, 2005
	Chronic CTE (9 years; year 2 to year 11 post-sinking)	2.0E-05	Aroclor 1254; IRIS, 2005a	1	central estimate - high risk and persistence; IRIS, 2005
TEQ Toxic Equivalence from dioxin-like PCBs	Chronic RME	----------	No toxicity value ----------	1.50E+05	CSF for 2,3,7,8-TCDD; HEAST, 1997

[1]These toxicity values are assumed to be applicable to adults and children.

[2]The TDM documentation (NEHC/SSC-SD 2006b) refers to the 0-90 day post-sinking period as an acute exposure period although, typically, acute exposures are evaluated for shorter exposure periods, from instantaneous to 2-week exposures.

IRIS - Integrated Risk Information System (EPA, 2005a)
HEAST - Health Effects Assessment Summary Table (EPA, 1997)
RME - Reasonable Maximum Exposure
CTE - Central Tendency Exposure
RfD - Reference Dose
CSF - Cancer Slope Factor
2,3,7,8-TCDD - 2,3,7,8-tetrachlorodibenzo-*p*- dioxin (commonly referred to as dioxin)
TEQ Toxic Equivalence from dioxin-like PCBs - Sum of predicted congener concentrations that have been multiplied by applicable toxicity equivalency factors to obtain the equivalent concentration of 2,3,7,8-TCDD (See Table 7.3 and discussion in Section 7.4.3)

Table 7-2

Tiers of PCB Cancer Slope Factors (CSFs) for Environmental Mixtures of PCBs

CSF central estimate $(mg/kg\text{-}d)^{-1}$	CSF upper bound estimate $(mg/kg\text{-}d)^{-1}$	Criteria for Use
High Risk and Persistence		
1.0	2.0	Food chain exposure sediment or soil ingestion dust or aerosol inhalation dermal exposure, if an absorption factor has been applied to reduce the external dose Presence of dioxin-like, tumor-promoting, or persistent congeners in other media early life exposure (all pathways and mixtures)
Low Risk and Persistence		
0.3	0.4	Ingestion of water-soluble congeners Inhalation of volatilized congeners dermal exposure, if no absorption factor has been applied to reduce the external dose
Lowest Risk and Persistence		
0.04	0.07	Congener or isomer analyses verify that congeners with more than four chlorines comprise less than 0.5% of total PCBs

Source: USEPA, 1996.

Table 7-3

Toxic Equivalency Factors (TEFs) for Dioxin-Like PCBs

Dioxin-like PCBs	TEF
77: 3,4,3’,4’-TeCB	0.0001
81: 3,4,4’5-TeCB	0.0001
126: 3,4,5,3’,4’-PeCB	0.1
169: 3,4,5,3’,4’,5’-HxCB	0.01
105: 2,3,4,3’,4’-PeCB	0.0001
114: 2,3,4,5,4’-PeCB	0.0005
118: 2,4,5,3’,4’-PeCB	0.0001
123: 3,4,5,2’,4’-PeCB	0.0001
156: 2,3,4,5,3’,4’-HxCB	0.0005
157: 2,3,4,3’,4’,5’-HxCB	0.0005
167: 2,4,5,3’,4’,5’-HxCB	0.00001
189: 2,3,4,5,3’,4’,5’-HpCB	0.0001

Source: Van den Berg et al., 1998 mammalian TEFs

Table 8-1
Adult and Child Fish Consumers: Cancer Risks and Subchronic Hazard Quotients
Associated with Predicted Fish Tissue Concentrations for the ex-ORISKANY for the First Two Years Post Sinking

	Total PCB (mg/kg, whole body wet weight fish tissue)	Hazard Quotient - Adult		Hazard Quotient - Child		Cancer Risk - Adult	
		RME	CTE	RME	CTE	RME	CTE
USEPA Acceptable Level		**1.0**	**1.0**	**1.0**	**1.0**	**1.0E-06**	**1.0E-06**
0-60 meters from ship							
Benthic fish (flounder)	0.00043	0.0005	0.0002	0.0009	0.0004	4E-09	8E-10
Benthic shellfish (lobster)	0.00012	0.0002	0.00006	0.0002	0.0001	1E-09	2E-10
Pelagic fish (jack)	0.00019	0.0002	0.0001	0.0004	0.0002	2E-09	4E-10
Reef fish TL-IV (grouper)	0.045	0.06	0.02	0.1	0.04	4E-07	9E-08
Reef fish TL-III (triggerfish)	0.035	0.04	0.02	0.07	0.03	3E-07	7E-08
Reef shellfish (crab)	0.025	0.03	0.01	0.05	0.02	2E-07	5E-08
0-45 meters from ship							
Benthic fish (flounder)	0.00045	0.0006	0.0002	0.0010	0.0004	4E-09	9E-10
Benthic shellfish (lobster)	0.00013	0.0002	0.00006	0.0003	0.0001	1E-09	2E-10
Pelagic fish (jack)	0.00020	0.0003	0.0001	0.0004	0.0002	2E-09	4E-10
Reef fish TL-IV (grouper)	0.045	0.06	0.02	0.1	0.04	4E-07	9E-08
Reef fish TL-III (triggerfish)	0.036	0.05	0.02	0.07	0.03	3E-07	7E-08
Reef shellfish (crab)	0.025	0.03	0.01	0.05	0.02	2E-07	5E-08
0-15 meters from ship							
Benthic fish (flounder)	0.00053	0.0007	0.0003	0.001	0.0005	5E-09	1E-09
Benthic shellfish (lobster)	0.00015	0.0002	0.00008	0.0003	0.0001	1E-09	3E-10
Pelagic fish (jack)	0.00023	0.0003	0.0001	0.0005	0.0002	2E-09	5E-10
Reef fish TL-IV (grouper)	0.046	0.06	0.02	0.1	0.04	4E-07	9E-08
Reef fish TL-III (triggerfish)	0.036	0.05	0.02	0.07	0.03	3E-07	7E-08
Reef shellfish (crab)	0.025	0.03	0.01	0.05	0.02	2E-07	5E-08

RME - Reasonable Maximum exposure
CTE - Central tendency estimate
TL III - Trophic Level within the food web. Triggerfish is a representative fish species.
TL IV - Trophic Level within the food web. Grouper is a representative fish species.

Table 8-2

Adult and Child Fish Consumers: Cancer Risks and Chronic Hazard Quotients

Associated with Predicted Fish Tissue Concentrations for the ex-ORISKANY Under Steady State Conditions

(Two Years Post Sinking to 32 Years Post Sinking)

	Total PCB (mg/kg, whole body wet weight fish tissue)	Hazard Quotient Adult		Hazard Quotient Adult + Child *		Hazard Quotient Child		Cancer Risk Adult		Cancer Risk Adult + Child *		Cancer Risk Child	
		RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
USEPA Acceptable Level		**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0E-06**	**1.0E-06**	**1.0E-06**	**1.0E-06**	**1.0E-06**	**1.0E-06**
ZOI = 2													
Benthic fish (flounder)	0.0012	0.005	0.005	0.004	0.002	0.006	0.002	6E-08	4E-09	7E-08	6E-09	2E-08	4E-09
Benthic shellfish (lobster)	0.00034	0.001	0.001	0.001	0.0007	0.002	0.0007	2E-08	1E-09	2E-08	2E-09	6E-09	1E-09
Pelagic fish (jack)	0.00058	0.002	0.002	0.002	0.001	0.003	0.001	3E-08	2E-09	4E-08	3E-09	1E-08	2E-09
Reef fish TL-IV (grouper)	0.11	0.4	0.4	0.4	0.2	0.6	0.2	6E-06	4E-07	7E-06	5E-07	2E-06	4E-07
Reef fish TL-III (triggerfish)	0.065	0.3	0.2	0.2	0.1	0.3	0.1	4E-06	2E-07	4E-06	3E-07	1E-06	2E-07
Reef shellfish (crab)	0.036	0.1	0.1	0.1	0.07	0.2	0.07	2E-06	1E-07	2E-06	2E-07	7E-07	1E-07
ZOI = 5													
Benthic fish (flounder)	0.00069	0.003	0.003	0.002	0.001	0.004	0.002	4E-08	2E-09	4E-08	3E-09	1E-08	3E-09
Benthic shellfish (lobster)	0.00020	0.001	0.001	0.0007	0.0005	0.001	0.0005	1E-08	6E-10	1E-08	1E-09	4E-09	7E-10
Pelagic fish (jack)	0.00034	0.001	0.001	0.001	0.0007	0.002	0.0007	2E-08	1E-09	2E-08	2E-09	6E-09	1E-09
Reef fish TL-IV (grouper)	0.11	0.4	0.4	0.4	0.2	0.6	0.2	6E-06	4E-07	7E-06	5E-07	2E-06	4E-07
Reef fish TL-III (triggerfish)	0.065	0.3	0.2	0.2	0.1	0.3	0.1	4E-06	2E-07	4E-06	3E-07	1E-06	2E-07
Reef shellfish (crab)	0.036	0.1	0.1	0.1	0.07	0.2	0.07	2E-06	1E-07	2E-06	2E-07	7E-07	1E-07

* Adult + Child includes 24 years of exposure as an adult plus 6 years of exposure as a child

CTE - Central tendency exposure

RME - Reasonable maximum exposure

ZOI - Zone of influence. ZOIs 2 and 5 bound the predicted EPCs in fish tissue

TL III - Trophic Level within the food web. Triggerfish is a representative fish species.

TL IV - Trophic Level within the food web. Grouper is a representative fish species.

Table 9-1
Estimates of Exposures to PCBs in Breast Milk from Adult Fish Ingestion -- RME Scenario

ADD Calculation - RME		Calculation of PCBs in Milk Fat	
Ingestion Rate (kg/day)	0.026	Half life of PCBs in adult body (h, days)	2,190
Fractional Intake (unitless)	0.170	Fraction ingested stored in fat (f_1)	0.9
Exposure Frequency (days/year)	365	Fraction of mother's weight as fat (f_2)	0.3
Exposure Duration (years)	30		
Body Weight (kg)	70		
Averaging Time Non Cancer (days)	10,950		

Fish Tissue	Cf	ADD	Predicted PCBs in Milk Fat	Mean Background PCBs in Milk Fat	Ratio of Predicted to Background Concentrations of PCBs in Milk Fat
	(mg/kg wet wt)	(mg/kg-day)	(mg/kg lipid)	(mg/kg lipid)	
Benthic fish (flounder)	2.42E-03	1.54E-07	0.0015	0.32	0.005
Benthic shellfish (lobster)	5.77E-04	3.66E-08	0.0003	0.32	0.001
Pelagic fish (jack)	1.25E-03	7.94E-08	0.0008	0.32	0.002
Reef fish TL-IV (grouper)	1.01E-01	6.42E-06	0.061	0.32	0.190
Reef fish TL-III (triggerfish)	5.70E-02	3.61E-06	0.034	0.32	0.107
Reef shellfish (crab)	3.01E-02	1.90E-06	0.018	0.32	0.056

RME = Reasonable maximum exposure, defined in Table 6-2
Cf = Concentration of PCBs in fish tissue, from PRAM, ZOI = 2
ADD - Average daily dose to mother from fish ingestion

Table 9-2
Estimates of Exposures to PCBs in Breast Milk from Adult Fish Ingestion -- CTE Scenario

ADD Calculation - CTE		Calculation of PCBs in Milk Fat	
Ingestion Rate (kg/day)	0.007	Half life of PCBs in adult body (h, days)	2,190
Fractional Intake (unitless)	0.2500	Fraction ingested stored in fat (f_1)	0.9
Exposure Frequency (days/year)	365	Fraction of mother's weight as fat (f_2)	0.3
Exposure Duration (years)	3		
Body Weight (kg)	70		
Averaging Time Non Cancer (days)	1,095		

Fish Tissue	Cf	ADD	Predicted PCBs in Milk Fat	Mean Background PCBs in Milk Fat	Ratio of Predicted to Background Concentrations of PCBs in Milk Fat
	(mg/kg wet wt)	(mg/kg-day)	(mg/kg lipid)	(mg/kg lipid)	
Benthic fish (flounder)	2.42E-03	6.23E-08	0.0006	0.32	0.002
Benthic shellfish (lobster)	5.77E-04	1.48E-08	0.0001	0.32	0.0004
Pelagic fish (jack)	1.25E-03	3.22E-08	0.0003	0.32	0.001
Reef fish TL-IV (grouper)	1.01E-01	2.60E-06	0.025	0.32	0.077
Reef fish TL-III (triggerfish)	5.70E-02	1.47E-06	0.014	0.32	0.043
Reef shellfish (crab)	3.01E-02	7.73E-07	0.007	0.32	0.023

CTE = Central tendency exposure, defined in Table 6-2
Cf = Concentration of PCBs in fish tissue, from PRAM, ZOI = 2
ADD - Average daily dose to mother from fish ingestion

Figure 1-1
Relative Location of the Proposed Resting Place of the ex-ORISKANY within the Escambia East Large Area Artificial Reefs Site (LAARS) – Escambia County, Florida

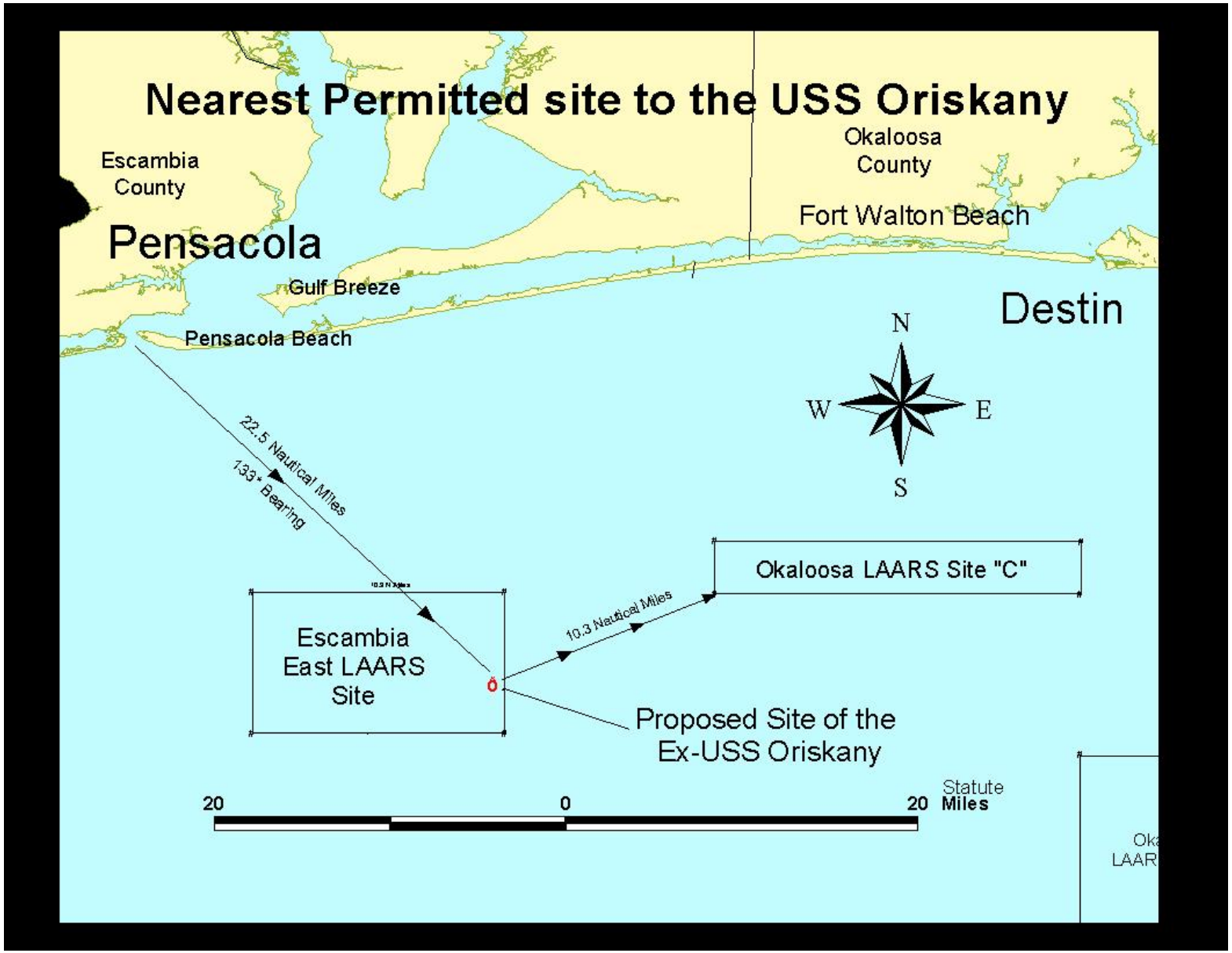
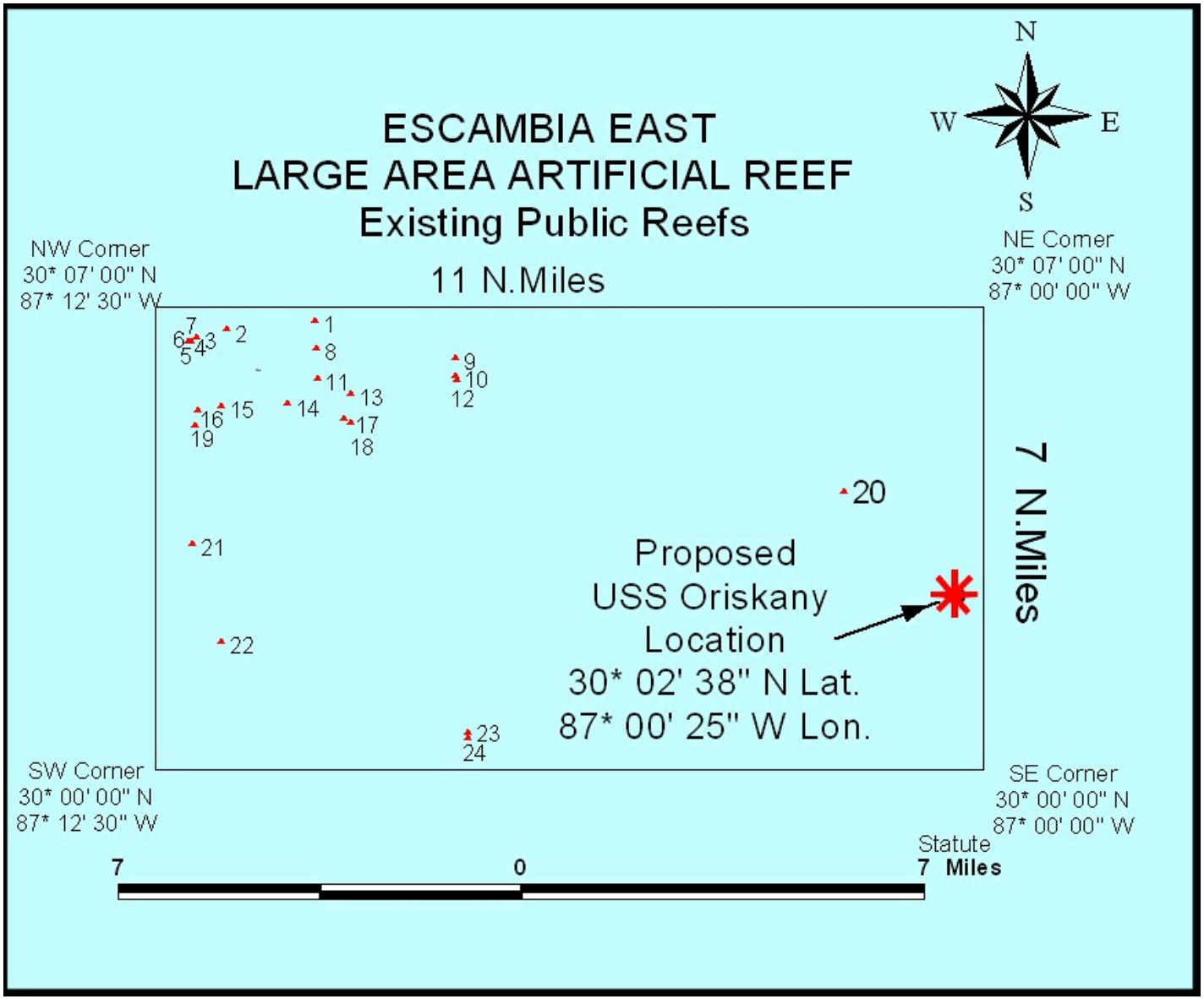


Figure 1-2
Current Public Reef Locations Relative to the Proposed ex-ORISKANY Reef within the Escambia East LAARS Area



REEFEX Project Organization

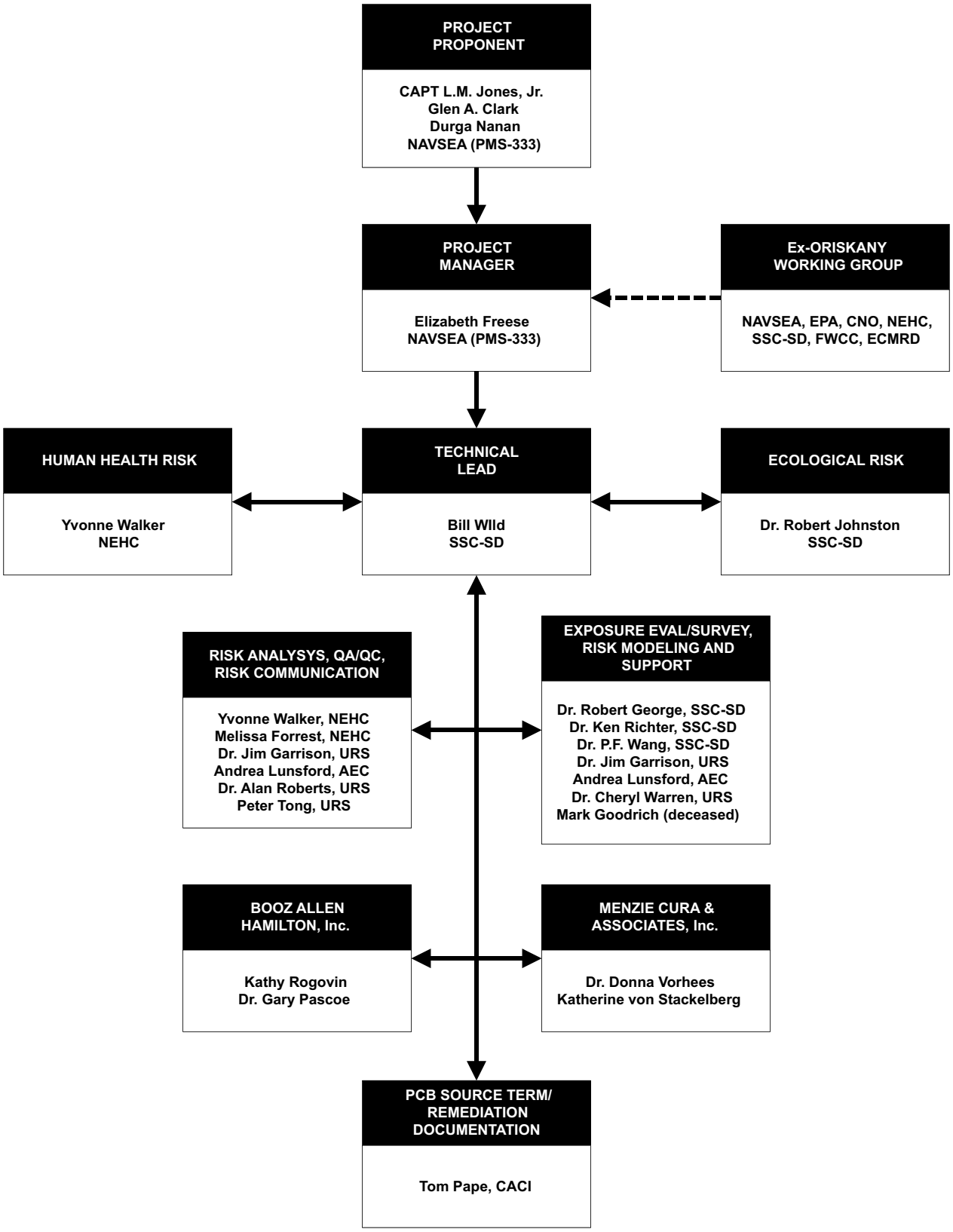
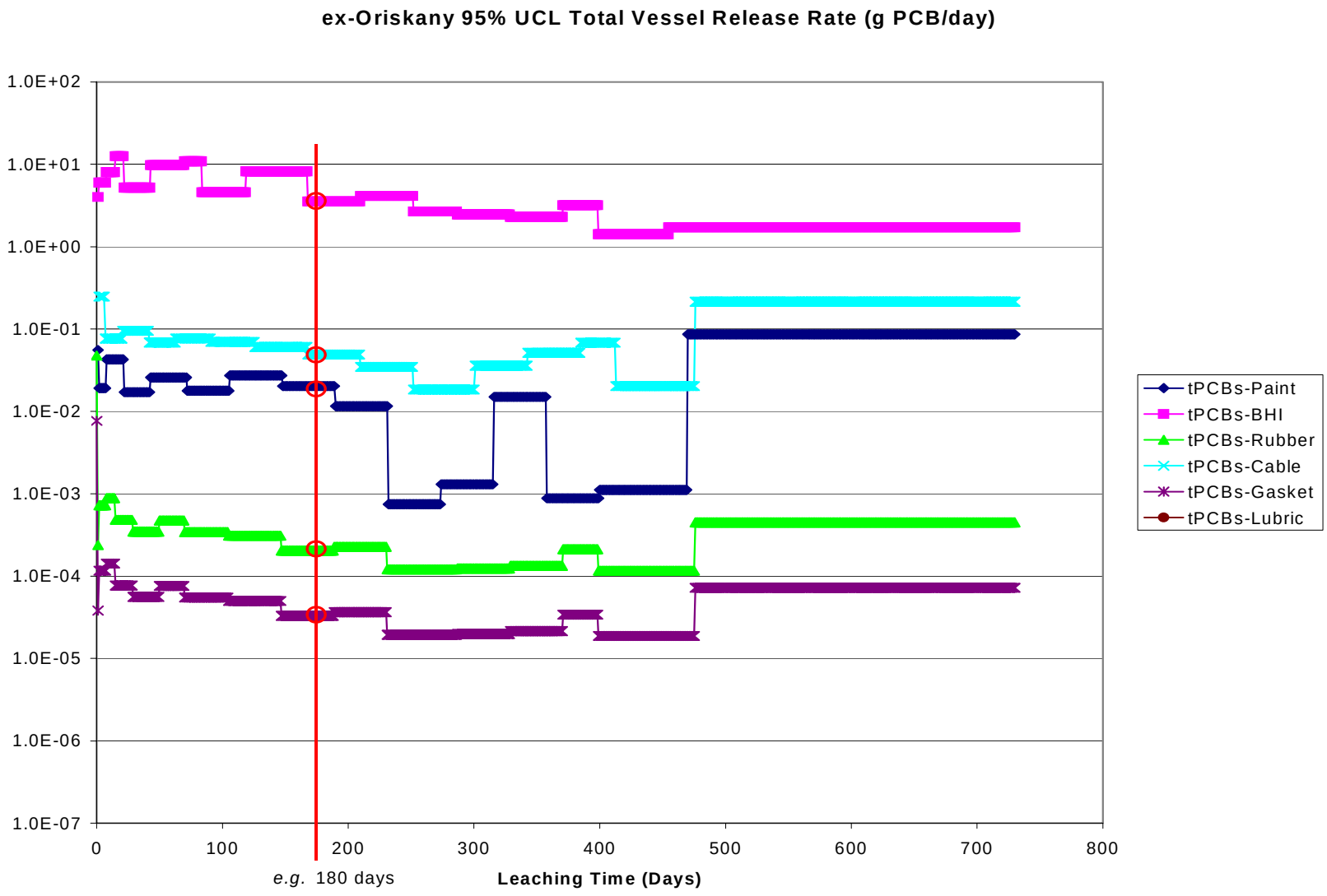


Figure 1-3

Figure 4-1

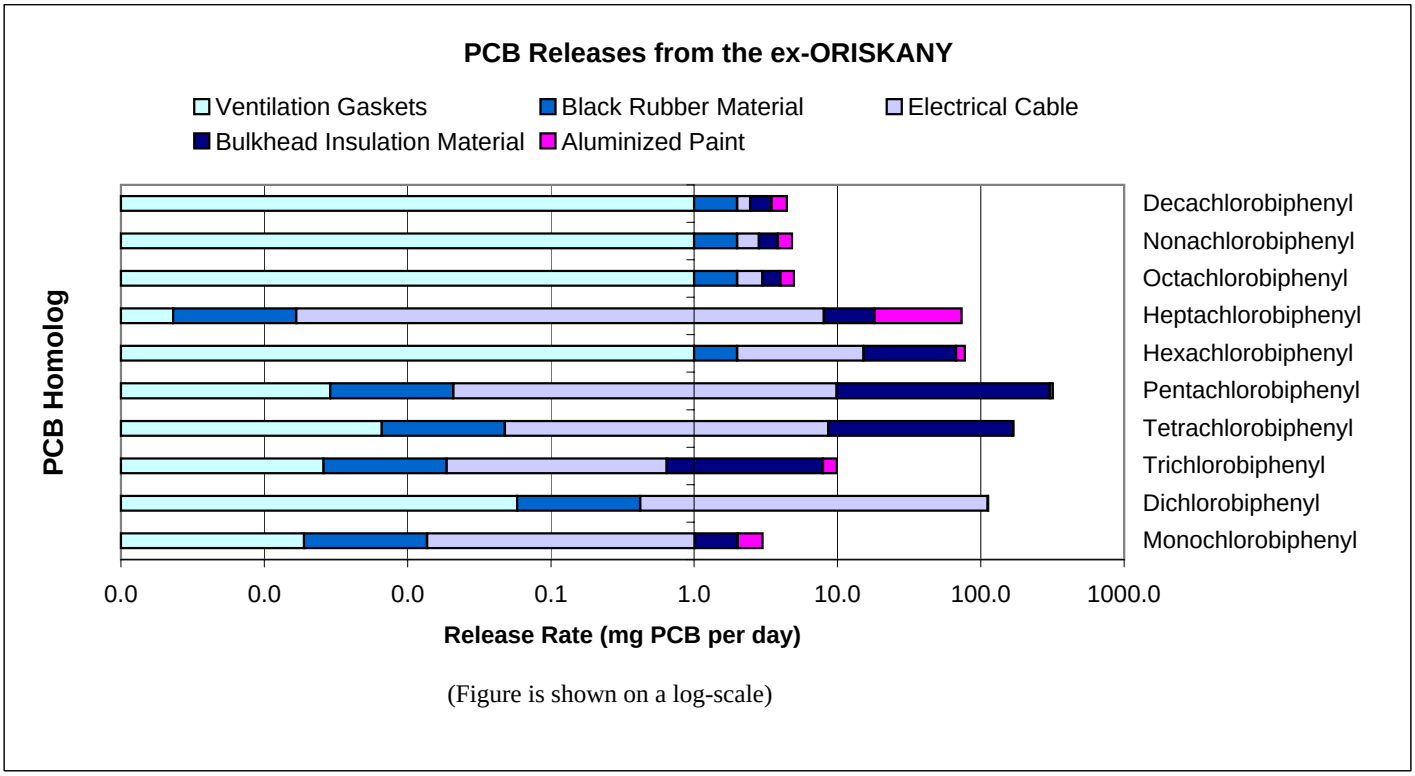
95% UCL Total Vessel Release Rates from the Leach Rate Report



Note: This graph depicts materials onboard all Navy vessels. For the ex-ORISKANY, there are no remaining lubricants and the only remaining rubber is black rubber.

Figure 4-2

PCB Release Rates by PCB Homolog and Material Assumed in PRAM



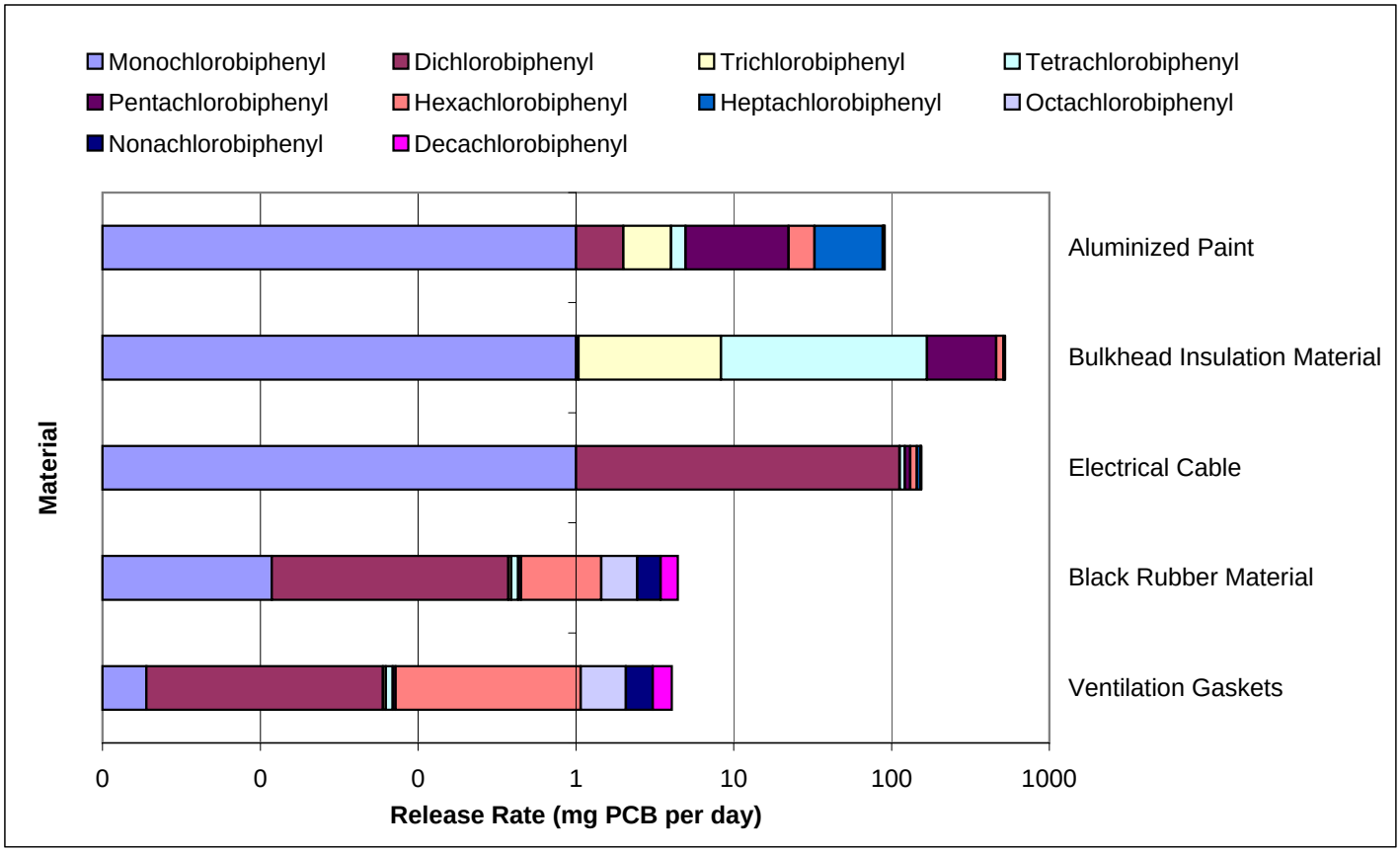


Figure 4-3

PRAM: Modules, Inputs, and Outputs

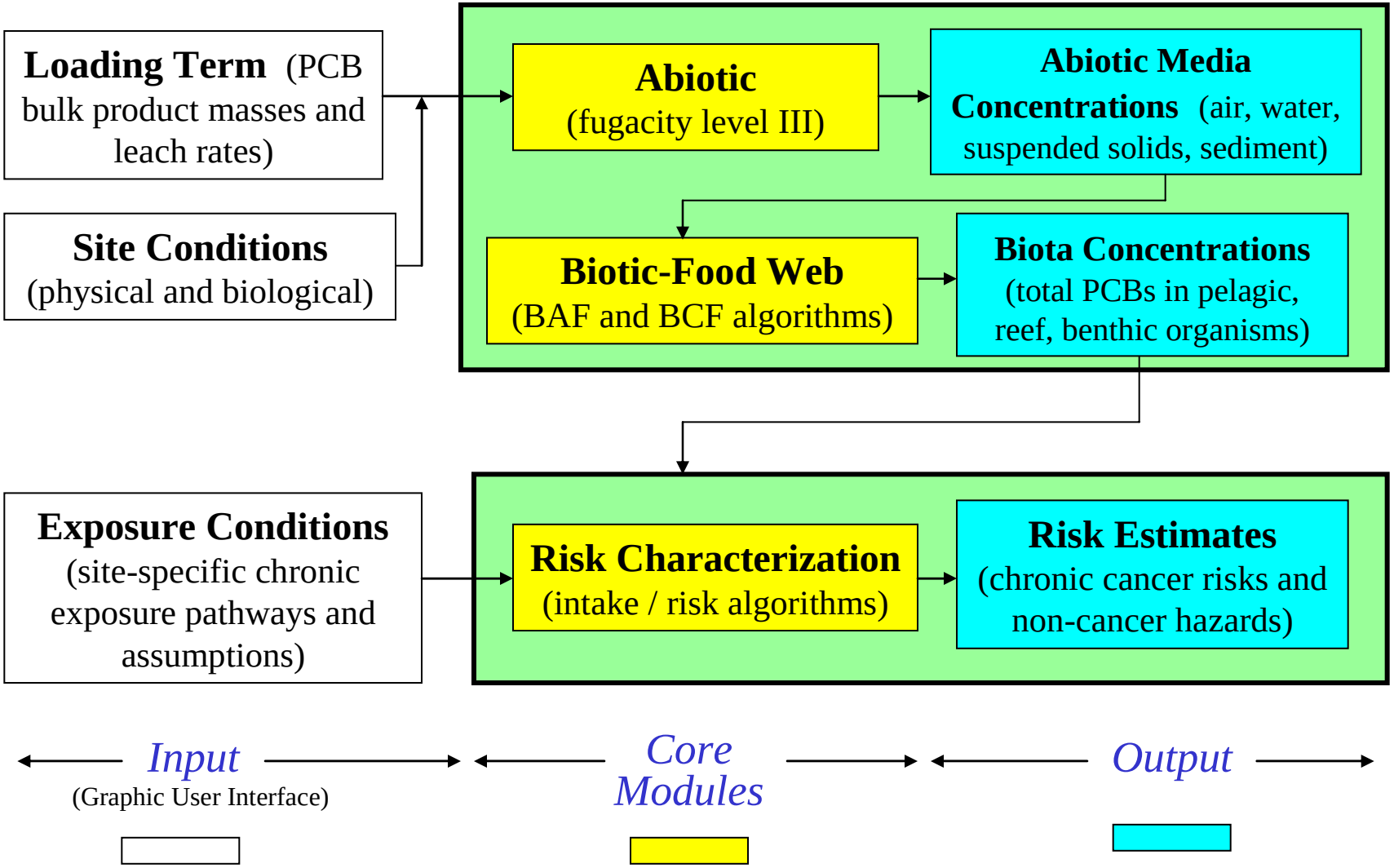
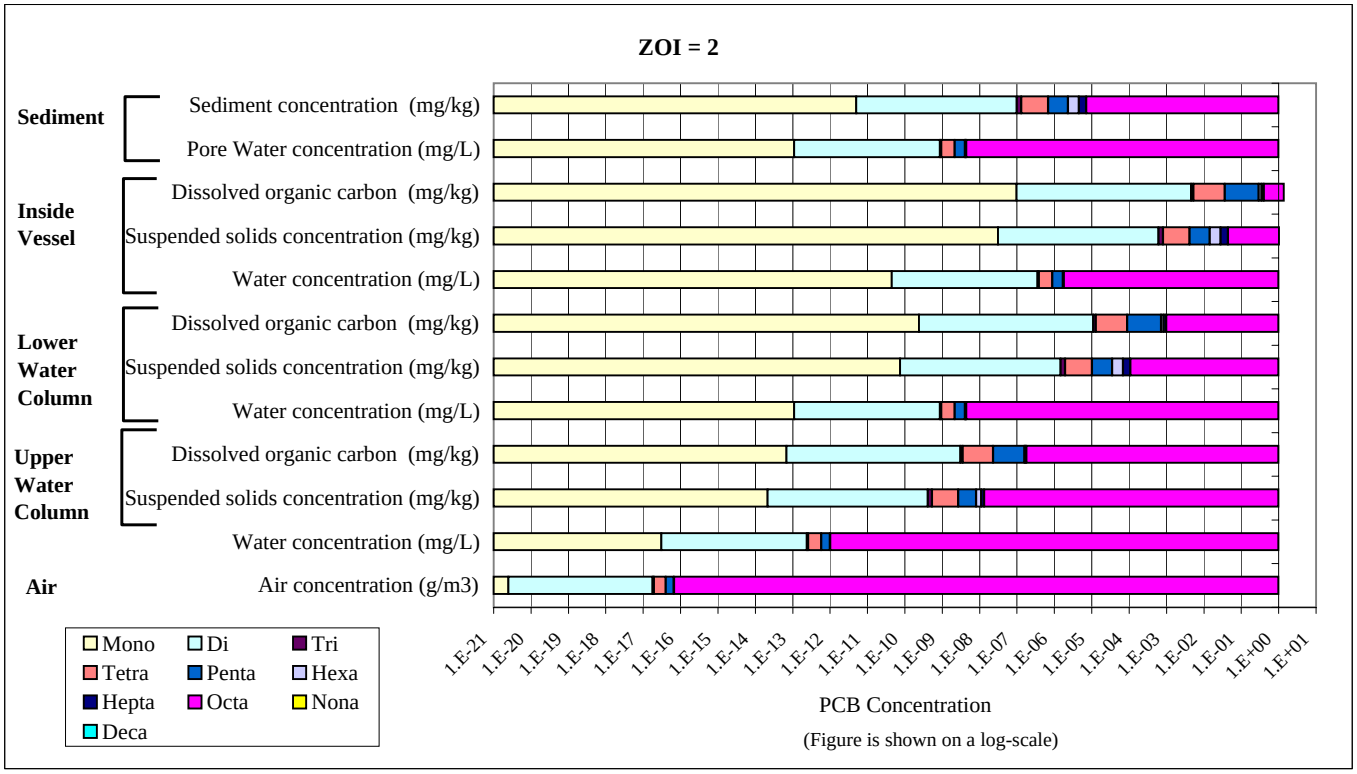


Figure 4-4

Predicted Abiotic Concentrations from PRAM for ZOI = 2



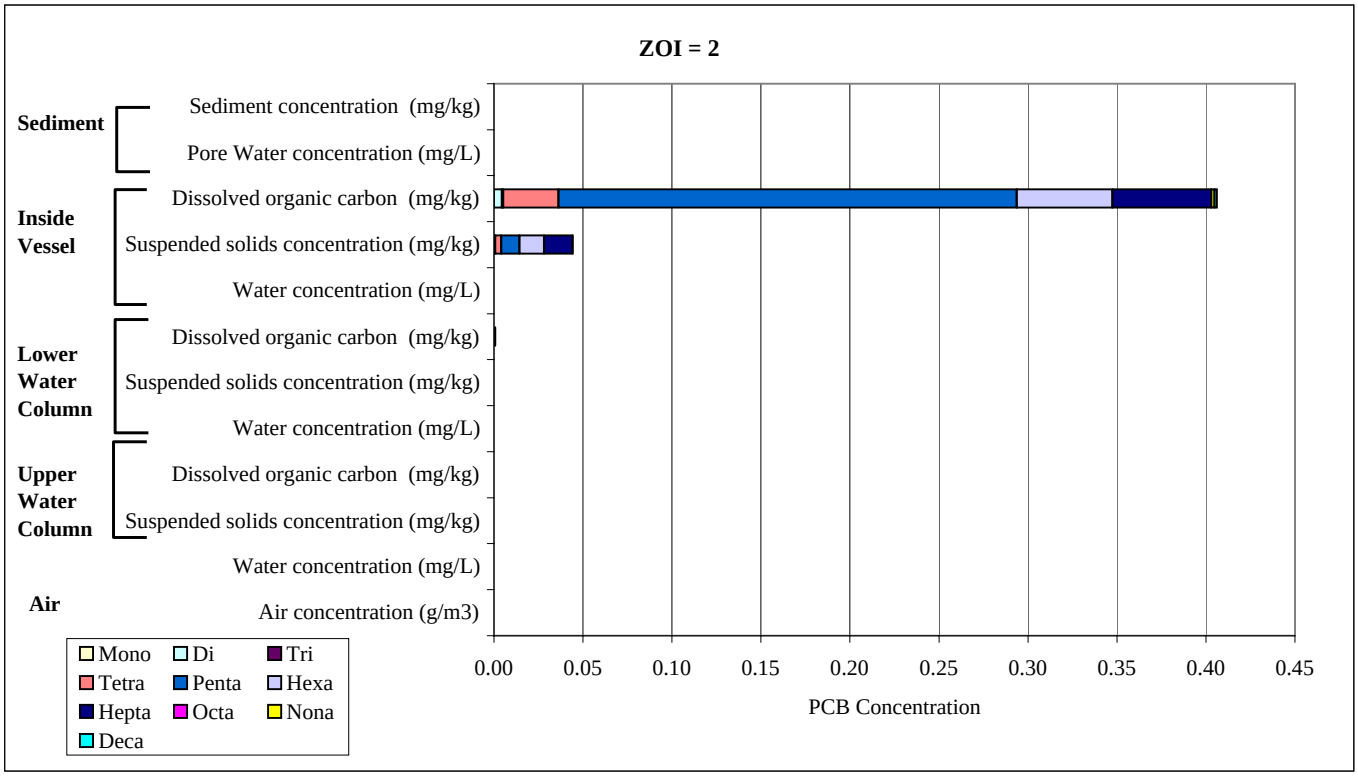
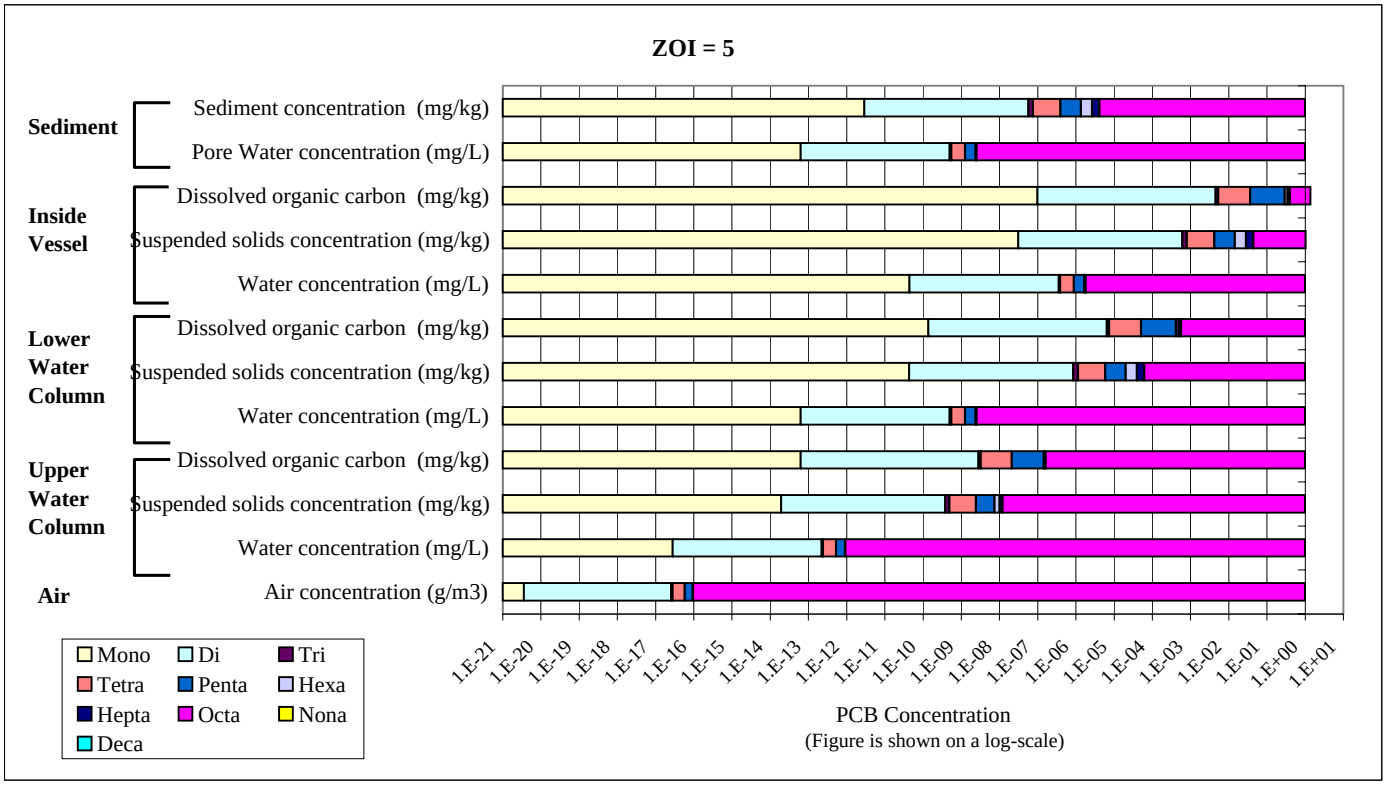


Figure 4-5

Predicted Abiotic Concentrations from PRAM for ZOI = 5



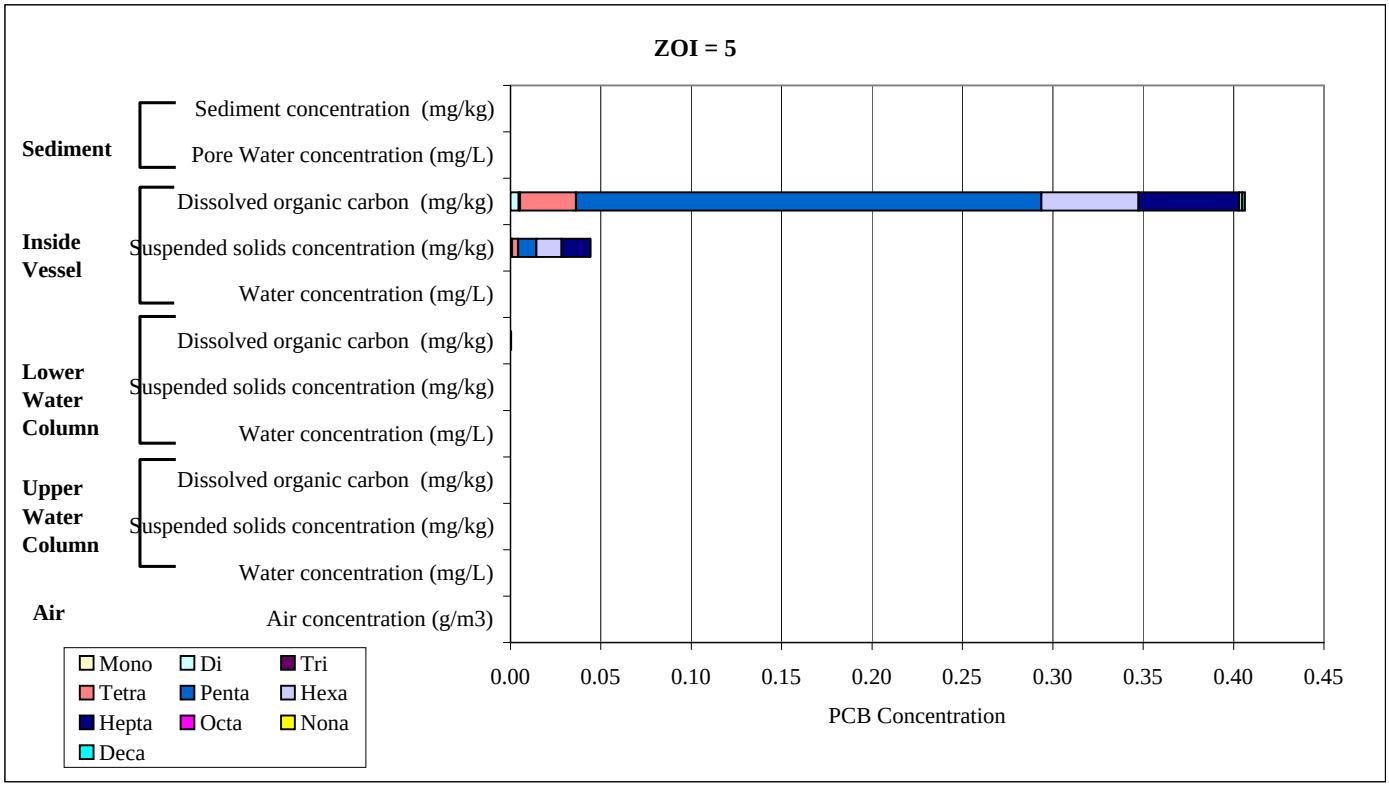
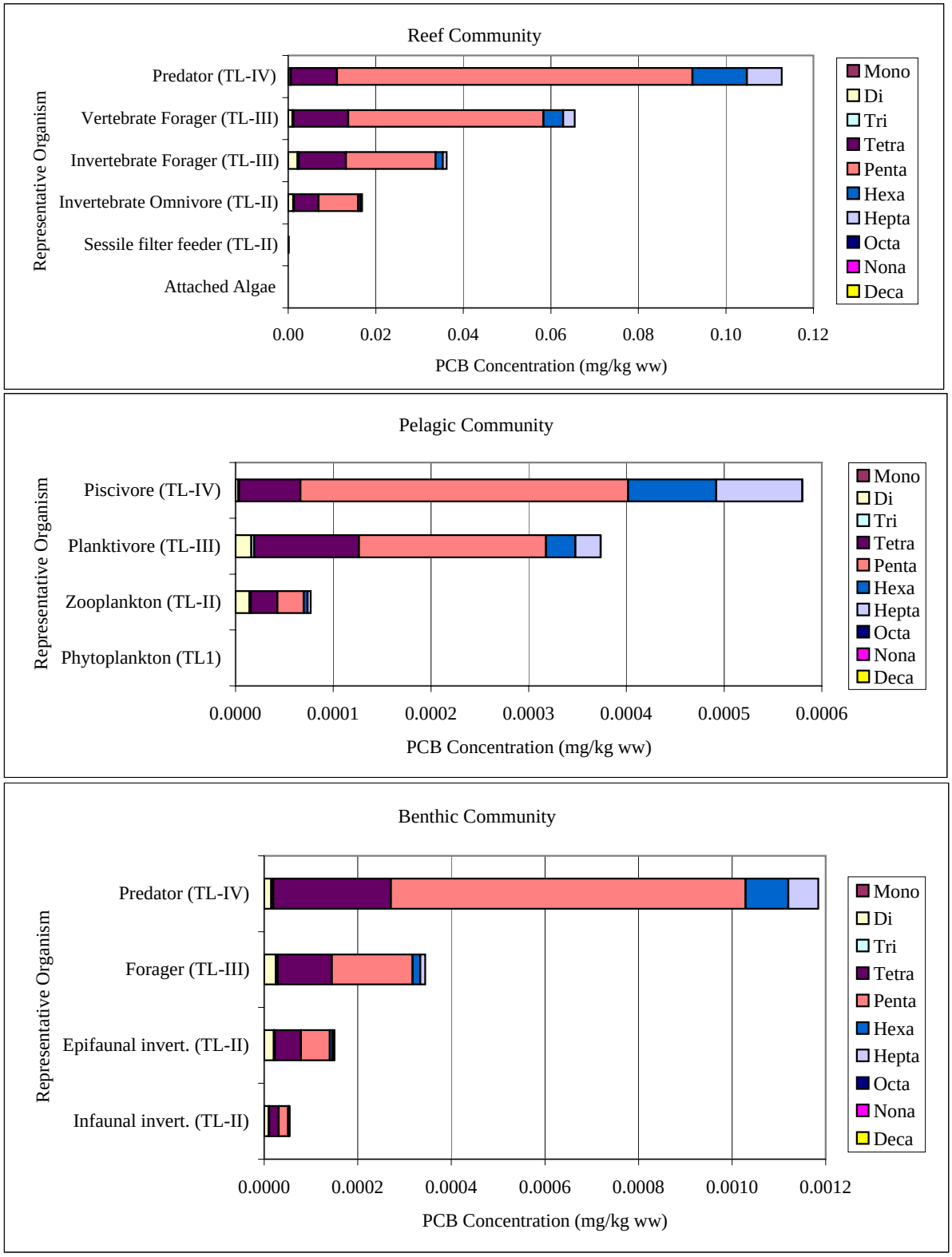


Figure 5-1

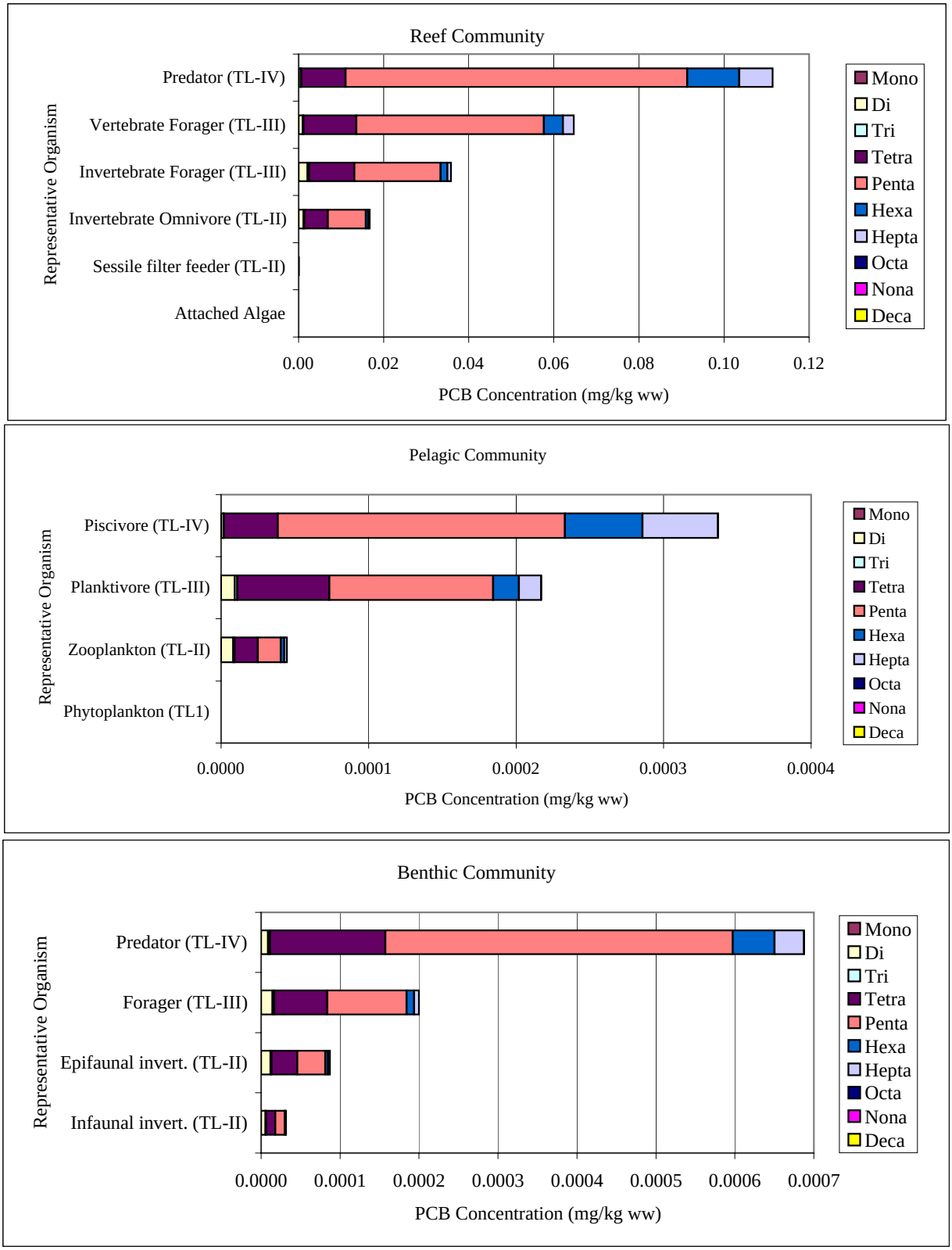
Predicted Biota Concentrations from PRAM for ZOI = 2



Note the change in PCB concentration scale for each community.

Figure 5-2

Predicted Biota Concentrations from PRAM for ZOI = 5



Note the change in PCB concentration scale for each community.

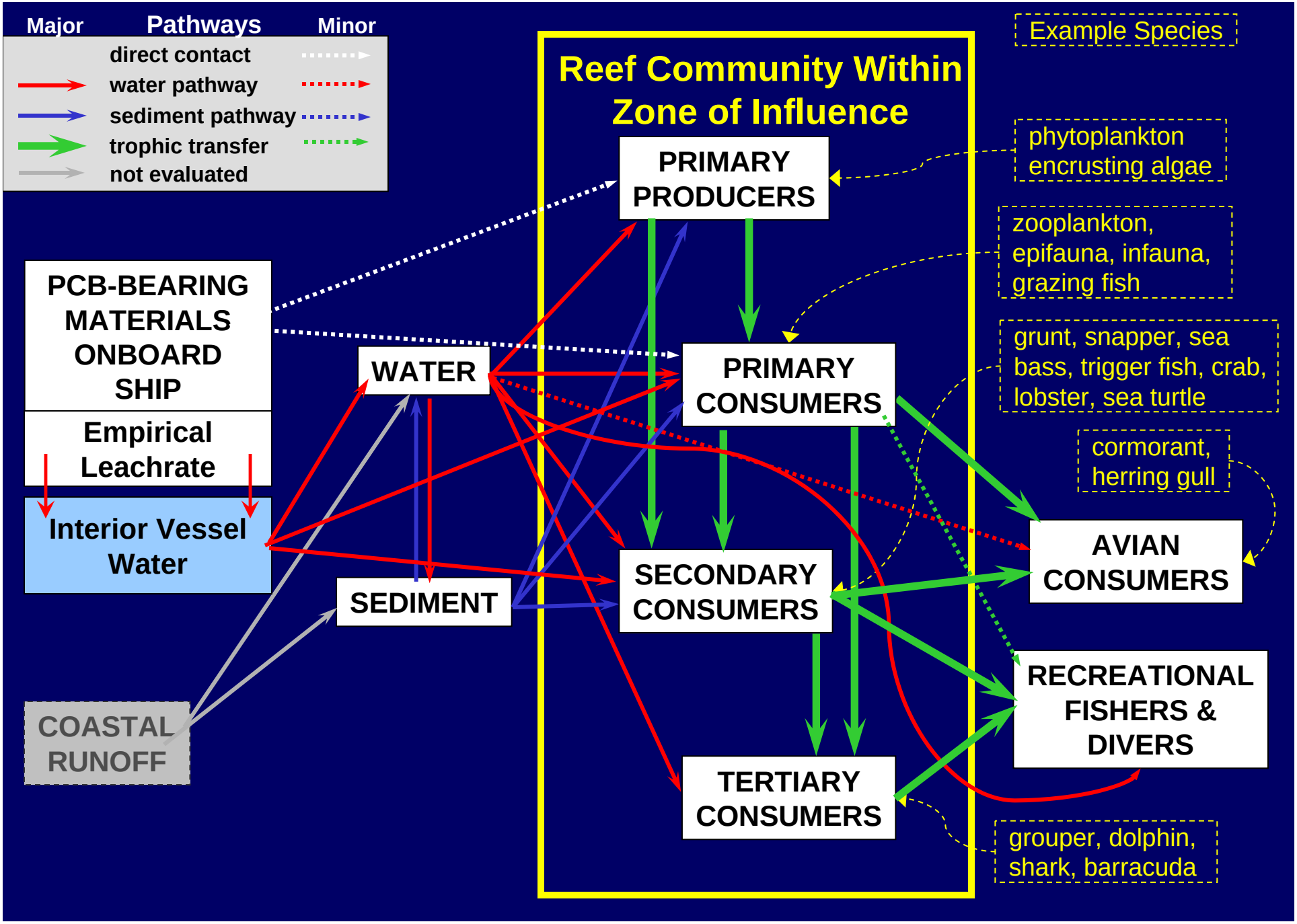


Fig. 6-1. Site Conceptual Exposure Model

Figure 7-1

PCB Homolog Weight Percents Predicted for Fish and Surface Water by PRAM v.1.4c, and PCB Homolog Weight Percents in Commercial Aroclor Mixtures (ATSDR, 2000)

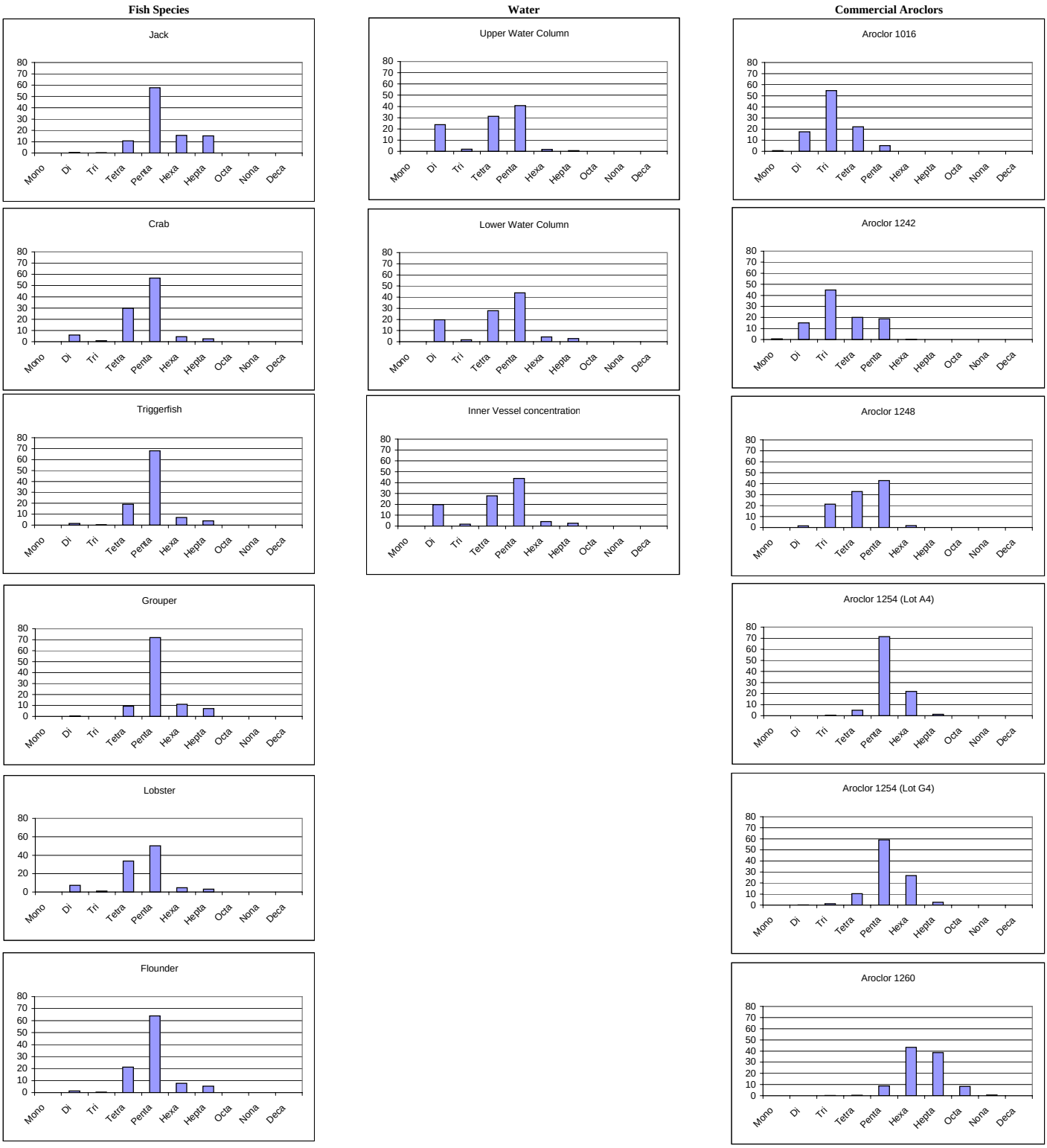
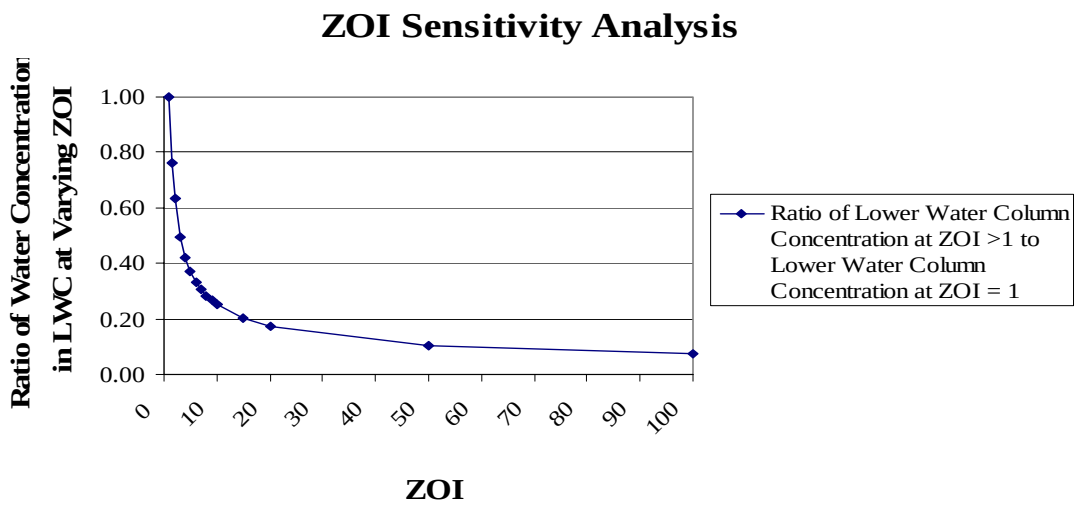


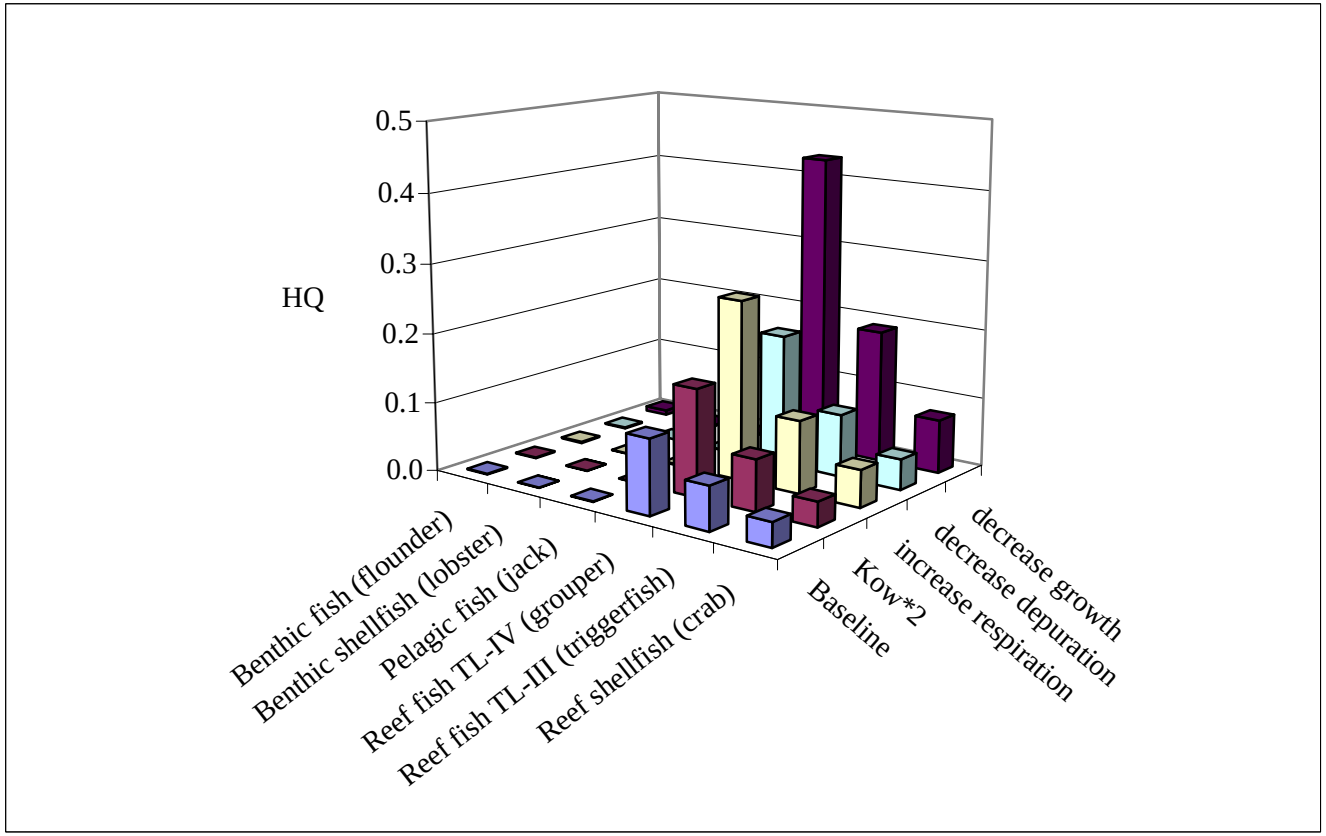
Figure 9-1



Note: The horizontal (x-axis) represents the ZOI, and the vertical (y-axis) represents the ratio of the PCB concentration in the lower water column (LWC) at the given ZOI value divided by the maximum PCB concentration in the LWC that occurs when ZOI =1. The ratio represents the fractional amount of the original PCB concentration remaining as the ZOI increases. See Section 9.1.4.1 for further discussion.

Figure 9-2

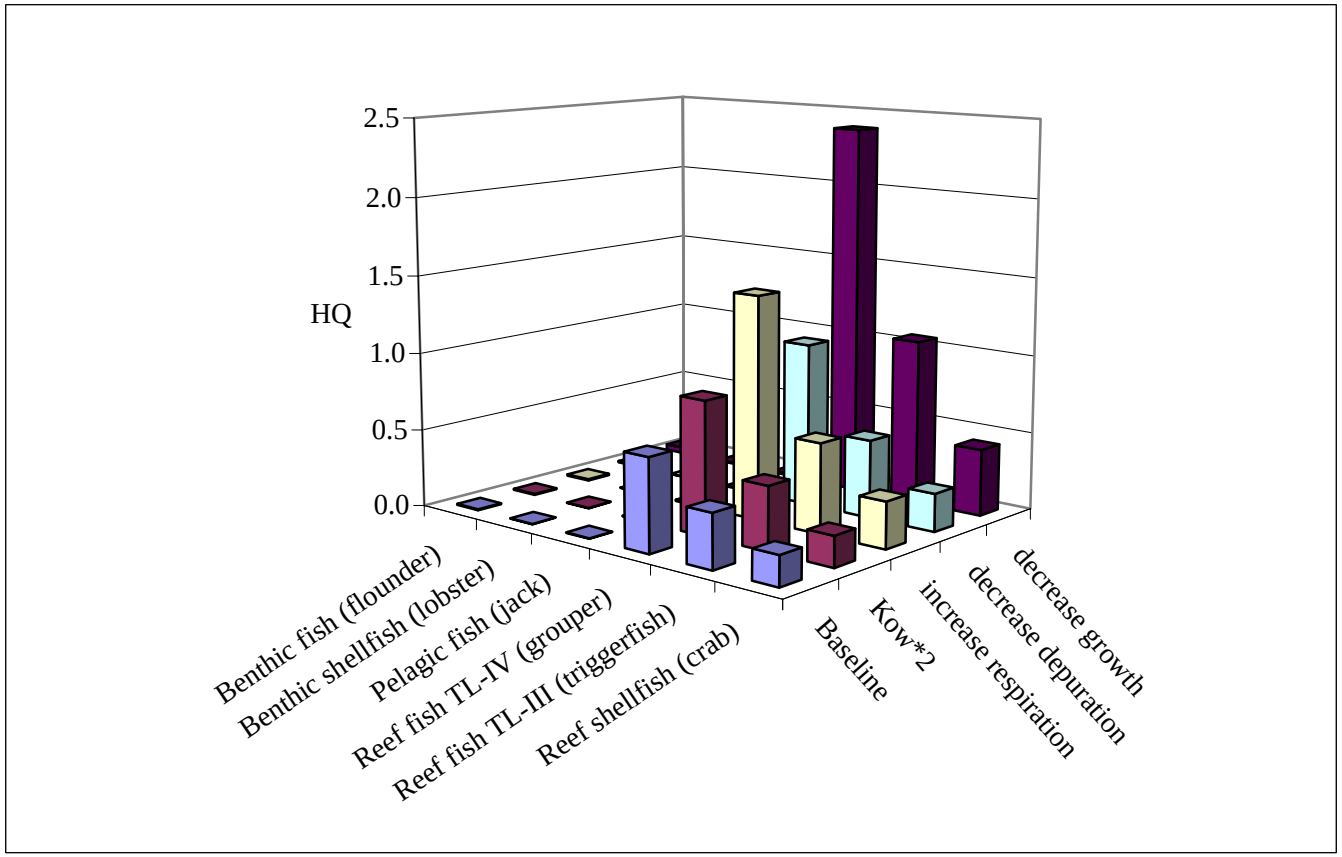
Differences in Predicted HQ to CTE Child from Sensitivity Analysis



Graph displays impact of varying key parameters on the predicted PRAM calculated HQ. Sensitivity analysis on PRAM input parameters is discussed in Section 9.2.

Figure 9-3

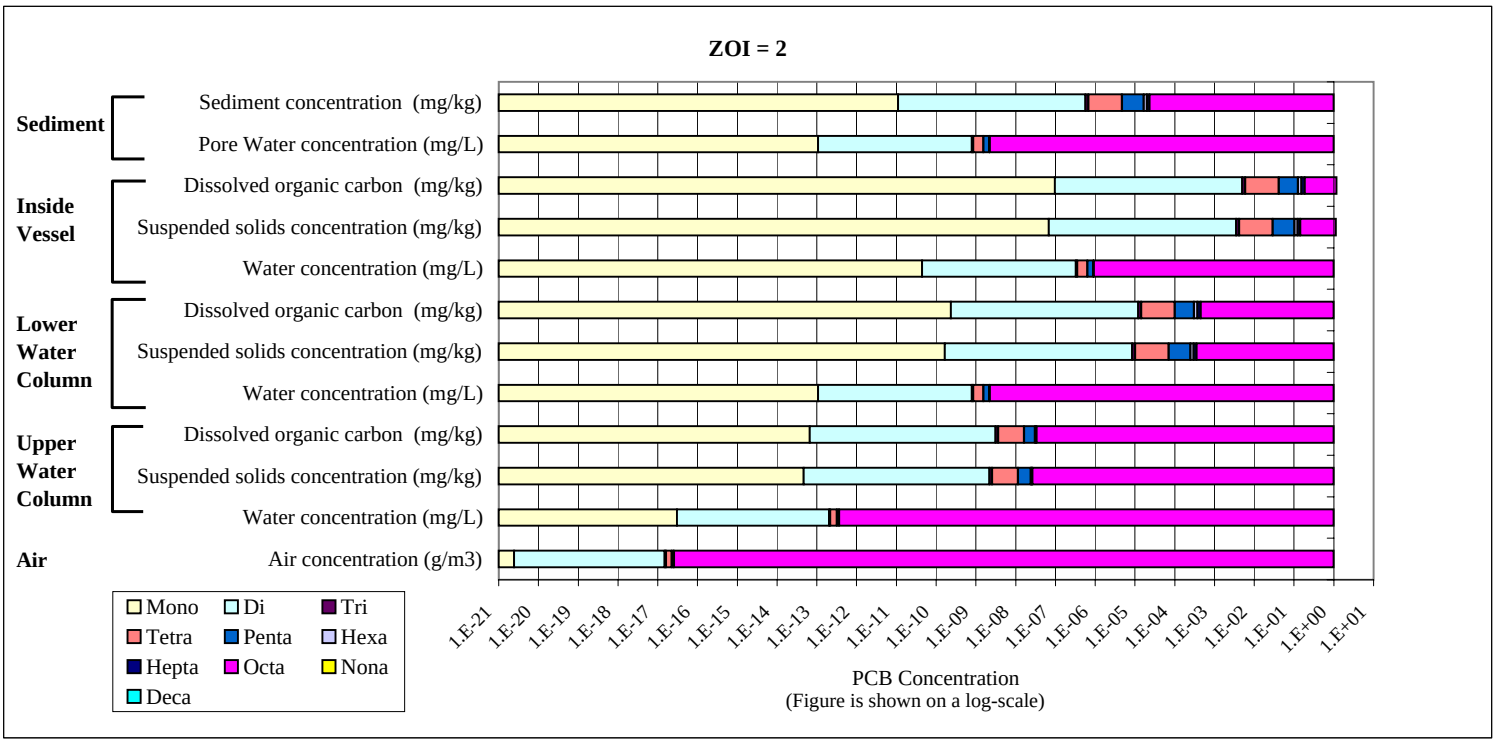
Differences in Predicted HQ to RME Child from Sensitivity Analysis



Graph displays impact of varying key parameters on the predicted PRAM calculated HQ. Sensitivity analysis on PRAM input parameters is discussed in Section 9.2.

Figure 9-4

Predicted Abiotic Concentrations under ZOI = 2, Kow = 95% UCL, and Koc = 0.35*Kow



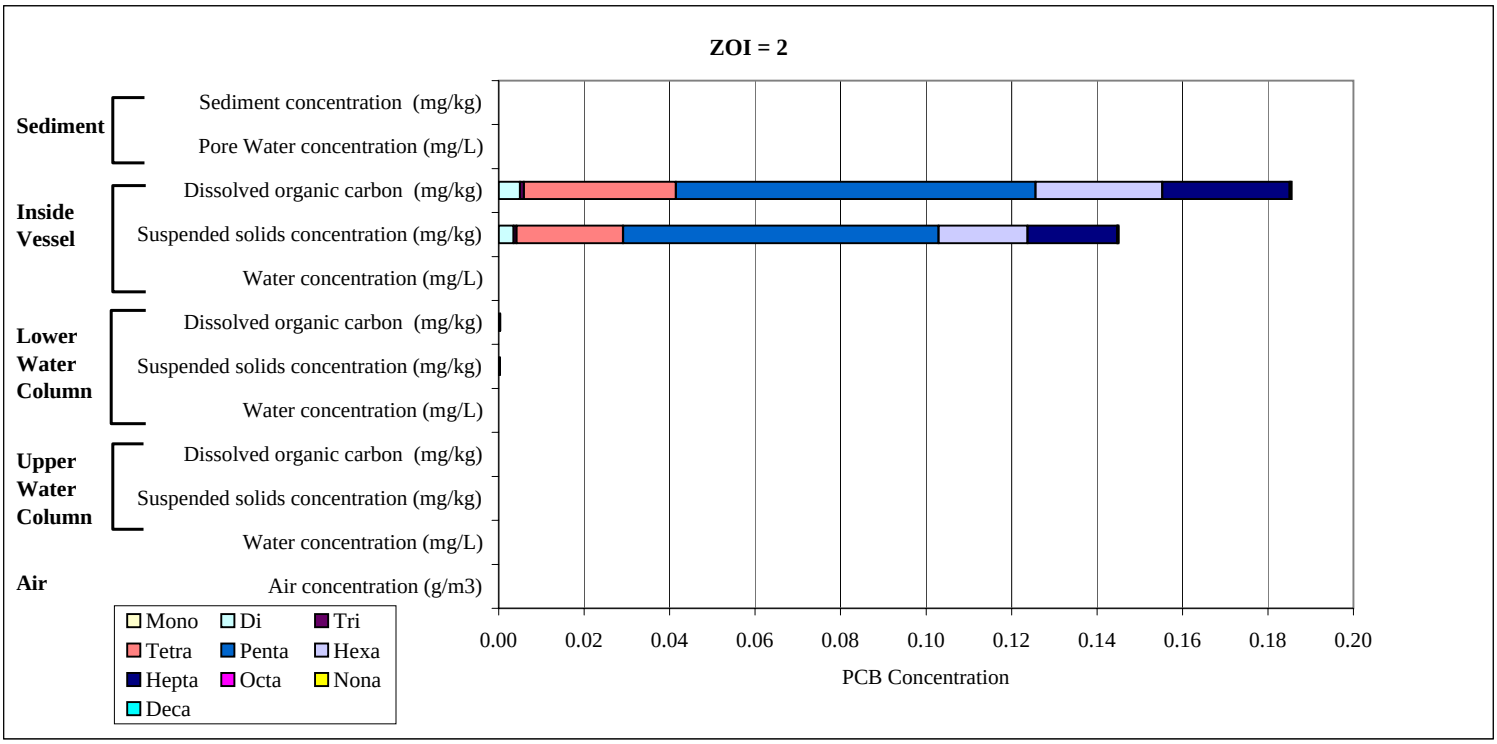
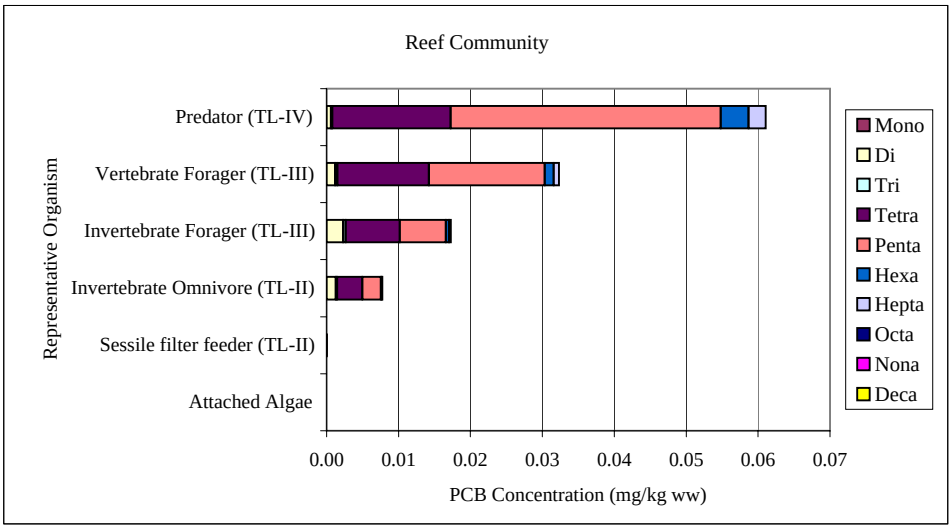
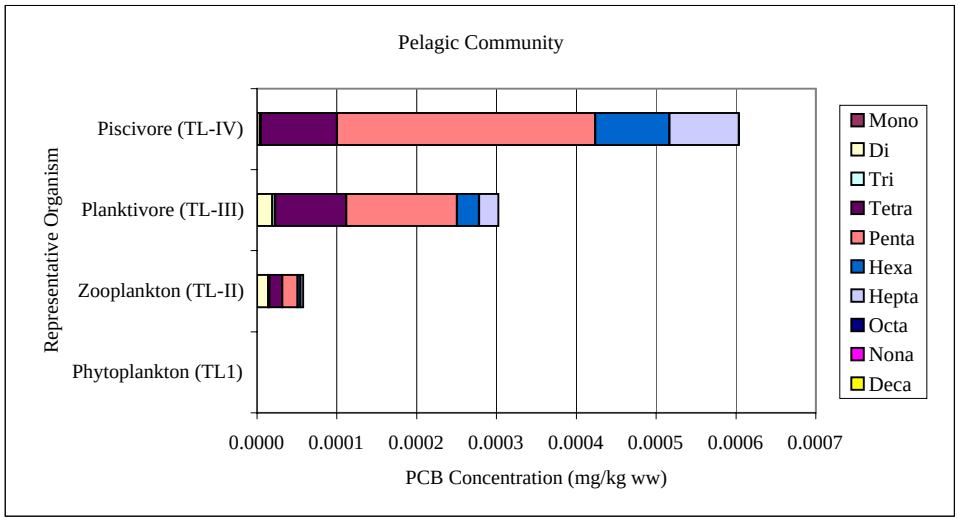
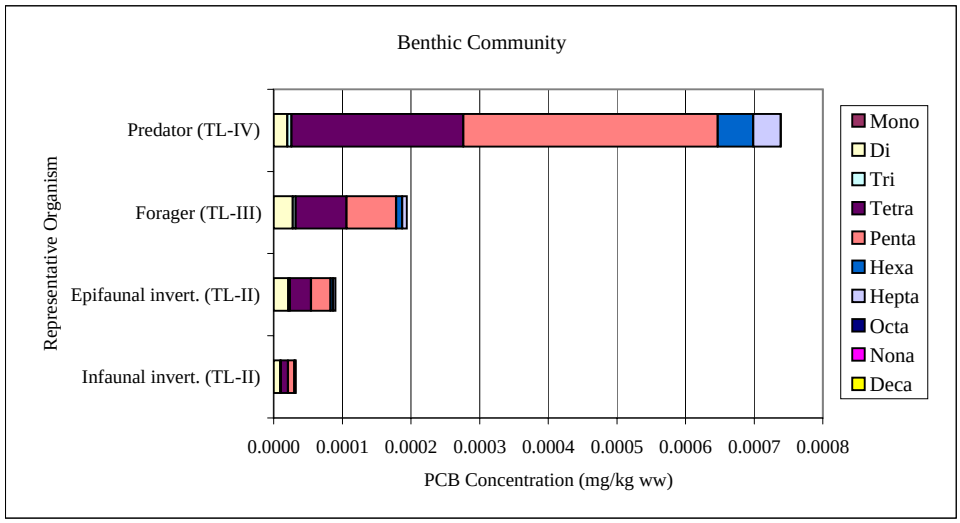


Figure 9-5

Predicted Biotic Concentrations under ZOI = 2, Kow = 95% UCL, and Koc = 0.35*Kow







Note the change in PCB concentration scale for each community.

APPENDIX A

Construction and Operational History of the ex-ORISKANY

APPENDIX A

DEPARTMENT OF THE NAVY -- NAVAL HISTORICAL CENTER
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WASHINGTON, D.C. 20374-5060

Online Library of Selected Images:
-- U.S. NAVY SHIPS --

USS *ORISKANY* (CV-34, later CVA-34 and CV-34), 1950-1994

USS *ORISKANY*, a 27,100 ton *ESSEX* class aircraft carrier, was built at the New York Navy Yard. Though she was launched in October 1945, construction was suspended in August 1947 and she was completed to a revised design that was also used in modernizing several other ships of the *ESSEX* and *Ticonderoga* classes. Commissioned in September 1950, *ORISKANY* deployed to the Mediterranean Sea between May and October 1951 and steamed around Cape Horn to join the Pacific Fleet in May 1952. She made one Korean War combat cruise, from September 1952 to May 1953.

Following the end of the Korean conflict, *ORISKANY* continued her Pacific Fleet service for more than two more decades, deploying regularly to the Western Pacific for tours of duty with the Seventh Fleet. She was out of commission from January 1957 until March 1959, during which time she was modernized with a new angled flight deck, steam catapults, an enclosed "hurricane" bow and many other improvements that permitted safer operation of high-performance aircraft. In 1961, she became the first aircraft carrier to be fitted with the revolutionary Naval Tactical Data System (NTDS).

ORISKANY's second war began with her 1965 WestPac cruise, during which her planes hit targets in North and South Vietnam. Several more combat tours followed as the Southeast Asian conflict waxed and waned. Tragedy struck the carrier on 26 October 1966, during her second Vietnam War deployment, when fire ravaged her forward compartments, killing 44 members of her crew and air group. *ORISKANY* was repaired in the U.S., returned to the war zone in mid-1967 and rendered assistance to USS *Forrestal* when that carrier also suffered a major fire. Following twenty-six years of service, USS *ORISKANY* was decommissioned in September 1976. She was stricken from the Naval Vessel Register in July 1989 and sold for scrapping in 1994. However, after a prolonged effort that exhibited the perilous state of the domestic ship-breaking industry at the end of the Century, she was repossessed in 1997 and is presently in U.S. Government custody awaiting her final fate.

Photo # NH 97410 USS Oriskany off the San Francisco Naval Shipyard, 27 April 1959

Appendix B

Site Characterization Report

(FFWCC and Escambia County Application)

APPENDIX B

LETTER OF APPLICATION TO THE DEPARTMENT OF TRANSPORTATION, MARITIME ADMINISTRATION FOR TRANSFER OF AN OBSOLETE SHIP PURSUANT TO PUBLIC LAW 92-402 (16 U.S.C. 1220 *et. seq*.) APPROVED AUGUST 22, 1972, AS AMENDED BY H.R. 4546 SECTION 3504(a) TO THE STATE OF FLORIDA FOR USE AS AN ARTIFICIAL REEF

PART I. Applicant

a. State of Florida, represented by: The Florida Fish and Wildlife Conservation Commission (FWC) who is sponsoring this project on behalf of Escambia County, Florida.

b. FWC Point of Contact: Jon Dodrill, Natural Science Manager
Florida Fish and Wildlife Conservation Commission (FWC)
Division of Marine Fisheries
620 South Meridian Street, Box MF-MFM
Tallahassee, Florida
32399-1600
(850) 922-4340, ext. 209
jon.dodrill@fwc.state.fl.us

c. Escambia County Point of Contact: Robert K. Turpin, Chief
Escambia County Marine Resources Division (ECMRD)
1190 West Leonard Street
Pensacola, FL 32501
(850) 595-4395; (850) 554-5869
robert_turpin@co.escambia.fl.us

PART II. Ship Desired

Ex U. S. S. ORISKANY (Aircraft Carrier, CVA-34, Essex class)

PART III. Preparation of Ship for Sinking

Per Solicitation No. N62678-03-R-0070, the U. S. Navy, in accordance with a contract entered into with Resolve Marine Group, is the party responsible for contracting the movement of the ship from the Beaumont Reserve Fleet to a Navy approved facility for preparation of the ship. Navy will also oversee vessel preparation in accordance with Draft Best Management Practices for Cleaning Large Military Vessels as developed by a federal multi-agency working group. (Elizabeth Freese, MARAD, personal communication)

a. Additional preparations beyond the scope of Solicitation No. N62678-03-R-0070 will be managed by Jon Dodrill (FWC) 620 South Meridian Street, Box MF-MFM, Tallahassee, Florida 32399-1600, and Robert Turpin (ECMRD) 1190 West Leonard St., Pensacola, FL 32501.

b. The location of work to be performed under Solicitation No.N62678-03-R-0070, has not yet been finalized by the Navy and its contractor, Resolve Marine Group, as of the time of the submittal of this application. We anticipate that additional preparations would be accomplished at the site of the work performed under Solicitation No. N62678-03-R-0070.

PART IV. Estimated Time of Reef Construction

The timeline for the cleaning, towing and sinking process will be determined by the U. S. Navy. At the time of this application, the approximate date for completion of cleaning and other preparations (per Solicitation No N62678-03-R-0070) is planned to be late April, 2004. Deployment of the vessel as an artificial reef is tentatively planned to occur in May-June, prior to the beginning of hurricane season (June-November).

Because additional work, beyond the scope of Solicitation No N62678-03-R-0070, is planned by the applicant, this work should begin as soon as possible after the Navy/MARAD determination of the recipient. Should the Florida proposal be selected, a separate solicitation of bids will be accomplished by Escambia County. If possible, the additional preparation will be accomplished concurrently with the work presently contracted by the Navy.

US Army Corps of Engineers Permit No. 199402365 (IP-CP) presently authorizes (Expiration date July 21, 2006) the use of steel hull vessels at the proposed ORISKANY deployment site (See Part V). Federal permit documents are contained in Attachment 2. Army Corps of Engineers Regulatory Office in Pensacola, Florida has been notified of the proposal to deploy the decommissioned aircraft carrier USS ORISKANY as an artificial reef at the proposed location. Clif Payne (ACOE), in an email to Jon Dodrill and Robert Turpin, has indicated that the proposed project is consistent with permit criteria (Attachment 2).

Because the proposed location is not within state territorial waters (extending seaward 9 nautical miles) no permits from the State of Florida are required. However, in a November 6, 2003 letter from Davis Struhs (Attachment 4), Secretary, Florida Department of Environmental Protection (FDEP) to Ken Haddad, Executive Director, FWC, the following statement was made: “Placement of the vessel in federal waters eliminates the need for authorization to use sovereign submerged lands and obtaining state permits; however, the state would review the project under the federal consistency provisions of the Coastal Zone Management Act and would have similar concerns for habitat and water quality impacts to federal waters adjacent to state waters.”

US Coast Guard, Marine Safety Office, Mobile, Alabama inspects all vessels deployed as artificial reefs within Escambia LAARS. We prefer to have the ORISKANY inspected by US Coast Guard (MSO Mobile or designated MSO nearest to ORISKANY preparation facility) prior to being towed to the proposed deployment site. In addition to the US Coast Guard inspections required in Solicitation No. N62678-03-R-0070, we anticipate that at least three inspection events would be accomplished: 1) an initial inspection to allow familiarization with the vessel and to identify additional necessary work beyond the scope of the work required in Solicitation No. N62678-03-R-0070; 2) an inspection to be conducted approximately midway through the work being conducted; and, 3) final inspection to ensure thorough and complete preparation in accordance with all Environmental Protection Agency (EPA), FDEP, Navy, US Coast Guard, and FWC/ECMRD requirements. These represent the minimum number of inspections; additional inspections may be required.

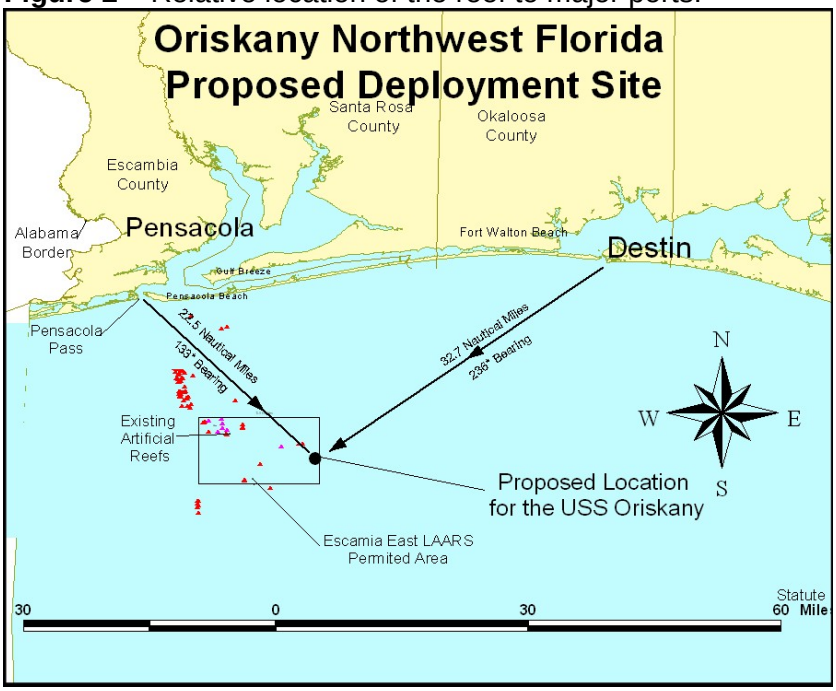
We understand that donation of the ship to a state is contingent upon issuance to the Navy by EPA of a risk-based polychlorinated biphenyl (PCB) disposal permit which allows non-liquid PCB containing materials (e.g., electrical cable insulation, ventilation duct gaskets, paints, and various rubber products) to remain onboard the vessel to be sunk as an artificial reef (Elizabeth Freese, MARAD, 10/23/03 clarifying comments: Application Instructions for the USS ORISKANY.)

PART V. Location of Vessel Sinking

Figure 1- General area of the proposed *USS ORISKANY* Reef

a. **Geographical position**: The ship will be deployed in federal waters of the Exclusive Economic Zone (EEZ) in the northeast Gulf of Mexico (GoM) (Figure 1). The vessel will be placed within the Escambia East Large Area Artificial Reef Site (LAARS) (Figures 2 and 3). This site is permitted for artificial reef construction by the United States Department of the Army, Corps of Engineers Permit No. 19940 2365 (IP-CP) (Corps permit). The 11 nautical mile x 7 nautical mile Escambia East LAARS is described by the following corner coordinates and is graphically represented in Figures 2 and 4:

Figure 2 – Relative location of the reef to major ports.

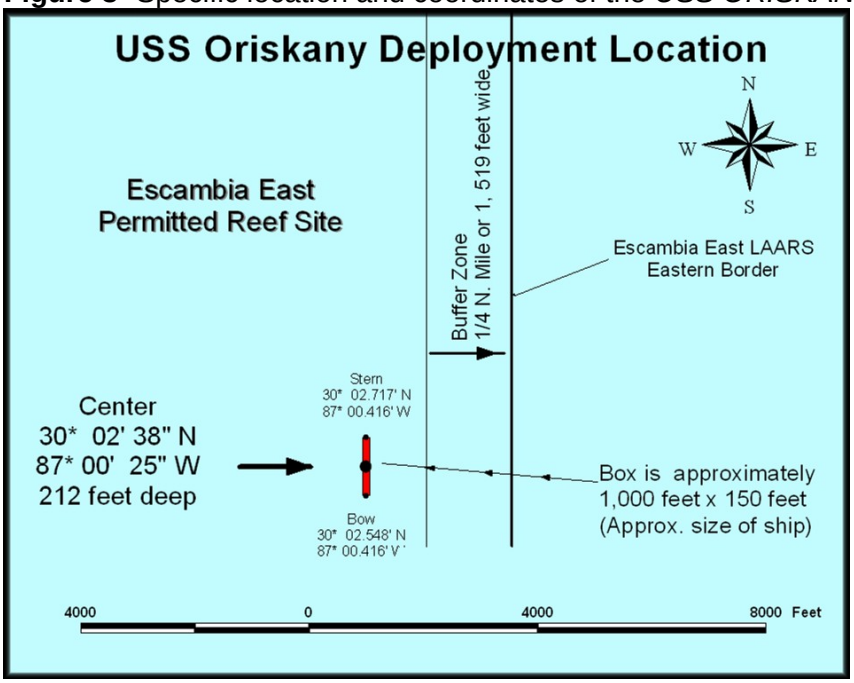


NE Corner	30° 07’ 00” North latitude, 87° 00’ 00” West longitude
SE Corner	30° 00’ 00” North latitude, 87° 00’ 00” West longitude
SW Corner	30° 00’ 00” North latitude, 87° 12’ 30” West longitude
NW Corner	30° 07’ 00” North latitude, 87° 12’ 30” West longitude

The specific site chosen for the vessel within the Escambia East LAARS is defined by the following geographical coordinates and is graphically represented in Figure 3:

Bow	30° 02’ 33” North latitude, 87° 00’ 25” West longitude
Approx. center (superstr.)	30° 02’ 38” North latitude, 87° 00’ 25” West longitude
Stern	30° 02’ 43” North latitude, 87° 00’ 25” West longitude

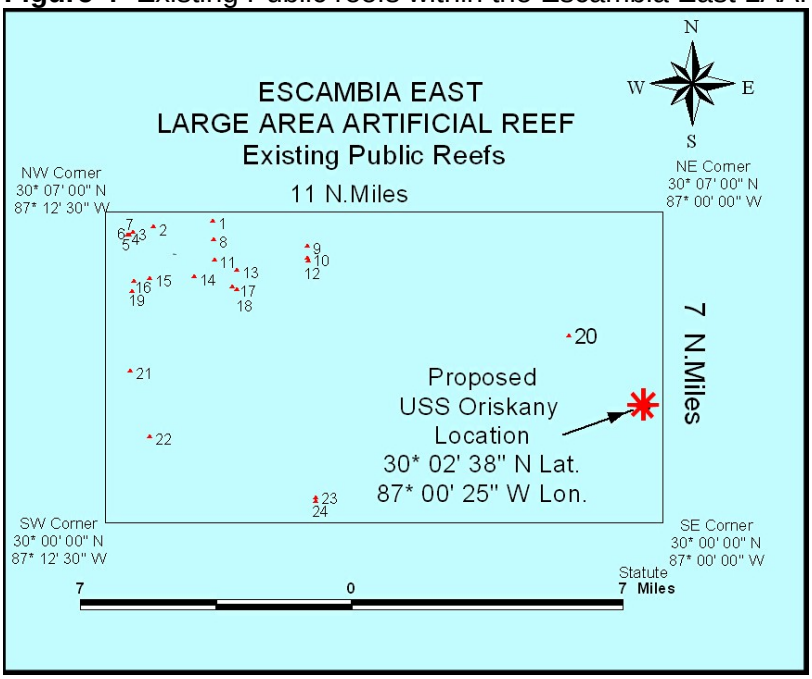
Figure 3- Specific location and coordinates of the *USS ORISKANY* Reef



This location was selected to provide adequate water depth (212 feet) needed to maintain the Permit-required safe navigation clearance (55 feet) over the vessel. The location is more than 1/3 nautical mile from the permitted site's nearest (eastern) boundary (Figure 3). The proposed site is 22.5 nautical miles on a bearing of 133 degrees from Pensacola Pass, and 32.7 nautical miles on a bearing of 236 degrees from Destin Pass.

The preferred orientation of the *USS ORISKANY* is with the bow facing south. This is due to our desire to present a minimal surface area exposure to the anticipated direction of storm-generated waves. Additionally, this orientation will allow access to the ship by the maximum number of vessels (in summer) due to prevailing wind directions from the southeast (trade winds) and southwest (summer convection winds). This allows boat operators to anchor or drift over the largest dimension of the artificial reef.

Figure 4- Existing Public reefs within the Escambia East LAARS.



The Escambia East LAARS permitted site is approximately 77 square nautical miles and contains a minimal known quantity of low relief ephemeral natural limestone ledges. Twenty-four (24) publicly constructed artificial reefs (Table 1) have been placed in the site (Figure 4) since 1994, including: concrete prefabricated artificial reef modules, concrete bridge rubble, concrete culverts, steel (M60) battle tanks, steel tugboats and barges, and two retired energy production platform jackets. Past public artificial reef construction within Escambia East LAARS has been concentrated at the northwest corner. However, artificial reef projects utilizing materials with greater vertical profiles (e.g., retired energy production platform jackets) have been placed at other locations throughout the site. The closest public artificial reef to the proposed USS ORISKANY reef site is more than 1.5 nautical mile. This rate and pattern of public artificial reef development is planned to continue in the future.

Table 1 – Existing Public reefs within the Escambia East LAARS .

NUMBER	COUNTY	DEPLOYDATE	REEFNAME	LATITUDE	LONGITUDE	DESCRIPTION	DEPTH
1	SANTA ROSA	6/20/1996	EAST LAP REEFBALLS	3006.820	8710.080	2ND OF FIVE LOADS, 5 EACH ALSO AT 13270.4/47049.5 & 13285.6/47050.9	94
2	SANTA ROSA	6/19/1996	EAST LAP REEFBALLS	3006.680	8711.410	1 1ST OF FIVE LOADS,15 BALLS-5 EACH @ 13270.6/47049.8& 13270.3/47049.7	94
3	ESCAMBIA	12/18/1994	ARMY BATTLE TANK	3006.566	8711.876	REEF EX TANK #13-PENSACOLA	105
4	ESCAMBIA	12/18/1994	EAST LAP 'ARMY TANKS'	3006.508	8711.977	REEF EX TANK #11- PENSACOLA	105
5	ESCAMBIA	12/18/1994	EAST LAP 'ARMY TANKS'	3006.508	8711.957	REEF EX TANK #12-PENSACOLA	105
6	ESCAMBIA	12/18/1994	EAST LAP 'ARMY TANKS'	3006.507	8711.997	REEF EX TANK #9 -PENSACOLA	105
7	ESCAMBIA	12/18/1994	EAST LAP 'ARMY TANKS'	3006.507	8711.997	REEF EX TANK #10-PENSACOLA	105
8	SANTA ROSA	6/25/1996	EAST LAP REEFBALLS	3006.400	8710.070	3RD OF FIVE LOADS, 5 EACH ALSO AT 13286.1/47050.8 & 13286.8/47050.8	94
9	ESCAMBIA	6/20/2000	CONCRETE ' FISH HAVENS'	3006.257	8707.964	FISH HAVEN MODULES, 6 TOWER, 11 FH & 4 JUNIORS (1 OF 3)	86
10	ESCAMBIA	6/26/1999	CONCRETE ' FISH HAVENS'	3005.983	8707.960	CENTER FOR 53 FISH HAVENS (35-FHT & 18-FH)	87
11	SANTA ROSA	6/26/1996	EAST LAP REEFBALLS	3005.938	8710.052	4TH OF FIVE LOADS, 5 EACH ALSO AT 13285.1/47048.4 & 13286.4/47048.4	94
12	ESCAMBIA	6/20/2000	CONCRETE ' FISH HAVENS'	3005.916	8707.950	FISH HAVEN MODULES, 6 TOWER, 11 FH & 4 JUNIORS (3 OF 3)	86
13	SANTA ROSA	6/27/1996	EAST LAP REEFBALLS	3005.710	8709.540	5TH OF FIVE LOADS, 5 EACH ALSO AT 13288.5/47044.9 & 13288.1/47045.0	94
14	SANTA ROSA	10/24/1996	EAST LAP 'CHEMICAL COURIER'	3005.560	8710.500	80 FT X 25 FT. WIDE X 38 FT. TALL TUG THE "CHEMICAL COURIER"	95
15	ESCAMBIA	2/9/2002	PENHALL REEF	3005.523	8711.497	BLACKWATER BRDIGE RUBBLE, 4 LOADS TOTAL	92
16	ESCAMBIA	6/14/2003	CELIA REEF	3005.465	8711.850	15 WALTER FLORIDA SPECIAL MODULES, 1 OF 2 DROPS THIS DAY & GRANT	95
17	ESCAMBIA	4/1/2000	NAVY DIVE TENDER YDT-14	3005.330	8709.640	132 FEET LONG , 312 TONS NAVY DIVE TENDER (1 1ST OF TWO THIS DATE)	90
18	ESCAMBIA	4/1/2000	NAVY DIVE TENDER YDT-15	3005.267	8709.550	132 FEET LONG , 312 TONS NAVY DIVE TENDER (2ND OF TWO THIS DATE)	90
19	ESCAMBIA	6/14/2003	MARA	3005.235	8711.895	16 WALTER FLORIDA SPECIAL MODULES, 2 OF 2 DROPS THIS DAY & GRANT	92
20	ESCAMBIA	10/18/1993	CHEVRON PLATFORM	3004.244	8702.118	OIL RIG STRUCTURE, TWO JACKETS LAYING SIDE BY SIDE	137
21	SANTA ROSA	6/2/2003	SANTA ROSA MARINE RESORT	3003.452	8711.933	4 TOWERS, 30 HAVENS AND 30 JUNIORS, 5 SITES	97
22	ESCAMBIA	2/12/2003	KNICKLEBINE BARGE	3001.974	8711.496	STEEL BARGE AND 14 PIECES OF CONCRETE BALLAST	124
23	ESCAMBIA	9/27/1995	ANTARES' SHIP	3000.594	8707.775	387 FOOT FREIGHTER - ANTARES	130
24	ESCAMBIA	5/8/1997	BRIDGE PILINGS	3000.519	8707.774	22 PIECES BRIDGE PILINGS, 4'X4'X30' (MPR), SECOND OF 3 LOADS	128

b. **Substrate and Physical Oceanography Conditions**: 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 feet. 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 feet, 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 feet 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.

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 (64 n. mi south of Dauphin Island, AL), average wind speed is less than 10 knots in summer, and less than 15 kn (September – April). Annual average wind speed at Pensacola is 7.4 knots (NOAA, 2003). Wave data from buoy #42040 indicate that wave heights average 2-3 feet in summer, and 3-4 feet 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) and dissipate with depth. Tidal currents are likewise weakened due to the water depth (>200 ft) and distance from estuary outlets (>20 nmi). 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 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. These analyses are presented as Attachment 1. 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 and 215 feet 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 wave height with 9 sec wave interval, determined the ORISKANY would be stable at both 215 feet and 190 feet 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.

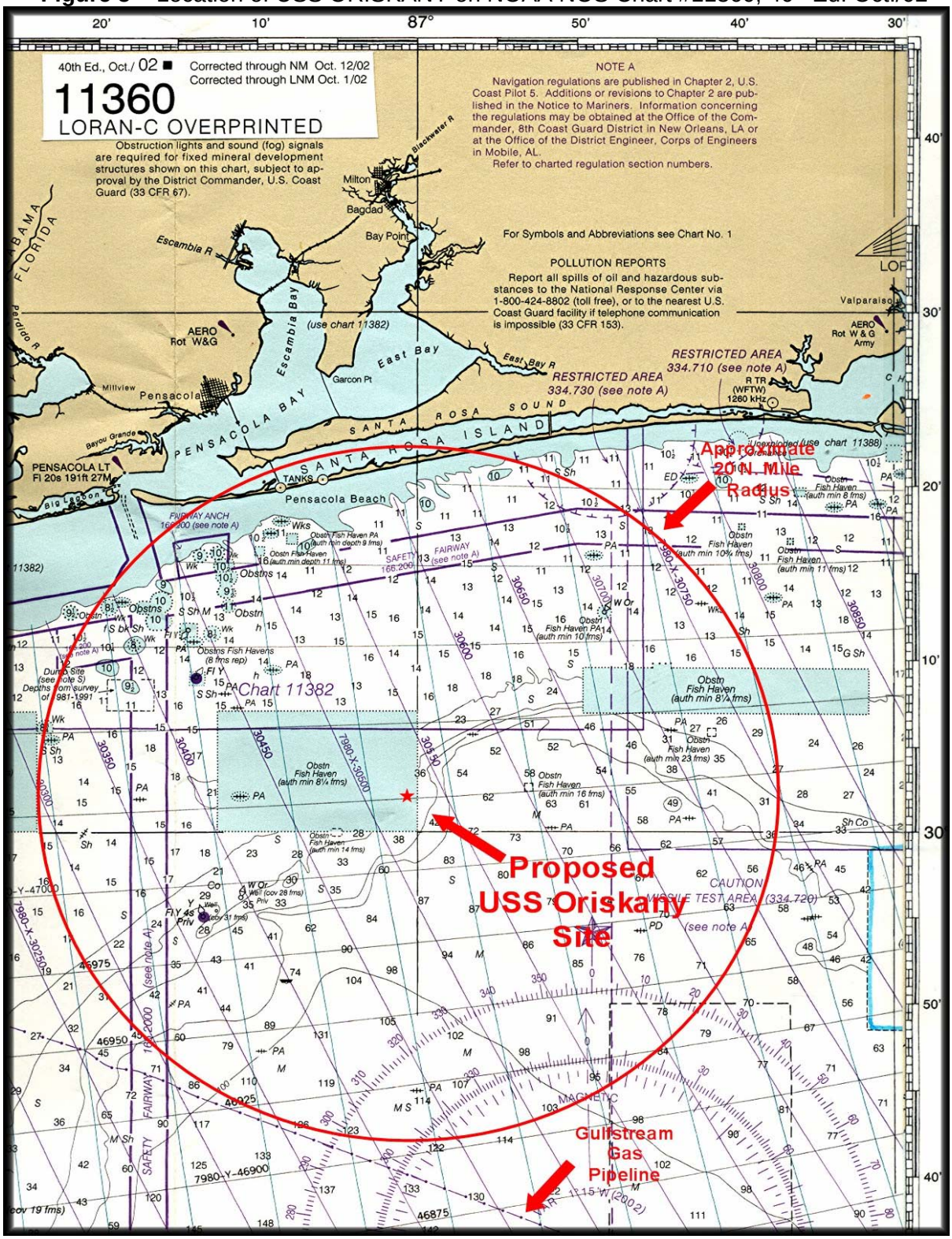
A study was performed on artificial reefs in an Escambia County artificial reef site after hurricanes Erin and Opal (Turpin and Bortone, 2002). Water depths in the study area were much less than at the proposed USS ORISKANY Memorial Reef site (85 ft vs. 212 ft).

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.)

c. **Effects of the Reef on Other Uses of the Area**:

During the initial application for the Escambia East LAARS site, an exclusionary mapping process was undertaken in conjunction with local commercial and recreational fishing interests and the Mineral Management Service in order to ensure the permitted site did not conflict with the other existing and/or proposed uses of Escambia East LAARS. The proposed location for the *USS ORISKANY* Memorial Reef is depicted on the following NOAA NOS Chart #11360, 40th Ed. Oct./02 (Figure 5).

Figure 5 – Location of USS ORISKANY on NOAA NOS Chart #11360, 40th Ed. Oct./02



1. **Navigation considerations, including modification of existing channels and procedures of States to insure nautical chart corrections**
During initial permitting of Escambia East LAARS in 1994 (an again during permit reauthorization process in 2001) US Army Corps of Engineers consulted with numerous federal agencies including: US Coast Guard; NOAA (National Ocean Service, National Marine Fisheries Service); and Minerals Management Service. The location and dimensions of Escambia East LAARS reflect the thorough review and elimination of potential conflicts with other uses of the area. The artificial reef created by the proposed USS ORISKANY Memorial Reef is not expected to have any conflicts with navigational considerations as evidenced by issuance of the Corps permit. The main Safety Fairway into the Port of Pensacola is located 14 nautical miles to the west of the proposed deployment site. An auxiliary east-west Safety Fairway is located 14 nautical miles to the north of the proposed site (Figure 5). Two existing Fairway Anchorages bracket the Safety Fairway near the entrance to Pensacola Pass, approximately 18 nautical miles northwest of the proposed USS ORISKANY Memorial Reef site. The sinking of the ship will have no impacts on any existing navigational channel and therefore no modification of existing channels would be required. Additionally, no nautical chart corrections will be necessary (site is presently designated as and artificial reef site).

The proposed deployment site is located within the Escambia East LAARS which has previously been charted by the U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service (NOAA-NOS) as an artificial reef permit site and is shown of the latest version of Nautical Chart Number 11360 (October, 2002) as a “Obstruction/ Fish haven”(Figure 5). All bathymetric information has been removed from the chart ed artificial reef area and replaced with standard blue shading. Also, as noted on the chart, maximum clearance is 8 ¼ fathoms (50 feet), however Army Corps reef permit requires an additional five feet of clearance (total clearance: 55 feet). Direct notification will be made to the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service (NOAA-NOS) of the actual location of the ship on the bottom. This will occur within 14 days after the sinking, so that an interim Notice to Mariners can be issued by this agency. This notification is required by Special Condition Number 9 of the current Corps permit.

2. **Interference with commercial fishing**
The Escambia East LAARS permitted artificial reef site has been in existence for nearly a decade and contains public and private artificial reefs scattered throughout the site. Because of the designation on the nautical chart as an “obstruction” area, and the presence of artificial reef structures, commercial trawling within the site is highly unlikely. Commercial hook and line fishing currently occurs at existing artificial reefs located within the Escambia East LAARS. The creation of a new artificial reef using the vessel is anticipated to substantially benefit this industry by providing an extremely large artificial reef, which will provide shelter and food resources to commercially important pelagic and benthic fish species. The very large size of this structure is intended to provide habitat diversity to the naturally occurring isolated low-relief reefs, as well as small artificial reefs. This topic will be more fully explored in Part V(d)(3), as well as part VII(b)(1).

3. **Any uses of the area that will be curtailed by reef building, including commercial, recreational, and aesthetic uses**
Because the proposed USS ORISKANY Memorial Reef site is within a nine year old designated artificial reef permitted area that, in its original permitting, avoided other potential use conflicts, there are no anticipated conflicts from this proposed artificial reef project.

4. **Any enhancement of the area other than fishing benefits, likely to result from reef building**
Other uses of the Escambia East LAARS such as SCUBA diving and recreational fishing will not be curtailed by the deployment of the vessel, but rather will experience substantial benefits resulting from the enhancement of marine life habitat via placement of the ORISKANY on the seafloor, as described in Part VII(b)(1). The deployment of the vessel is anticipated to substantially enhance the Escambia East LAARS by providing a large amount of new physical structure upon which vertebrate and invertebrate, sessile and motile marine organisms will be able to settle on and subsequently colonize. The long-term effect of the vessel deployment will consequently result in a vast increase in both the diversity and biomass of a large number of reef obligate marine organisms and fish species. Thus, these marine life habitat enhancements are expected to generate concomitant benefits to fishing and diving interests.

In particular, recreational SCUBA diving is expected to be a significant and important utilization of the USS ORISKANY Memorial Reef. Because the ORISKANY will be the first aircraft carrier to be sunk for the intended purpose of creation of an artificial reef, and because of the strong relationship between the ship's purpose (i.e., naval aviation) and the adjacent Naval Air Station Pensacola, we anticipate a strong interest and utilization of the USS ORISKANY Memorial Reef by SCUBA divers. The existing inventory of dive charter vessels in the three closest ports (i.e. Pensacola, Destin and Gulf Shores, Alabama) are expected to benefit from additional diving demand. It is likely that additional dive as well as fishing charter boats will be added to the local charter fleet.

Placement of the USS ORISKANY at the proposed site will provide the impetus of a regional increase in interest of naval aviation and military history, as well as a regionally important addition to the state/local artificial reef program. Therefore existing local naval and maritime attractions should experience an increase in interest.

d. **Locate and Identify the Following that Exist or are Contemplated to Exist within a 20-mile Radius of the Proposed Site**: The following types of associated structures within a 20-mile radius of the proposed reef site are as follows:

1. **Submerged pipelines**: No submerged pipelines are present within, or adjacent to the site proposed for the sinking of the ship within a 20-mile radius. The closest pipeline, a 36" natural gas pipeline running from Mobile, Alabama to Port Manatee, Florida, on the SW Florida gulf coast, passes 23 nautical miles to the south of the proposed USS ORISKANY Memorial Reef site (Figure 5).

2. **Transmission cables**: According to NOAA Navigation Chart 11360 (Oct. '02 edition), no fiber optic cables or other types of transmission cable are present within, or adjacent to the site permitted for the sinking of the ship within a 20-mile radius.

3. **Coral reefs, recreation beaches, commercial fishing areas, or other historical or cultural sites**: No tropical stony coral reefs exist within 300 nautical miles of the proposed artificial reef site. As previously stated, isolated low-relief (<3ft) rock outcroppings occur (less than 3-5% occurrence) in the northeastern Gulf of Mexico. These rock outcroppings, also called "hard bottom" and "live bottom", provide suitable substrate for attachment of non-reef building stony corals, sea fans, sea whips, and sponges. Due to their low vertical relief and the shifting nature of sandy seafloor sediments, these low-relief rock outcroppings exist ephemerally. The closest reported rock outcropping to the proposed USS ORISKANY Memorial Reef site is a small (approximately 50 ft x 50 ft) low-relief structure approximately 3600 ft northeast of the proposed artificial reef site.

   Recreation beaches exist on Santa Rosa Island, 18+ nautical miles north of the proposed artificial reef site (Figure 5). Because environmental cleaning standards will be followed, no negative impacts to recreation beaches will result from the proposed artificial reef project.

   Commercial trawling within 20 nautical miles of the proposed artificial reef is rare. There is no known trawling within the nine year old, 77 square nautical mile permitted Escambia East LAARS. However, very sporadic exploratory scallop trawling by vessel(s) from other areas has been reported from the northeastern Gulf of Mexico, and may have previously occurred within 20 nautical miles. Productive food shrimp habitat occurs in predominantly muddy bottom sediments. The closest food shrimp trawling occurs within Pensacola Bay, more than 20 nautical miles from the proposed artificial reef. Commercial longline operations are prohibited within the 50-fathom contour, thus may exist within 20 nautical miles, but not closer than three nautical miles, from the proposed USS ORISKANY Memorial Reef site.

   Fish traps are prohibited west of 85.5 degrees West longitude, therefore do not occur within approximately 75 nautical miles of the proposed USS ORISKANY Memorial Reef site.

   Commercial hook-and-line fishery operations occur in the NE Gulf of Mexico, and may utilize natural and artificial reefs within Escambia East LAARS, as well as outside Escambia East LAARS. Commercial hook-and-line "reef fish" fishery operations are generally multi-day trips that target fishes such as grouper, snapper, triggerfish, and jacks found at natural and artificial reefs. Additional artificial reef deployments, including the proposed USS ORISKANY Memorial Reef, will likely enhance the commercial hook-and-line fishery.

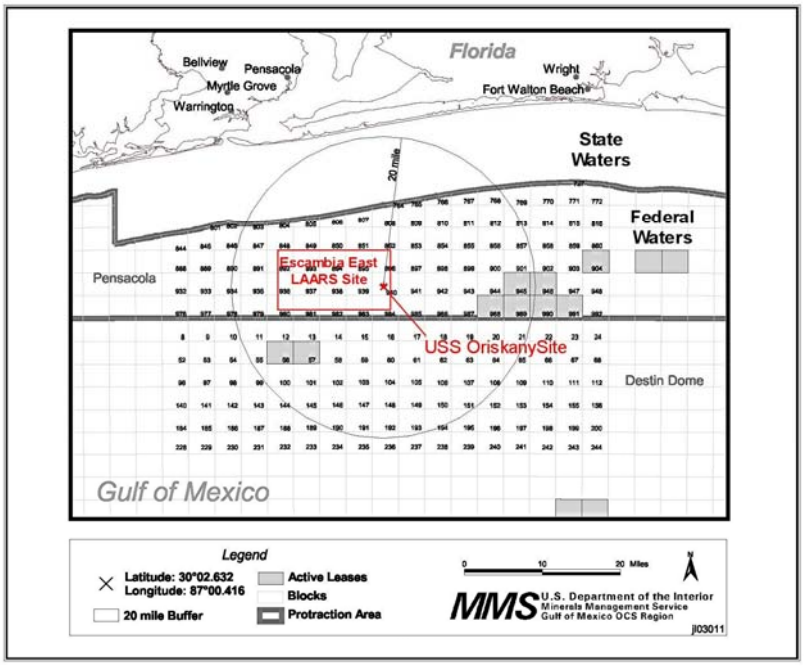
   The closest known historic and/or cultural site to the proposed USS ORISKANY Memorial Reef is the Battleship USS Massachusetts (CB-2, previously BB-2), approximately 22 miles northwest of the proposed USS

ORISKANY Memorial Reef. This coastal battleship was designated as an Underwater Archaeological Preserve by the State of Florida in 1993 (Florida Dept. of State).

4. Additional potential items of consideration, including: offshore mineral resources and/or exploration and extraction activities, military target or other restriction areas, dredge spoil disposal areas, unexploded ordinance disposal areas

Active oil and gas lease areas: At present, two Department of the Interior, Minerals Management Service (MMS) Outer Continental Shelf (OCS) leases exist approximately 11 nautical miles southwest of the proposed USS ORISKANY Memorial Reef site (Figure 6). These two adjacent nine square nautical mile leases (OCS Destin Dome Blocks 56 and 57) are leased to Murphy Oil, Inc. Three leases (Pensacola Blocks 945, 988, and 989) are located approximately 12 nautical miles east of the proposed artificial reef site. However oil and gas activities have been prohibited in the eastern Gulf of Mexico offshore of Florida for a number of years. Current oil and gas activities, including lease purchases and exploration, are occurring in much deeper water off Alabama and westward (MMS *GULF Focus Newsletter*, October 2003). Regardless of future utilization of these OCS leases, the distance between the leases and the proposed site of the USS ORISKANY Memorial Reef virtually eliminates any potential conflicts.

Figure 6 – Active oil or gas lease blocks in the area.



Previous beach restoration projects at Santa Rosa Island and Perdido Key have utilized sand resources from inshore/nearshore navigation channel dredging activities and an additional suitable sand source site approximately 15 nautical miles northwest of the proposed USS ORISKANY Memorial Reef site. Additional potential sand source sites have

been investigated. A particular potential sand source site is limited by sand quality and/or water depth and distance to the beach to be renourished. The proposed USS ORISKANY Memorial Reef site, due to its distance offshore and water depth, has not been investigated for beach renourishment sand resources. Due to water depth and distance to shore, it is unlikely that the proposed site will be utilized for beach renourishment projects.

Military target or other restriction areas: During initial permitting of Escambia East LAARS, US Navy was contacted to determine if any operational conflicts would exist from the use of the proposed artificial reef area. No potential conflicts were identified.

A general Note to navigation interests "Caution Missile Test Area" is shown on NOAA Navigation Chart No. 11360 (Figure 5), more than ten nautical miles southeast of Escambia East LAARS. In addition, just south of the Missile Test Area is a charted "Unexploded Ordnance" area 16.85 nautical miles southeast of the proposed USS ORISKANY Memorial Reef site. Neither the Missile Test Area or Unexploded Ordnance Area present safety or operational concerns to Escambia East LAARS in general, nor the ORISKANY site specifically.

Dredge spoil disposal areas: No Dredge Spoil Disposal areas exist within 20 nautical miles of the proposed USS ORISKANY Memorial Reef site. However, a "Dump Site" is depicted on NOAA Chart No. 11360 on the western side of the main Safety Fairway into Pensacola. This site is approximately 17 nautical miles northwest of the proposed USS ORISKANY Memorial Reef site, therefore will not be negatively impacted by the proposed artificial reef project.

e. <u>Method of Marking Reef Locations</u>:

No navigation of surface mooring buoys are anticipated for the proposed USS ORISKANY Memorial Reef unless required by the US Coast Guard, Eighth District, New Orleans, LA. Adherence to the permit-required 55 foot navigation clearance over the uppermost portion of the ship obviates the necessity of a marking buoy.

1. Type of buoy:

Mooring Buoys: Presently, no artificial reefs in the northeastern Gulf of Mexico are fitted with mooring buoys. Telephone consultations with other northwest Florida artificial reef managers were accomplished; all parties concluded that no mooring buoys should be attached to the *USS ORISKANY* Memorial Reef. Justifications for this conclusion include: lack of success with previous buoys; likelihood that unlit buoys pose a threat to navigation safety; historic and present use patterns of artificial reef do not include mooring buoys; presence of buoys would negatively impact trolling, drift fishing, etc.; buoy lines would entangle fishing lines and increase loss of fishing line and tackle (marine debris); substantial initial cost ($12, 000) and annual maintenance cost ($4,000/year); potential exposure to liability; and, reduction of the potential number of boats that could utilize the

structure. Presently, local boat operators utilize artificial reefs for fishing and diving by: anchoring to the structure with a “wreck anchor”; anchoring in the sand upwind & up-current of the structure; buoy the structure and/or drift over the site or use boat engine to hold position over the structure; and, troll over and around the structure.

Although present use patterns of existing artificial reefs in the region do not indicate the necessity of installing mooring buoys (surface or subsurface buoys), we plan to provide attachment points on the ship prior to deployment. These attachment points, either pad-eyes welded to the superstructure and hull, or holes through which chain could be run, will provide attachment points for dive operators. These attachment points will also provide the flexibility for installation of mooring buoys in the event that actual utilization of the USS ORISKANY Memorial Reef necessitates.

Navigational Buoys: Navigational buoys are not required within the Escambia East LAARS site by the U. S. Coast Guard unless the minimum navigational clearances specified in the Corps permit are not followed. As the minimum navigational clearance will be met given the most likely final resting orientations of the vessel on the bottom, it is not proposed to place any navigational buoys at the deployment site.

2. **Charting:**

The Escambia East LAARS is currently located on the most recent revision of NOAA Nautical Chart Number 11360, October 2002 (Figure 5). The LAARS has been charted for nearly a decade. Direct notification to the U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service (NOAA-NOS) of the actual position of the ship on the bottom will occur within 14 days after the sinking so that a Notice to Mariners can be issued; as required Special Condition Number 9 of the Corps permit.

3. Buoy Maintenance:

Based on the information provide in sections 1 and 2 (above), Escambia County Marine Resources Division recommends that no buoys be attached to the *USS ORISKANY* Memorial Reef. However, if it is determined that buoys must be utilized, Escambia County marine Resources Division would be responsible for maintaining them on behalf of the State of Florida.

4. Minimum Depth of Water over Sunken Ship when in Place:

As per Special Condition Number 9 of the Corps permit, a minimum of 55 feet of navigational clearance will be maintained over the vessel at Mean Low Water. The proposed location for the vessel sinking has taken into consideration the possibility that the vessel may not land exactly upright, nor exactly flat on either the starboard or the port side (due to the concave configuration of the hull below the flight deck). Given the worst case scenario (in terms of maintaining minimum navigational clearances) with a maximum beam dimension of 157 feet, it is estimated that the vessel could

rest at as much as a 90 degree angle relative to the seafloor. This would result in the overall vertical relief of the vessel at its maximum would be approximately 157 feet. Therefore, the site proposed for the vessel sinking has been selected so as to have a minimum of depth of 212 feet, resulting in the ability to maintain minimum navigational clearances. At this site, if the vessel settles in the preferred upright orientation, the minimum navigational clearance would be increased to 61 feet. In addition, based on previous vessel deployments in the local artificial reef program, the USS ORISKANY is expected to subside several feet into the seafloor. Therefore, additional clearance over the vessel would be achieved.

PART VI. Plan and Procedures for Vessel Sinking

The plan and procedures for sinking the vessel will be determined by the U. S. Navy. A detailed sinking plan will be requested from the Navy in accordance with the turn-key nature of this project. Escambia County Marine Resources Division will assist during the deployment through the placement of temporary marker buoys at the bow, center, and stern coordinates for the vessel to identify the proposed sinking location while the vessel is being anchored in place. Escambia County Marine Resources Division will also provide the coordination with local law enforcement agencies such as the Florida Fish and Wildlife Conservation Commission Division of Law Enforcement, Escambia County Sheriff's Marine Unit, and U. S. Coast Guard to maintain the buffer zone required during the sinking process. If additional vessel support is needed, Escambia County Marine Resources Division will coordinate support from local chapters of Coast Guard Auxiliary and US Power Squadron.

PART VII. Conservation goals

a. Short Term and Long Range Conservation Goals:

1. Short Term Conservation Goals

Upon deployment, short-term conservation goals are to provide substrate for future colonization of the vessel by benthic marine organisms, and to create horizontal and vertical relief as well as structural complexity to provide shelter from predation for a broad spectrum of fish and invertebrate species. Based upon prior experiences with large structures deployed as artificial reefs in tropical waters, the substantial ship habitat will support a widely diverse community of invertebrates and fishes. This topic is more fully discussed below in Part VII(b)(2).

2. Long Range Conservation Goals

The primary long range conservation goal is to provide a stable, long-term, complex artificial reef that will establish habitat for invertebrate and fish species for at least a century. This duration is based on the current performance of the aircraft carrier USS Saratoga (CV-3) intentionally sunk during nuclear weapons testing at Bikini Atoll (National Park Service and US Department of Energy shipwreck assessment 1989-90).

In addition, the proposed USS ORISKANY Memorial Reef is intended to integrate with Escambia County's Artificial Reef Plan (Turpin, 2002). Goals of the Escambia County Artificial Reef Plan (ECARP) include:

i. enhance the (primarily sand) seafloor of the marine and estuarine waters of, and adjacent to, Escambia County by the placement of stable and durable artificial reef materials for the purpose of creating habitat for reef-associated species of fishes and invertebrates
ii. increase regional abundance of marine life species
iii. reduce negative impacts to natural reefs
iv. provide fishing and diving opportunities for the residents and tourists of Escambia County
v. increase fishing and diving success, and artificial reef-user satisfaction

A specific example of how the USS ORISKANY Memorial Reef may accomplish a fishery conservation goal involves the red snapper (*Lutjanus campechanus*), the most commercially and recreationally important fish species in the region. Presently, this species is being managed through bag and size limits, as well as a closed season which occurs between November 1 and April 15 each year. During the closed season this species potentially would be able to increase in size and biomass without the threat of fishing mortality, thus may contribute to the fishery production of this species within the Escambia East LAARS.

An additional long range conservation goal is the establishment of a reef community in an underutilized section of Escambia East LAARS, at a greater water depth than presently utilized in Escambia County's artificial reef program.

In response to Army Corps of Engineers Request for Additional Information during permit renewal, FWCC summarized long term benefits [goals] of artificial reef construction within Escambia LAARS: "The FWCC by requesting a reauthorization of the Escambia East and West permits seeks to enhance fishery resources under the existing conditions of allowing continued fishing access to these areas. This will be done in two ways. The first will be by continued support of science-based stronger fishery management initiatives for over-exploited reef fish species in the Gulf of Mexico. The Gulf of Mexico Fishery Management Council has continued to move towards reductions in bag limits of some reef fish species, increases in minimum size limits, and has instituted some closed season requirements."

Long term conservation goals are accomplished through the long term availability of suitable habitat. Suitable habitat is particularly important, and may be limited, after hurricanes. Northwest Florida and Alabama fisheries are greatly dependent upon a system of relatively small artificial reefs. The deleterious effects of hurricanes on artificial reefs have been investigated (Turpin and Bortone, 2002). Additionally, tagging studies on red snapper have been done by Shipp, et al. at the University of South Alabama, and demonstrated red snapper displacement to the east (towards Florida) after major hurricanes. Based upon previous experience with large vessels as artificial reefs, we expect the USS ORISKANY Memorial Reef to provide dependable, long term reef fish habitat, therefore satisfying these long term conservation goals.

b. Fisheries Analysis – With Ship Reef

1. Sport fishery benefits, including annual catch and worth

The creation of this artificial reef will provide an additional offshore location for the regional recreational fishery. Recent estimates of the amount of naturally occurring hard bottom from Cape San Blas to Pensacola indicate that approximately 3% of the west Florida shelf in this region contains hard bottom (Thompson, M. J., W.W. Schroeder and N.W. Phillips 1999). Therefore, in the Pensacola area, any addition of substrate will have a positive effect on the reef fish fishery resources in the region, especially for those species requiring structure in order to complete their life cycles. Given the large size of the ship, it is anticipated that it will have greater benefits to the recreational fishery than any of the 24 smaller existing public artificial reefs within Escambia East LAARS.

The exact degree of impact on the annual recreational catch and fishery enhancement value of the ship as a site-specific entity is unknown, since specific data on recreational fishing activities and associate landings on individual artificial reefs are not available in Florida; nor is this data available for ships as a broader category that have been intentionally sunk as artificial reefs. However, there are some data available on the magnitude of recreational fishing within Escambia County and the adjacent counties to the east. The National Marine Fisheries Service conducts a Marine Recreational Fisheries Statistics Survey (MRFSS) annually (data courtesy of the Florida Marine Research Institute). Data are not summarized for specific cities such as Pensacola, but rather are recorded on a regional basis (Gulf Coast and Atlantic Coast). The smallest sub-region for which estimates could be obtained for recreational sport fisherman in 2001 was from Escambia County eastward to Gulf County . These data are summarized in Table 2.

Table 2. Recreational Sport Fishery Harvest: Gulf to Escambia Counties in 2001

Distance from shore	Estimated number of fishing trips	Estimated number of fish harvested	Estimated number of fish released
Less than 10 miles	1,740,812	6,237,239	5,879,406
Greater than 10 miles	139,258	1,101,651	859,982

From 1991-1993, a multi-year artificial reef research project was conducted on 64 artificial reefs of various materials and size off the northwest Florida coast. A total of 122 fish species were observed on the study's 64 artificial reefs. Individual reefs had greatly varying fish assemblages. Number of species per reef ranged from two to 20 (mean = 9.52; Std. Dev. = 3.29); number of individuals per reef ranged from 14 to 30, 011 (mean = 1,681; Std. Dev. = 3, 310) (Bortone, et al., 1997). Due to its large size and proposed location in deeper waters farther offshore (than those in the Bortone et al., 1997 study) therefore less-affected by cold winter water temperatures, maximum estimates of fish assemblages for the proposed USS ORISKANY Memorial Reef are: >50,000 fishes from > 30 species; and, numerous

marine invertebrates from the following major taxa: Mollusca, Arthropoda, Echinodermata, Annelida.

Nearly all of the commercially and recreationally important benthic fish species that are commonly found within the Escambia East LAARS site are described as being species with high site fidelity, indicating that these fish tend to stay on the reef (natural or artificial) that they settle on either in the larval stage or recruit to as juveniles. However, as has been observed via tagging studies, adult fishes move from reef to reef to some degree, and particularly after significant environmental events such as seasonal changes and hurricanes. Such species include gray snapper (*Lutjanus griseus*), vermilion snapper (*Rhomboplites aurorubens*), gray triggerfish (*Balistes capriscus*) and red snapper (*Lutjanus campechanus*). These species, as well as greater amberjack (*Seriola dumerili*) and cobia (*Rachycentron canadum*) are species that seem to prefer waters immediately adjacent to artificial reefs. Therefore, the majority of the fish species that will utilize the ship after it is sunk will tend to remain on, or near the ship, taking advantage of the shelter from predation and the food resources present both on the ship and in the surrounding sand bottom.

The Escambia East LAARS is located only 22 nautical miles east of the Alabama border, and recreational anglers from Alabama harvest 35% of the four (4) million pounds of red snapper landed each year in the Gulf of Mexico (Patterson *et. al* 2001). Subsequently, it is anticipated that the placement of the vessel in the site will not only benefit the commercial and recreational fishing sectors of Florida, but those of Alabama as well.

2. Commercial fishery benefits, including annual catch and worth

The U.S.S. ORISKANY may potentially be used for commercial fishing, especially at night or weekdays when recreational fishing and SCUBA diving activities are limited. The latest complete data available from the Florida Marine Research Institute for commercial landing are from 2002. Data are not summarized for specific cities such as Pensacola, but rather are recorded on a county-by-county basis. The 2002 data for Escambia and Okaloosa Counties are presented in Table 3.

Table 3. Commercial Fishery Landings and Value: Escambia and Okaloosa Counties in 2002.

COUNTY	Escambia	Okaloosa
Amberjacks (lbs.)	19,238	44,121
Amberjacks (value)	$18,912	$49,140
Grouper species (lbs.)	75,487	287,744
Grouper species (value)	$179,267	$686,142
Red snapper (lbs.)	131,790	591,519
Red snapper (value)	$295,216	$1,375,993
Vermillion snapper (lbs.)	476,083	367,680

Vermillion snapper (value)	$821,562	$706,323
Gray triggerfish (lbs.)	23,431	44,491
Gray triggerfish (value)	$29,773	$63,591

The total number and revenue generated from the sale of saltwater fishing licenses during fiscal year 2001-02 are summarized in Table 4.

Table 4. Florida Saltwater Fishing License Sales and Revenues from July 1, 2001 through June 30, 2002

Type of License	Escambia	Santa Rosa	Okaloosa
Resident saltwater (number)	8,703	6,761	8,572
Resident saltwater (revenue)	$104,436	$81,132	$102,864
Non-resident saltwater - 12 mo. (number)	1,402	900	2,374
Non-resident saltwater -12 mo. (revenue)	$42,060	$27,000	$71,220
Non-resident saltwater – 7 day (number)	773	1,177	2,509
Non-resident saltwater – 7 day (revenue)	$11,565	$17,655	$37,635
Non-resident saltwater – 3 day (number)	5,514	5,522	15,399
Non-resident saltwater – 3 day (revenue)	$27,570	$27,610	$76,995
Small vessel saltwater (1-4 pass.) (number)	24	8	44
Small vessel saltwater (1-4 pass.) (revenue)	$4,800	$1,600	$8,800
Medium vessel saltwater (5-9 pass.) (number)	47	6	58
Medium vessel saltwater (5-9 pass.) (revenue)	$18,800	$2,400	$23,200
Large vessel saltwater (10+ pass.) (number)	13	3	41
Large vessel saltwater (10+ pass.) (revenue)	$10,400	$2,400	$32,800

The data in Table 4 indicate that total revenue to the state of Florida annually from license sales for individuals and vessels is approximately $750,000 annually from these three counties. Due to the relative paucity of natural and artificial reef habitat in the region, the net increase of approximately 300,000 ft^2 of “reef” substrate is expected to provide a noticeable positive effect.

2. Ecosystem, including productivity, species diversity, and population dynamics

Following the sinking of the ship, the benthic invertebrate community within the vessel footprint will be replaced by a high profile hard substrate expected to be colonized by a wide variety of sessile marine invertebrate species as well as motile

invertebrate species. This change in habitat and community structure is expected to result in an increase in both diversity and abundance of both reef obligate fishes and invertebrates. The benthic community that currently exists on the site will be transformed into a “reef” community. After the sinking of the ship, the sand bottom biological community at the immediate site of the hull footprint on the ocean bottom will be altered over an area of approximately 90,000 ft^2. This altered habitat will be mitigated by the addition of an estimated 300,000 ft^2 of new “reef” substrate extending up into the water column and available for settlement by numerous species of benthic invertebrates and vertebrates. Reef organism species diversity and productivity of the site are expected to significantly increase. Based upon artificial reef research in the northern Gulf of Mexico by Bortone, Turpin, and others, more than 50 species of fish may aggregate and associate with the new artificial reef. The substantial vertical relief of the ship is expected to provide refuge for numerous species of baitfish including members of the scad genus (*Decapterus*) and herring species (Family *Clupeidae*). The presence of these baitfish species is certain to attract predatory fishes, particularly great barracuda (*Sphyraena barracuda*), greater amberjack (*Seriola dumerili*), mackerels (*Scomberomorus spp.*), and several species of jacks in the genera *Caranx* and *Seriola*. A review of representative steel hull vessels over 150 feet in length, sunk at depths of 80 –300 feet in the Gulf of Mexico off Florida, and their associated communities is listed in Table 5 (Barnett, 2003). These vessels, although sunk as artificial reefs, provide an indication of the potential long term “reef community” performance of the USS ORISKANY Memorial Reef.

Table 5. Protected Species and Recreationally Important Fishes Observed on Some Representative Florida Gulf of Mexico Shipwrecks Sunk in 80-300 Feet Depths as Reported by National Marine Fisheries Service Ecologist Michael Barnette
(Source: Shipwrecks of the Sunshine State: Florida's Submerged History by Michael C. Barnette, 2003).

Roatan Express-180 ft. offshore supply vessel sank 1992, in 190 ft. of water off Fort Myers.
"The wreck harbors a large population of Goliath grouper (protected), large gag grouper, schools of amberjack.

U.S.S. Ozark (MCS-2)-458 ft. Catskill Class Mine Counter Measuere Support Ship. Sunk as a target ship in 330 feet of water off Destin, Florida. A visual report indicated: "Marine life is abundant on the wreck, with large numbers of scamp grouper, snapper, and amberjack swimming about. Deep-water species such as short bigeyes and snowy grouper can also be spotted on the wreck. The popularity of the wreck with fishermen is attested by the copious amounts of fishing line that covers the vessel."

San Pablo -315 ft. refrigerated steamer badly damaged by German submarine*U-161* in 1942. Disposed of off Panama City in 80 ft. of water as a target ship in 1943. "The wreckage… support(s) a thriving marine community. Large schools of silvery baitfish flow over the wreck as solitary barracuda patrol the perimeter. Grouper and snapper flourish amongst the debris, while cobia and flounder, two other popular species pursued by fishermen, make regular seasonal appearances."

M.S. Rhein-*German freighter sunk by British warship in 1940 off Dry Tortugas, FL in 250 ft. of water. "The* Rhein *is a spectacular Florida wreck, and there are simply not enough superlatives to describe a dive on this site. …The entire wreck is heavily encrusted by luxurious invertebrate growth…Large sea turtles and rays frolic about the wreck, while copious amounts of grouper and snapper move about the deck."*

M/V Holsten- freighter sank in violent October 1992 storm 100 miles off Pensacola in 200 feet of water. "The wreck supports healthy assemblages of fish species. Schools of circling amberjack accompany divers during their visit, while large gag grouper can be found around the base of the wreck. A few solitary Goliath grouper have been observed, unusual given the extreme distance from their typical shallow, preferred habitat. Also of note are numerous queen angelfish and swarms of butterfly fish that present the illusion that one is visiting a shallow tropical reef instead of a deep shipwreck."

Empire Mica-oil tanker sunk June 1942 by *U-67* in 105 feet of water off Panama City, FL. "The wreck site attracts abundant marine life including amberjack, barracuda, snapper, and grouper."

Baja California- 266 ft. freighter sunk July 1942 by U-84 off SW Florida in 115 feet of water. "This wreck has been identified as a spawning aggregation site for Goliath Grouper"

U.S.C.G Blackthorn-180 ft. buoy tender severely damaged in mid-channel ship collision in Tampa Bay, January 1980. Beyond, repair the vessel was towed offshore and intentionally sunk 20 miles off Tampa in 80 feet of water as an artificial reef. "Heavily encrusted, the wreck attracts large amounts of marine life, including schools of spadefish, several Goliath grouper, mangrove snapper, red grouper, swarms of baitfish, and mackerel. Encounters with whale sharks have been experienced in the vicinity of the *Blackthorn."*

The productivity and population dynamics of the invertebrate community (Classes: Arthropoda, Mollusca, and Annelida) previously present on the seafloor will likely undergo some level of alteration. The primary mechanism of change will be predation by "reef-associated" species. Thus, the previous trophic system will be expanded to include recreationally and commercially important vertebrate and invertebrate species. The previous underutilized benthic food web is expected to contribute biological energy into snappers, groupers, triggerfishes, jacks, mackerels, lobsters, etc.

Addition of the USS ORISKANY Memorial Reef onto the proposed site will also attract large schools of planktivorous baitfishes. Channelization of planktonic primary and secondary production into baitfish biomass will provide additional food resources for piscivorous fishes (e.g., jacks, mackerels, cobia, dolphin, wahoo).

Addition of the artificial reef structure into the water column will create a planktonic forage zone of 59,000,000 ft^3. Feces from the “reef-fish” aggregation will channel some of the biological energy to benthic detritivores, thereby “recycling” energy into the benthos.

Net biological production at the site will potentially locally increase reproduction of reef-associated species. Results of increased reproductive capacity of fishes and invertebrate species will likely be realized in nearby waters, and potentially regionally via water current transport of planktonic life stages.

As previously mentioned, numerous scientific studies have established that artificial reefs provide increased reef habitat that may provide for increases in local populations of numerous fish and invertebrate species. A recent study by NOVA Southeastern University indicates that artificial reefs from ships between 80 and 133 feet in length had statistically higher fish abundances and statistically higher fish species diversity compared to adjacent coral reefs offshore of Ft. Lauderdale, Florida (Arena *et al*., 2002).

c. <u>Fisheries analysis – without ship reef</u>

1. Sport fishery benefits, including annual catch and worth

Without the creation of new reef habitat, the annual catch and worth of both commercially and recreationally important fin fish and invertebrate species is expected to remain the same, with fluctuations in stock levels dependent on the weather and climatic variables, and the level of mortality due to natural causes and fishing pressure.

Without reef habitat, minimal biological energy available at the proposed reef site will be transported into recreationally or commercially important fish or invertebrate biomass. Benthic forage organisms will undergo natural mortality and decompose.

Unless artificial reef construction can keep pace with increases in population and fishing pressure, potential overcrowding and overuse of existing natural and artificial reefs may occur. Additionally, without the construction of large, high-profile artificial reefs, a long range plan for a range of artificial reef types is limited.

2. Ecosystem, including productivity, species diversity, and population dynamics

Without the creation of the new reef, no changes are expected to the ecosystem in terms of productivity, species diversity and population dynamics. Benthic forage organisms will undergo natural mortality; biological energy will be consumed via decomposition; carbon, nitrogen, and phosphorous will be recycled. The opportunity to increase species diversity and to channel biological energy into higher trophic levels will be lost.

PART VIII. Preparation Costs and Funding

The U.S. Navy has committed to the vast majority of the preparation, towing and sinking costs associated with this ship. A total of $2.8 million was budgeted by the US Navy for preparation, transportation, and deployment of the USS ORISKANY as an artificial reef. A contract for approximately $2.1 million has been awarded by the US Navy for environmental preparation (Solicitation No. N62678-03-R-0070) of the USS ORISKANY. However, Escambia County will comply with any reasonable additional environmental requirements specified by the US Navy, MARAD, and Florida Department of Environmental Protection (FDEP).

Escambia County, via Resolution No. R2003-152, has committed financial assistance up to $1,000,000 for preparation, transportation, and deployment of the USS ORISKANY at the proposed site as an artificial reef (Attachment 3).

1. Environmental Preparation

The most recent information available form the Florida Department of Environmental Protection (Attachment 4) suggests that additional environmental preparation may include (See Attachment 5 for cost estimates):

a. removal of wooden decking covered by a layer of asphalt will be required by Florida Department of Environmental Protection (FDEP). An estimate of the cost of removal/disposal from a local artificial reef contractor indicates that an additional $35,000. Escambia County will fund those expenses.

b. removal and disposal of non-liquid PCBs. The federal multi-agency working group responsible for the development of Best Management Practices (BMPs) for reefing large military ships provided the list of environmental preparations in the Navy's contract for the USS ORISKANY. Although existing Toxic Substance Control Act standards require the removal of materials which contain non-liquid PCBs at concentrations greater than 50ppm, results of a recent Navy study, not yet released publicly, indicate that no substantial human health or ecosystem risks result from the presence of those materials if used as an artificial reef. However, if those materials are required by the US EPA to be removed, Escambia County will share with the Navy those costs, to the extent the county's available resources allow.

2. Non-environmental vessel preparations

Other preparations of the vessel to reduce potential hazards for SCUBA divers include (See Attachment 5 for cost estimates):

a. removal of steel hatches, companionway doors, and glass from the conning tower to enhance diver safety. Escambia County has secured an estimate of $2,500 for the removal of hatches, doors, and glass.
b. Escambia County is willing to cover the cost (estimated $10,000 – 25,000) of removing portions of wiring from the island/conning tower that may reasonably be expected to create an entanglement to divers or other marine life.

3. Towing and positioning for sinking

Escambia County has secured an estimate of $298,000 for the cost of towing the USS ORISKANY to Escambia East LAARS. Included in this estimate is the cost of acquiring

and deploying two 30,000 lb anchors to maintain the ships position during deployment as an artificial reef. Escambia County is willing to cover these costs, within the overall local funding amount of $1,000,000.

4. Reefing

Due to the ship's large size and complex configuration, an unknown array of items and expenses related to sinking the ship may be required. Although the Navy has committed to sinking the *USS ORISKANY* as an artificial reef, any remaining portions of Escambia County's $1,000,000 funding commitment may be used to assist the Navy with the expenses they incur.

In summary, Escambia County is committed to contribute up to $1,000,000 of local funding in partnership with the US Navy to successfully prepare, transport, and deploy the *USS ORISKANY* Memorial Reef off the coast of northwest Florida.

PART IX. Permits

A copy of the reauthorization of the Corps permit for Escambia East LAARS site dated July 25, 2001 is provided (Attachment 2). The permit, which expires July 21, 2006, allows for the *USS ORISKANY* to be deployed as artificial reef habitat. The permit requires a 55-foot clearance between the top of the ship and the sea surface. Sufficient water depth (i.e., 212 feet) is available at the proposed reef site. Army Corps of Engineers regulatory oversight of Escambia LAARS is accomplished by Clif Payne, Army Corps of Engineers, Pensacola Regulatory Office. When contacted regarding the proposed USS ORISKANY Memorial Reef, Mr. Payne stated in a 10/30/03 email (in Attachment 2) that there are no concerns or requirements beyond the conditions of the existing Army Corps Permit No. 1999402365 (IP-CP).

No other permits are required, however, Florida Department of Environmental Protection may review the project under its authority granted in the Coastal Zone Management Act. (See FDEP letter, Attachment 4)

APPLICATION EVALUATION CRITERIA

1. Meeting the requirements of the National Fishing Enhancement Act (33 U.S.C 2101)

a. Enhance fishery resources to the maximum extent practicable:

Given the extremely small percentage (3% of the west Florida shelf) of existing natural hard bottom in the Pensacola region, the creation of a new artificial reef using the *U.S.S. ORISKANY* would enhance regional fishery resources to a great extent. The additional reef habitat would provide the greatest proportional increase in total reef habitat. The vast expanse of open sand ("non-reef") habitat holds enormous potential forage for reef fishes and invertebrates. The potential for channelization of this biological energy from the benthos into reef fish biomass is not presently achieved.

Results of previous research around artificial reefs in the northern Gulf of Mexico suggests a reasonable estimate of forage radius at 100 feet. Thus, the creation of the USS ORISKANY Memorial Reef would provide 300,000 square feet of benthic forage area. In addition, 59,000,000 cubic feet of planktonic forage area would be available to baitfish and reef fish. See also Part VII.

b. Facilitate access and utilization by U.S. recreational and commercial fishermen:

Since the 1980's, LORAN C has been available to local boaters. More recently, Global Positioning System (GPS) provides inexpensive and easily used navigational information. The vast majority of fishermen and divers in the northeastern Gulf of Mexico utilize LORAN C and/or GPS to locate reefs. LORAN C and GPS latitude/longitude coordinates of the *USS ORISKANY* Memorial Reef will be published in local newspapers, fishing publications, websites, etc.

Although the proposed location for the ship is approximately 23 nautical miles southeast of Pensacola Pass, this is not an extraordinary travel distance for vessel operators (both private and charter) in this region, and subsequently will not pose an unreasonable location due to its distance from shore. Additionally, the selection of the proposed sinking site has taken into consideration facilitating access from vessels operating out of the adjacent port to the east via Destin Pass as well as Alabama.

The large dimensions of the ship and its intended orientation will also provide the opportunity for numerous vessels to utilize the ship at the same time, thereby relieving pressure on adjacent public artificial reefs and small limestone outcroppings of hard bottom.

c. Minimize conflicts among competing uses of water covered under this title and the resources in such waters:

In the Pensacola region, there generally exists minimal conflicts between various users groups of offshore resources. On occasions, during busy holiday weekends, a portion of the artificial reefs within the Escambia East LAARS may experience overcrowding and conflicts between fishing and diving vessels, both private and charter. Therefore, through the creation of a very large artificial reef using the ship, these existing conflicts are anticipated to be minimized regionally. Experience observed with the U.S.S. Spiegel Grove in Key Largo has indicated that various user groups apparently have reached 'gentleman's agreements' regarding the timing of their use on the ship in order to minimize potential conflicts. It is anticipated that given the close-knit community of private and charter vessels in the Pensacola region that a similar situation between competing user groups will develop in a short period of time.

d. Minimize environmental risks and risks to personal health and property:

The U.S. Navy is preparing the ship according to the Best Management Practices (BMPs) currently being established by the U. S. Environmental Protection Agency. Application of these guidelines should result in the ship deployed in a condition that will minimize or eliminate any risks to the environment and to human health.
In addition to vessel preparations presently funded by the US Navy, Escambia County has secured cost estimates from a qualified artificial reef contractor to perform the following: remove all hatches, companionway doors, and glass from the conning tower; remove portions of overhead wiring that may pose a threat to diver safety. Due to the extreme water depths below the flight deck (i.e., deeper than the 130 foot [dive industry-wide] recognized depth limit for recreational SCUBA diving), modifications below this depth should not be necessary. However, if Florida Fish and Wildlife Conservation Commission and/or US Navy/MARAD require additional hatches, doors, and windows to be removed, Escambia County will utilize a portion of the 1 million dollars in local funding committed to this project.

e. Be consistent with generally accepted principles of international law and shall not create any unreasonable obstruction to navigation:

1. Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter, London, October-November 1972

The intent of this international environmental treaty was to protect the marine environment and the living organisms that it supports for the benefit of all mankind. The treaty is primarily concerning with the dumping of pollutants by vessels operating on the open seas, with the term ‘dumping’ being defined in Article 3 of the treaty. Within this definition, Section 1(b)(ii) indicates that ’dumping’ does not include “placement of matter for a purpose other than the mere disposal thereof, provided such placement is not contrary to the aims of this convention…”. Since the sinking of obsolete military vessels under Public Law 92-402 (16 U.S.C. 1220 *et seq.*) would be for the express purpose of creating an artificial reef, and not mere disposal of the ships, the request to utilize the U.S.S. ORISKANY under Public Law 92-402 (16 U.S.C. 1220 *et seq.*) is excluded from the convention’s provision.

2. Law of the Sea: Convention on the Continental Shelf, Geneva, April 1958

This environmental treaty deals exclusively with activities taking place on or above the continental shelf, which is defined as the ocean floor from the coastline to a depth of 200 meters (660 feet). Article 2 of the treaty allows the coastal state the right to explore and exploit the natural resources of its portion of the continental shelf. Specifically, Article 5(2) allows the coastal state to “construct and maintain or operate on the continental shelf installations and other devices necessary for its exploration and the exploitation of its natural resources,…..”. Since the creation of an artificial reef using the requested ship represents the exploitation of a natural resource of the ocean (sedentary invertebrate species as per Article 2(4)) for the purpose of providing additional substrate for these species to settle on and grow, this activity does not violate the requirements of this treaty.

Additionally, the specific prohibitions under this treaty (Article 5(1) require that the exploitation of the natural resources must not result in unjustifiable interference with navigation. Article 5(6) of the treaty requires that any installations created on the sea floor may not cause interference to the use of recognized sea lanes essential to international navigation. Since the site selected for the sinking of the ship has received approval from both of the federal agencies responsible for insuring safe navigation (the ACOE and the USCG), the sinking of the ship will not violate the provisions of this article.

3. Principal 21 – Declaration on the Human Environment, Stockholm Conference, June 1972

This environmental treaty is primarily concerned with the consequences of man's activities on the environment. Principal 21 indicates that "States have, in accordance with the Charter of the United Nations and the principals of international law the sovereign right to exploit their own resources pursuant to their own environmental policies,…". Since the sinking of the ship will abide by all established environmental policies of the United states and the state of Florida, the creation of an artificial reef using the ship will not violate the tenets of this treaty.

2. <u>Availability of existing reef site and permits</u>

The Escambia East LAARS is currently permitted by the U. S. Department of the Army, Corps of Engineers Permit No. 199402365 (IP-CP); valid. A copy of the permit is contained in Attachment 2. See also Part IX.

3. <u>Plan for use, monitoring and managing the ship reef, including prevention of diver deaths</u>

Escambia County Marine Resources Division presently manages the Escambia County Artificial Reef Program. Management activities include: artificial reef construction, artificial reef materials monitoring (materials stability and durability; use patterns and user preferences/satisfaction; presence/abundance of commercially and recreationally important fishes), grants management. In addition, Escambia County Marine Resources Division provides permitting and local "private" artificial reef management on behalf of Florida Fish and Wildlife Conservation Commission for Escambia East and Escambia West LAARS.

The *USS ORISKANY* Memorial Reef will be included in the inventory of artificial reefs monitored by Escambia County marine Resources Division. University of West Florida Biology Department has expressed a high level of interest in utilizing the *USS ORISKANY* Memorial Reef for research. University of West Florida faculty and students have made significant contributions to the scientific literature; numerous studies have been performed on artificial reef trophic relationships and biological communities. In addition, Escambia County Marine Resources Division will establish contact with REEF (Reef Environmental Education Foundation) and collaborate with fish observation data.

Escambia County Marine Resources Division will accomplish the following monitoring of the *USS ORISKANY* Memorial Reef:

Level 1: Geographic Monitoring

After the deployment, the exact coordinates (latitude/longitude and LORAN) of the *USS ORISKANY* Memorial Reef and permit area boundary will be confirmed using separate Differential Geographic Positioning System (DGPS) and LORAN receivers. Latitude/longitude coordinates should be recorded in degrees and decimal minutes (e.g., 30° 12.345'N; 87° 12.345'W). To determine with certainty the position of artificial reefs, after the materials have been located using fathometer, visual certification (via SCUBA or other visual remote equipment) will be accomplished. Plotting of artificial reefs will be performed utilizing latitude/longitude coordinates from DGPS equipment.

These data are important to certify to permitting agencies that materials are at the designated location(s) and to verify permit compliance. The information is also important for comparison after storms or other events to determine if the artificial reef has been moved.

Level 2: Artificial Reef Physical Attribute Monitoring

Physical characteristics (e.g., length, width, height, materials type(s), and configuration) of the *USS ORISKANY* Memorial Reef will be measured and recorded using waterproof writing materials and/or underwater photography/videography. Other important data include: habitat complexity, condition and orientation of materials, and percent of materials that have subsided below the seafloor.
These data are important to determine the stability and durability of the artificial reef materials under consideration. Underwater configuration may also provide information regarding effectiveness of deployment methods. Amount of reef that has subsided into the seafloor may yield information regarding sediment suitability and hydrodynamic forces at that location.

Level 3: Reef utilization and user satisfaction

Reef utilization and user satisfaction information will be obtained in two general ways, each with its advantages and disadvantages. On-site surveys are conducted on the water while the artificial reef user is located at an artificial reef. Advantages of this approach include: ease of determination of the number of vessels at a particular (and nearby) artificial reef; fish catch information at the specific reef may be obtained; answers to survey questions are more likely to reflect user's satisfaction while at the reef; and ability to sample users at a predetermined number/variety of artificial reefs. Disadvantages include high cost of survey due to the need for surveyor to use a boat, vessel-to-vessel communication difficulty, and reef user may become irritated at the interruption of fishing/diving activities.

An alternate approach, ramp-intercept survey, is less expensive and easier to communicate, however, the accuracy of the responses may be lower than that of on-water surveys. Catch information may not allow determination of specific catch at specific reef(s); this information, combined with Level 4 data, may help explain some of the variation in Level 4 data.

Reef utilization and user satisfaction information are important to artificial reef managers for short and long term planning. Reef preferences and overcrowding may guide decisions for reef materials and/or placement. Level 3 data are important for the evaluation of Escambia county artificial reef Program Goals (#'s: 3,5, and6). On-water surveys have a "public relations" benefit, and artificial reef managers may make more confident decisions with knowledge gained in the field.

Level 3 data will be gathered at the *USS ORISKANY* Memorial Reef during the first , third, fifth years after construction.

Level 4: Biological Monitoring

After construction of the *USS ORISKANY* Memorial Reef, biological data regarding fish assemblages will be taken once each spring, summer and fall. These data will be gathered via underwater visual observation, and will occur concurrently with level two data.

Although arguably the most difficult and expensive to obtain, Level 4 data have the potential to be the most valuable in artificial reef Program management. As previously mentioned, Level 3 (catch) data may explain some of the variation in Level 4 data.

In addition to vessel preparations presently funded by the US Navy, Escambia County has secured cost estimates from a qualified artificial reef contractor to perform the following: remove all hatches, companionway doors, and glass from the conning tower; remove portions of overhead wiring that may pose a threat to diver safety. Due to the extreme water depths below the flight deck (i.e., deeper than the 130 foot [Dive Industry- wide] recognized depth limit for recreational SCUBA diving), modifications below this depth should not be necessary. However, if Florida Fish and Wildlife Conservation Commission and/or US Navy/MARAD require additional hatches, doors, and windows to be removed, Escambia County will utilize a portion of the 1 million dollars in local funding committed to this project.

The location of the proposed *USS ORISKANY* Memorial Reef Site is approximately 23 miles from Pensacola Pass and 33 miles from Destin Pass. In the event of a diving accident that required hyberbaric treatment, the victim would have to be transported to shore by boat (1-2 hours, depending upon weather conditions and vessel) or, if possible, by USCG helicopter (<1hr). Once ashore, the victim could be transported to one of several hyperbaric chambers: 1) Bay Memorial Hospital, Panama City, FL (1 hr via helicopter; 2-3 hrs via ambulance); 2) Springhill Memorial Hospital, Mobile AL (<1hr via helicopter; 1-2 hrs via ambulance); or, if life-or-death situation and if proper staffing available 3) Navy Hospital in Pensacola may be used (<1hr transport time). Total time from onset of symptoms to hyberbaric treatment could be as long as 4 hours or more. However, Divers Alert Network data indicates that in the majority of cases, hyberbaric treatment is delayed 6-12 hours or longer. Analysis of the effectiveness of hyperbaric treatment indicates that the vast majority of cases are successfully treated, even when recompression is delayed more than 12 hours(DAN, 2003).

At present, barotraumatic SCUBA diving injuries occur infrequently off northwest Florida. Placement of the *USS ORISKANY* Memorial Reef at the proposed location is not expected to create an unreasonable risk to diving safety for divers that adhere to the standards of their training.

In addition to the above, a diving safety outreach and education effort will be accomplished using web-based as well as printed materials to provide the diving public with appropriate information regarding the *USS ORISKANY*. Local dive shops, charter boats, and dive clubs will be invited to participate. In addition, the major dive training agencies will be invited to assist and provide specific input.

4. Impact on:

a. National Marine Sanctuaries

The geographical position of the proposed sinking site is more than 300 nautical miles from the closest National Marine Sanctuary (Flower Garden Banks NMS off Texas). Consequently, there are no anticipated impacts to this federally protected natural resource that would result from the sinking of the ship.

b. Coral Reefs

The Pensacola region is slightly beyond the northern range of hard coral species in the United States due to low water temperatures during the winter months. Therefore, there will be no impact to hard coral species as a consequence of deploying the ship in the Pensacola region.

Although no coral reefs are present in the region, low-relief limestone ledges and outcroppings are present in the region and in the vicinity (within 20 nmi) of the proposed *USS ORISKANY* Memorial Reef. Great care has been taken to avoid the potential of negative impacts to any hard-bottom substrate. The closest known natural reef to the proposed site is a small (50ft x 50ft), low-relief limestone outcropping more than one-half nautical mile to the north-northeast.

The *USS ORISKANY* Memorial Reef is expected to provide a net positive effect on natural reefs in the vicinity by providing alternative fishing and diving locations, thereby reducing impacts on natural formations.

5. <u>Plan for accomplishing vessel preparation requirements beyond the EPA Best Management Practices (BMP) for:</u>

A. Ship artificial reefing

1. Removal of wooden “underdecking”. An estimate of the cost of removal/disposal from a local artificial reef contractor indicates that an additional $35,000 may be required. Escambia County will, if required, fund those expenses, or contract the work to a capable entity.

2. Removal of “floatables” not identified in the Navy’s contract for environmental preparation. Escambia County will, if required, fund those reasonable expenses. Care must be taken to ensure that the Navy’s contract for environmental preparation has been fully completed. In the event that floatable materials remain after completion of the Navy’s vessel preparations contract, and after it has been determined that the contractor (i.e., Resolve Marine, Inc) has fully satisfied the requirements of it’s cleanup contract for the Navy, Escambia County will share in the costs (to the greatest extent possible) of completing additional environmental preparations. It must be recognized and understood that Escambia County makes this offer in good faith that the Navy’s contract for environmental preparations will be accomplished to the maximum extent required under contract.

3. Removal and disposal of non-liquid PCBs. The federal multi-agency working group responsible for the development of Best Management Practices (BMPs) for reefing large military ships provided the list of environmental preparations in the Navy’s contract for the USS ORISKANY. Although existing Toxic Substance Control Act standards require the removal of materials which

contain non-liquid PCBs at concentrations greater than 50ppm, results of a recent study indicate that no substantial human health or ecosystem risks result from the presence of those materials if used as an artificial reef. The fact that the $2.19 million US Navy contract for preparation of the USS ORISKANY does not require the removal of materials containing non-liquid PCBs strongly suggests that US EPA is likely to concur with the results of the report. However, if those materials are required to be removed, Escambia County will share with the Navy those costs.

B. Plan for accomplishing all vessel preparation requirements

Because the Navy has contracted with Resolve Marine, Inc., at a cost of approximately $2.1 million, for environmental preparations to the *USS ORISKANY*, it is not yet known the extent of further vessel preparation requirements. However, this section contains information that Escambia County, through consultation with Florida Fish and Wildlife Conservation Commission staff, foresees as reasonable additional vessel preparations (in addition to the items listed in Section IX. 5.A.), and has secured cost estimates for the following:

1. towing to proposed artificial reef site. Escambia County has secured an estimate of $298,000 for the cost of towing the *USS ORISKANY* to Escambia East LAARS. Included in this estimate is the cost of acquiring and deploying two 30,000 lb anchors to maintain the ships position during deployment as an artificial reef;

2. removal of steel hatches, companionway doors, and glass from the conning tower to enhance diver safety. Escambia County has secured an estimate of $2,500 for the removal of hatches, doors, and glass. In addition, Escambia County is willing to share in the cost (estimated $10,000 – 25,000) of removing portions of wiring from the conning tower that may reasonably be expected to create an entanglement to divers or other marine life.

Through consultation with the Navy/MARAD, Escambia County will contract with a qualified artificial reef contractor for the completion of these and other reasonable vessel preparations.

6. <u>Towing and sinking plan, if accomplished by the state:</u>

This section is the responsibility of the U. S. Navy and the Maritime Administration.

7. <u>Cost sharing proposals:</u>

The U.S. Navy has committed to the vast majority of the preparation, towing and sinking costs associated with this ship. A total of $2.8 million was budgeted by the US Navy for preparation, transportation, and deployment of the USS ORISKANY as an artificial reef. A contract for approximately $2.1 million has been awarded by the US Navy for environmental preparation (Solicitation No. N62678-03-R-0070) of the USS ORISKANY. However, Escambia County will comply with any reasonable additional environmental requirements required by the US Navy, MARAD, and Florida Department of Environmental Protection (FDEP).

Escambia County, via Resolution No. R2003-152, has committed financial assistance up to $1,000,000 for preparation, transportation, and deployment of the USS ORISKANY at the proposed site as an artificial reef (Attachment 3).

1. Environmental Preparation

The most recent information available (Attachment 4) suggests that additional environmental preparation may include (See Attachment 5 for cost estimates):

a. removal of wooden decking covered by a layer of asphalt will be required by Florida Department of Environmental Protection (FDEP). An estimate of the cost of removal/disposal from a local artificial reef contractor indicates that an additional $35,000. Escambia County will fund those expenses.

b. removal and disposal of non-liquid PCBs. The federal multi-agency working group responsible for the development of Best Management Practices (BMPs) for reefing large military ships provided the list of environmental preparations in the Navy's contract for the USS ORISKANY. Although existing Toxic Substance Control Act standards require the removal of materials which contain non-liquid PCBs at concentrations greater than 50ppm, results of a recent study indicate that no substantial human health or ecosystem risks result from the presence of those materials if used as an artificial reef. However, if those materials are required to be removed, Escambia County will share with the Navy those costs.

2. Non-environmental vessel preparations

Other preparations of the vessel to reduce potential hazards for SCUBA divers include (See Attachment 5 for cost estimates):

a. removal of steel hatches, companionway doors, and glass from the conning tower to enhance diver safety. Escambia County has secured an estimate of $2,500 for the removal of hatches, doors, and glass.

b. Escambia County is willing to cover the cost (estimated $10,000 – 25,000) of removing portions of wiring from the island/conning tower that may reasonably be expected to create an entanglement to divers or other marine life.

3. Towing and positioning for sinking

Escambia County has secured an estimate of $298,000 for the cost of towing the USS ORISKANY to Escambia East LAARS. Included in this estimate is the cost of acquiring and deploying two 30,000 lb anchors to maintain the ships position during deployment as an artificial reef. Escambia County is willing to cover these costs, within the overall local funding amount of $1,000,000.

4. Reefing

Due to the ship's large size and complex configuration, an unknown array of items and expenses related to sinking the ship may be required. Although the Navy has committed to sinking the *USS ORISKANY* as an artificial reef, any remaining portions of Escambia County's $1,000,000 funding commitment may be used to assist the Navy with the expenses they incur.

In summary, Escambia County is committed to contribute up to $1,000,000 of local funding in partnership with the US Navy to successfully prepare, transport, and deploy the *USS ORISKANY* Memorial Reef off the coast of northwest Florida.

5. Monitoring

As described in Section 3 above, Escambia county Marine Resources Division will accomplish all monitoring of the USS ORISKANY Memorial Reef utilizing its own resources.

A. Buoys

As previously stated in Section V.E.1.and 2., Escambia County has determined that buoys are unnecessary and may actually reduce utilization of the *USS ORISKANY* Memorial Reef. Furthermore, buoys will likely interfere with fishing activities, and create and unnecessary exposure to potential liability. Therefore, Escambia County recommends allowing individual boaters to determine the best method for utilization of the reef. Should a boat skipper choose to anchor or otherwise make fast, he/she may do so utilizing the boat's gear and established practices of prudent and proper seamanship.

However, if Florida Fish and Wildlife Conservation Commission or US Navy requires that buoys be installed at the *USS ORISKANY* Memorial Reef, Escambia County Marine Resources Division will implement those requirements using existing staff, and/or contract a portion or all requirements.

8. <u>Availability of studies demonstrating the:</u>

A. Environmental benefits

Because the seafloor in the Gulf of Mexico waters off Pensacola, Florida are predominantly (>95-97%) featureless sand, the creation of additional "reef" habitat will increase the potential for additional fish and invertebrate production (biomass) and/or reproduction. Moreover, via establishment of optional sites for fishermen and SCUBA divers, overuse of existing natural and artificial reefs may be reduced.

B. Fishery resource benefits

The question of how artificial reefs affect marine ecosystem productivity has long been a debate (the attraction versus production question). Recent research by Dr. Richard Spieler (Spieler, 1999) of NOVA Southeastern University in Dania, Florida compared total fish biomass on small patches of natural reefs and the northern jetty of Government Cut (Miami, Florida) prior to, and following the installation of numerous small artificial reefs. The preliminary results indicate that not only did the artificial reefs provide additional substrate with a subsequent increase in fish species richness and abundance on the artificial reefs, but also that the reefs provided an overall increase in fish diversity and abundance within the entire study area. In another study (Spieler, 2001) offshore of Ft. Lauderdale, Florida, Dr. Spieler and his colleagues have also reported that certain species of fishes have been recorded only on artificial reefs composed of ships and not recorded on adjacent natural reefs and other artificial reefs composed of different materials. Therefore, it is possible that the deployment of the largest ship ever intentionally sunk as an artificial reef may have an impact on the population dynamics of certain

fish species. However, more research on the population dynamics of these species is needed to determine the settlement to harvest process that is limiting population increases of these and other species in order to determine if artificial reefs can alter the population dynamics of certain fish species.

Studies at artificial reef sites in the Florida Keys have documented between 70 - 103 different fish species at the artificial reefs studied (Kruer and Causey 1992). A recent study by NOVA Southeastern University indicates that artificial reefs from ships between 80 and 133 feet in length had statistically higher fish abundances and statistically higher fish species diversity, biomass and abundance compared to adjacent coral reefs offshore of Ft. Lauderdale, Florida (Arena *et. al* 2002) and (Spieler 2003).

Numerous scientific studies have documented the magnitude of these changes that have occurred following the creation of artificial reefs throughout the world (Relini *et. al* 1999)

C. Economic benefits of ship reefing within the state

A socio-economic study of the impacts of NW Florida artificial reefs was performed in 1998 (Bell *et. al* 1998). Results of the study that the existing artificial reefs provide the following economic benefits to Escambia, Santa Rosa, Okaloosa, Walton, and Bay Counties:

Total Annual Use Value:	$19.68 – 31.24 million
Asset Value:	$656 - 1,168 million
Expenditures Generated:	$415 million
Wages Generated	$84 million
Employment:	8163 jobs

Although it may appear that the creation of an artificial reef using a large ex-military ship to provide both a highly desirable SCUBA diving location and a large fish haven for recreationally and commercially important fish species represents a local, short-term use of man's environment; in reality the newly created artificial reef is expected to provide an enhancement to the economic return to the region for many decades. Given that similar vessels sunk either accidentally or through acts of war world-wide still provide substantial habitat and economic value after 40 or more years (Truk Lagoon for example). The life expectancy of the ship as an artificial reef is expected to be in excess of 100 years, thus providing over a century of economic benefits to the NW Florida region.

Due to the geographic position of the NW Florida proposed location of the *USS ORISKANY* Memorial Reef, economic benefits are expected to accrue to coastal communities from Alabama to Panama City, Florida,

9. <u>Demonstration of public support for the proposed ship reef:</u>

A. Elected officials and community leaders
Escambia County has received letters of support from 12 elected officials. (Attachment 6)

B. Corporate entities
Escambia County has received letters and emails of support from 278 area businesses. (Not attached, but available upon request)

C. Municipalities
Escambia County has received resolutions of support from 10 local governments. (Attachment 7)

D. Public
Escambia County has received letters and emails of support from 346 citizens. (Not attached, but available upon request).

E. Stakeholder organizations
Escambia County has received 16 letters, emails, and resolutions of support from various stakeholder groups including: fishing clubs, civic organizations, Chambers of Commerce, residents association, and a local university. (Attachment 8)

F. Navy and other military support (See also ORISKANY Veterans in Section G below)
Escambia County has received five letters of support from NAS Pensacola Commanding Officer, Local USO Chapter, and other retired and active military officers (Attachment 9).

G. USS ORISKANY veterans
Escambia County has received 94 letters and emails of support from ORISKANY Association members and other men who served aboard the USS ORISKANY. A subset of 46 letters and emails are provided in Attachment 10.

10. Connection with or enhancement of Naval or Maritime heritage

FLORIDA

Florida had significant Naval and maritime tradition during the World War II era. The Florida Museum of History, Tallahassee, has an exhibit entitled “Florida Remembers WWII “opened on Veterans Day November 11, 2003.

The following information was provided in this exhibit: Prior to World War II Florida had eight military installations. By the end of WWII there were more than 170 in the Sunshine State. Major Naval bases and naval air stations were at: Daytona Beach, Deland, Fort Lauderdale, Green Cove Springs, Jacksonville, Key West, Melbourne, Miami, Richmond, Pensacola, Sanford, and Vero Beach

There were at least 12 Naval Air station Complexes in FL during WWII with many auxiliary fields. In Escambia County alone, under the umbrella of Pensacola NAS there were 31 airfields and auxiliary naval air stations.

Lt (jg) George Herbert Walker Bush learned to fly Grumman TBF Avenger Torpedo Bombers in Florida. The carrier pilots who turned the tide in the war against Japan at Midway, and won other crucial Pacific carrier sea battles received a portion of their training at NAS Pensacola. During WWII 1,115 Floridians serving in the U.S. Navy were killed in combat actions out of a total of about 40,000 U.S. naval personnel killed in action

At Fort Pierce more than 150,000 Navy, marine, and army units went through amphibious training. The U.S. Coast Guard had a training center in St. Augustine. The Merchant Marine also had operations out of Florida. This branch lost 9,487 merchant seamen during WWII, a higher percentage than any other service.

Florida Shipyards operating during WWII included:
Tampa ship building and Engineering Co.
Tampa's Hooker's Point Ship yards
Wainwright Ship yard (Panama City)
St. Johns River Ship yard (Duval County)
Miami Ship building Corporation
Pensacola Ship yard and Engineering Co.
Orlando Ship building Co.

Florida produced Liberty Ships, patrol torpedo boats, aircraft rescue boats, minesweepers, landing craft, assault boats, and other vessels.

There was also significant American merchant mariner heritage in the Tampa Bay area of Florida. A former resident of the James River inactive reserve fleet, the WWII Victory Ship, *SS American Victory,* was acquired from MARAD as a nonprofit educational museum and moved to Tampa, Florida where volunteers began restoration work and opened the ship for visitors in 2001. On March 6, 2003 the ship sailed for the first time under her own power, setting the stage for monthly six –hour "Relive History" Cruises on Tampa Bay. The first interpretive passenger voyage with 400 people aboard took place in September 2003. There are plans to provide educational outreach statewide with the ship eventually sailing to other Florida ports, making it one of the few educational facilities nationwide that travels to its audience. To date over 75,000 volunteer hours have been invested in the project. This ship is intended to serve as an educational facility and a memorial to the seamen who hauled troops and supplies during wartime and in post war years. The vessel entered active service in June 1945 and was one of the many cargo ships that were the unsung heroes of the international wars against Fascism and Communism. According to Dr. Jay Martin, executive director of the American Victory Mariners Memorial and Museum Ship, "with its illustrious past and current initiatives, the *American Victory* has a bright and colorful future as the primary historical steward of Tampa Bay's maritime community."

Tampa shipbuilders created hundreds of merchant ships that were manned by mariners trained at St. Petersburg's U.S. Maritime Service school (Now the University of South Florida). The source of this information was Florida Public Radio (88.9 FM Tallahassee, news broadcast November 17, 2003; also "A new Mission for a Historic Ship" by Jay Martin. From news publication "Bay Soundings" summer 2003. p. 16. see also www.americanvictory.org. or call 813-228-8766 for additional details.

Artificial reef utilized military ships ahs been ongoing for many years. Currently were have 35 ships intentionally places as artificial reef in Florida and are located throughout the state. Table 6 lists these ships as reefs.

Table 6 –Military ships used as artificial reefs in Florida.

COUNTY	DEPLOYDATE	REEFNAME	DESCRIPTION	DEPTH	RELIEF
BAY	07/31/77	LIBERTY SHIP-USS GRIERSON	LIBERTY SHIP, THE "*BENJAMIN H. GRIERSON*"	72	20
BAY	08/18/95	HOVERCRAFT-LIcat	NAVY HOVERCRAFT, 100 FT LONG, ALUMINUM	74	10
BAY	12/31/87	USS STRENGTH	NAVY MINESWEEPER TENDER, THE 184 FT "*USS STRENGTH*"	75	32
BAY	07/12/78	GREY GHOST SHIP	NAVY TUGBOAT, THE 105 FT "*GREY GHOST*"	105	
BAY	12/31/70	CHICKASAW	NAVAL TUGBOAT, THE 107 FT LONG "*CHICKASAW*"	70	6
BAY	2/28/1990	CHIPPEWA	NAVAL TUGBOAT, THE 205 FT LONG "*CHIPPEWA*"	96	26
BROWARD	12/12/82	TRIO BRAVO	ARMY TUGBOAT-THE 149 FT. "*TRIO BRAVO*"	145	20
BROWARD	04/23/94	JIM TORGERSON	NAVAL SUPPORT VESSEL, THE 160' "*RSB-1.*"	120	25
BROWARD	07/08/86	SITE C -FLA. LEAGUE OF ANGLERS	NAVY MINESWEEPER, 144 FT LONG	388	25
BROWARD	02/20/90	CAPTAIN DAN GARNSEY	US COAST GUARD BUOY TENDER,THE 175 FT. "*HOLLYHOCK*"	110	
BROWARD	06/09/91	ANCIENT MARINER	US COAST GUARD CUTTER, THE 165 FT. "*NEMESIS*"	70	
BROWARD	12/11/89	ROBERT EDMISTER	US COAST GUARD CUTTER, THE 95 FT. FORMER "*CAPE GULL*"	76	30
DADE	10/16/69	LANDING CRAFT "LCI"	LANDING CRAFT-150' "*LCI*"	202	5
DADE	05/14/76	O.L. BODENHAMER	LIBERTY SHIP, THE 450' , "*O.L. BODENHAMER*"	372	20
DADE	11/08/90	C-ONE	NAVY STEEL TUGBOAT THE 120 "*C-ONE*"	68	33
DUVAL	07/31/72	CASA BLANCA	LST LANDING CRAFT , 327 FT "*CASA BLANCA*"	105	
ESCAMBIA	11/05/76	JOSEPH MEEK	LIBERTY SHIP, 400 FT. , "*JOSEPH L. MEEK*"	95	
ESCAMBIA	04/01/00	NAVY DIVE TENDER YDT-14	NAVY DIVE TENDER, 132 FEET LONG , 312 TONS THE "*YDT-14*"	90	28
ESCAMBIA	04/01/00	NAVY DIVE TENDER YDT-15	NAVY DIVE TENDER, 132 FEET LONG , 312 TONS THE "*YDT-15*"	90	28
GULF	12/31/93	LST PORT ST. JOE	LANDING CRAFT-75 FOOT LONG STEEL LST	90	10
MARTIN	10/09/82	SIROTKIN REEF	LANDING CRAFT, 200 FT. X 35 FT. "*DAVID T.*"	100	
MARTIN	UKNOWN	GUARDIAN REEF	LANDING CRAFT, THE *LC6*	60	
MARTIN	08/01/87	USS RANKIN	NAVY ATTACK CARGO SHIP, THE 467' *USS RANKIN.* L	130	70
MONROE	03/03/86	THUNDERBOLT	NAVY CABLE VESSEL, THE 188 FT "*USS THUNDERBOLT*"	118	60
MONROE	05/17/02	SPIEGEL GROVE	NAVY LSD-THE 510 FT "*USS SPIEGEL GROVE*" , PUSHED ON SIDE ON 6/10/02	135	84
MONROE	04/30/85	CAYMAN SALVAGE MASTER	US COAST GUARD BUOY TENDER A 187 FT LONG TENDER, UPRIGHT IN SAND	92	
MONROE	11/27/87	BIBB	USCG CUTTER, THE 327 FT. "*BIBB*", LAYING ON STARBOARD SIDE, 95' TO RAIL	130	35
MONROE	11/27/87	DUANE	USCG CUTTER, THE 327 FT. "*DUANE*", UPRIGHT DECK IS 90 FEET DEEP	118	50
OKALOOSA	11/29/00	EGLIN REEF #1	LANDING CRAFT-74 FOOT BY 21 FOOT (*LCM-8*)	94	22
OKALOOSA	04/17/77	LIBERTY SHIP- THOMAS HAYWARD	LIBERTY SHIP CALLED THE "THOMAS HAYWARD"	90	25
PINELLAS	12/31/82	PINELLAS II - BLACKTHORN	US COAST GUARD CUTTER, THE 180 FT "*BLACKTHORN*"	80	30
SANTA ROSA	12/31/80	J. BROWN-LIBERTY SHIP	LIBERTY SHIP, 440 FOOT THE "*JOSEPH E. BROWN*"	85	15
SARASOTA	12/10/85	M-8	LANDING CRAFT.	63	10
ST. LUCIE	01/21/89	MULLIPHEN REEF	NAVY ATTACK CARGO SHIP, THE *USS MULLIPHEN*	185	100
VOLUSIA	10/10/80	PORT AUTHORITY SITE #3	LIBERTY SHIP, THE 446' STEEL "*MINDANAO*"	80	20

PENSACOLA

Since its discovery by Don Tristan de Luna in 1553, and as the site of the first European settlement in the New World, Pensacola has become inextricably linked to maritime and Naval endeavors. Due to its favorable geographic and oceanographic features, the area grew in maritime commerce as well as militarily. Forts Pickens, Barrancas, and McRae were constructed and improved throughout the period between the Civil War and World War II. The military significance and importance of Pensacola was further recognized and realized with the construction of Naval Air Station Pensacola. As the “Cradle of Naval Aviation”, we are recognized throughout the world for our connection with the Navy. As home of the “Blue Angels”, we are honored and thrilled almost daily as they grace our skies.

Pensacola is a “Navy town”. We name our streets in its honor: Navy Boulevard and Blue Angel Parkway. We have Navy Point Park, Old Navy Cove, Blue Angels Classic Golf Tournament, and Blue Angels Marathon. The Museum of Naval Aviation at NAS Pensacola is the world’s finest collection of Naval aviation materials and displays. Also planned is a Maritime Museum. We welcome Navy personnel and their families into our community when they are stationed here. Often, years later, we welcome them again as they retire here.

Pensacola celebrates and honors its military throughout the year, but especially throughout the month of November. Veterans Day festivities and the Blue Angels Homecoming Air show are combined with more than a dozen other events held to honor and celebrate “Military Appreciation Month”.

We have demonstrated our dedication to preserve and protect our Naval inheritances such as the Battleship *USS Massachusetts*. After World War I, the *USS Massachusetts* was decommissioned, and towed to Pensacola in 1921. Scuttled on a shallow sand shoal in the Gulf of Mexico just outside Pensacola Pass, she served as a target for more than 100 rounds of experimental artillery. Afterwards, the *USS Massachusetts* was left in place and provided habitat for marine life. In the 1950's, several scrap companies attempted to salvage the ship, but the Pensacola community rallied to her defense and convinced the State of Florida to file an injunction. The case went to the Supreme Court, and title was awarded to Florida. In 1990, Pensacola rallied again in support of a nomination of the ship at the state's fourth archaeological preserve. On June 10, 1993, the 100th anniversary of her launching, the USS Massachusetts Archaeological Preserve was dedicated.

In a letter dated November 10, 2003, NAS Pensacola Commanding Officer, Captain John Pruitt, wrote:

"There is no other area in the world more fitting than Pensacola for the USS ORISKANY to make its final resting place. The USS ORISKANY's rich heritage, combat history, and contributions to the Navy, coupled with Pensacola's significance in the world of Naval aviation, make Pensacola the most logical final resting places for this great vessel" (Attachment 9).

The 2004 Reunion of the ORISKANY Association will be held in Pensacola. The men that care the most for the ship, her former crewmen, have written numerous requests (See Attachment 10) for the opportunity to visit her at her final resting place: the Gulf of Mexico waters off Pensacola. We hope to honor their request.

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C E R T I F I C A T I O N

The undersigned, State of Florida, 620 South Meridian Street, Box MF-MFM, Tallahassee, Florida 32399-1600 herby applies for the transfer of a ship, pursuant to the provisions of Public Law 92-402, (16 U.S.C. 1220 *et seq.*) as amended by H.R. 4546 Section 3504(a), for sinking and use of the ship solely as an offshore artificial reef for the conservation of marine life. Said state gives its assurance to the Secretary of Transportation that the transferred ship will be properly charted when sunk; and agrees to comply with the terms and conditions as stated in fulfillment of the provisions of Public Law 92-402, as amended. Said sate further agrees to accept the ship allocated in an “as is/where is” condition at no cost to the Federal Government except for any financial assistance provided under Section 7, and to remove said vessel at a mutually agreed upon date to be determined.

EXECUTION

IN WITNESS WHEREOF this application has been duly executed at
_____

This _____ day of _____, 2004.

State of Florida

By: _____
Signature of Authorized State Official

_____
Title

Appendix C

PCB Remediation Excerpt from Draft National Guidance: Best Management Practices for Preparing Vessels Intended to Create Artificial Reefs

APPENDIX C

EXCERPTED FROM:

Draft National Guidance: Best Management Practices for Preparing Vessels Intended to Create Artificial Reefs

United States Environmental Protection Agency

June 24, 2004

POLYCHLORINATED BIPHENYLS (PCBs)

Narrative Cleanup Goal: Remove all solid material containing PCBs greater than or equal to (≥) 50 parts per million (ppm) unless a disposal permit has been granted under 40 CFR 761.62(c); remove all liquid materials containing PCBs.

Environmental Impacts

PCBs are persistent and bio-accumulative. PCBs bio-accumulate in fatty or lipid rich tissues. PCBs have a limited solubility in aqueous solutions and it is suspected that PCBs can leach into a marine or aqueous environment (sediment and water column) where they can be taken up by organisms in the food web. PCBs bioaccumulate in fish and other animals; PCBs also bind to sediments. As a result, people who ingest fish may be exposed to PCBs that have been released into the environment.

There is a risk of human exposure during vessel preparation and after sinking the vessel. During vessel preparation, typical routes of human exposure include inhalation, accidental ingestion, or dermal contact. After sinking, exposure routes may be limited to accidental ingestion of or contact with contaminated water or ingestion of contaminated fish, shellfish, or crustaceans. (see Appendix C)

What are PCBs?

PCBs belong to a broad family of man-made organic chemicals known as chlorinated hydrocarbons. PCBs, which were domestically manufactured from 1929 until their manufacture was banned in 1979, have a range in toxicity and vary in consistency from thin light-colored liquids to yellow or black waxy solids. Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics, and rubber products; in pigments, dyes, and carbonless copy paper; and many other industrial applications.

Where are PCBs found on a ship?

Although no longer commercially produced currently in the United States, PCBs are present in vessels deployed before the 1979 PCB ban. PCBs are found in both the solid (waxy) and liquid (oily) forms in equipment and materials on ships that were built leading up to the ban. The equipment and materials that may contain PCBs in concentrations of at least 50 ppm include:

- Cable insulation
- Rubber and felt gaskets
- Thermal insulation material including fiberglass, felt, foam, and cork
- Transformers, capacitors, and electronic equipment with capacitors and transformers inside
- Voltage regulators, switches, reclosers, bushings, and electromagnets
- Electronic equipment, switchboards, and consoles
- Adhesives and tapes
- Oil used in electrical equipment and motors, anchor windlasses, hydraulic systems, and leaks and spills
- Surface contamination of machinery and other solid surfaces
- Oil-based paint
- Caulking
- Rubber isolation mounts
- Foundation mounts
- Pipe hangers
- Fluorescent light ballasts
- Any plasticizers

Items containing PCBs may be found throughout a ship and are not easily identifiable or accessible. PCBs may be found in a variety of shipboard materials, but the location and concentration may vary from item to item and within classes of items. PCB containing materials can also vary from ship to ship, and even ships in the same class can contain differing amounts of PCB containing materials. While these materials may be found throughout a ship, several areas on ships may have an increased likelihood of containing PCB bearing materials: areas or rooms subject to high heat or fire situations such as boiler rooms, engine rooms, electrical/radio rooms, or weapons storage areas.

Vessel Preparation

Even though it is not the intent of this document to focus on regulatory requirements, PCBs are regulated for disposal under 40 CFR Part 761, and will be discussed in this context. The regulations require that materials containing PCBs ≥ 50 ppm cannot be disposed in the marine environment. Although the ship itself is being “reused” or “recycled” as an artificial reef, the PCBs have reached the end of their useful life and must be removed and disposed. Disposal requirements are referenced below (also see Appendix B).

Where there is reason to suspect that equipment or components may contain PCBs ≥ 50 ppm, either remove the equipment or component from the vessel, provide proof that the equipment or component is free of PCBs, or apply to EPA for a PCB disposal permit. Thermally removing PCB containing materials is prohibited, as PCBs may volatize or form dioxin or dioxin-like compounds. Because PCB sampling and analytical procedures can be expensive and time consuming, there may be situations when the cost of sampling and analysis far exceed the cost for removal and disposal. In such cases, previous ship to reef projects have shown that removal of all electrical cables and wires suspected of containing some level of PCBs is more economical.

Liquid Materials Containing PCBs

Remove all liquid filled electrical equipment suspected of containing PCBs or PCB contaminated dielectric fluid. Materials such as lubricating oils and greases used for winches and cargo-handling machinery, hydraulic fluids, heat transfer fluids, and waste oils should be removed from the vessel as presented in the "Oil and Fuel" Section of this document.

Solid Materials Containing PCBs (non-liquid PCBs)

Remove all solid materials containing PCBs ≥ 50 ppm, which includes but is not limited to felt gasket and faying material, cables, paints, rubber gaskets as well as battle lanterns and fluorescent light ballasts. EPA recognizes that non-liquid PCBs may be difficult to locate and remove and that removal may jeopardize the integrity of the ship. If non-liquid PCBs ≥ 50 ppm are to remain in the vessel, then 40 CFR Part 761 requires you to obtain a PCB disposal permit under 40 CFR 761.62(c).

Appendix D

Final Report – Polychlorinated Biphenyls (PCBs) Source Term Estimates

Final Report

Polychlorinated biphenyls (PCB) Source Term Estimates

for ex-ORISKANY (CVA 34)

Rev. 4

December 7, 2004

Prepared for

Program Executive Office (Ships)
Navy Inactive Ships Program (PMS 333)
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Introduction

The FY04 National Defense Authorization Bill (HR 1588 Sec 1013) permits decommissioned ships stricken from the Naval Vessel Register to be transferred to States for use as artificial reefs[1]. This new artificial reefing authority allows the Navy's Inactive Ships Program under PEO SHIPS to reduce their inventories of unneeded vessels.

The Navy's program objective is to reduce the size of the inactive ships inventory in a cost-effective and environmentally sound manner. The Navy will accomplish the environmental remediation of transferred vessels in accordance with draft EPA Best Management Practices[2]. The purpose of this report, determining the amount of PCB containing materials aboard the subject vessel, supports those objectives.

The vessel, the first warship offered for transfer by the Navy for sinking as an artificial reef, is the ex-*Oriskany* (CVA 34).

Background

USS *Oriskany*, a 27,100 ton *Ticonderoga* class aircraft carrier, was built at the New York Navy Yard. Though she was launched in October 1945, construction was suspended in August 1947 and she was completed to a revised design that was also used in modernizing several other ships of the *Essex* and *Ticonderoga* classes[3]. Designated SCB-27, the modernization was very extensive, requiring two years for each carrier. *Oriskany* became the prototype. To handle much heavier, faster aircraft, flight deck structure was massively reinforced. Stronger elevators, much more powerful catapults, and new arresting gear were installed.

A distinctive new feature was a new island. Ready rooms were moved to below the hangar deck, with a large escalator on the starboard side amidships to move airmen up to the flight deck. Internally, aviation gasoline storage was increased by nearly half and its pumping capacity enhanced. Also improved were electrical generating power, fire protection, and weapons stowage and handling facilities. All this added considerable weight: displacement increased by some twenty percent. *Essex* was the second carrier to be modernized to the SCB-27A design[4].

Commissioned in September 1950, *Oriskany* deployed to the Mediterranean Sea between May and October 1951 and steamed around Cape Horn to join the Pacific Fleet in May 1952. She made one Korean War combat cruise, from September 1952 to May 1953.

Oriskany was out of commission from January 1957 until March 1959, during which time she was modernized with an angled flight deck, steam catapults, an enclosed "hurricane" bow and many other improvements that permitted safer operation of high-performance aircraft. In 1961, she became the first aircraft carrier to be fitted with the revolutionary Naval Tactical Data System (NTDS).

After twenty-six years of service, USS *Oriskany* was decommissioned in September 1976. She was stricken from the Naval Vessel Register in July 1989 and sold for scrapping in 1994, but was repossessed by the US Government in 1997. *Oriskany* is presently being prepared for use as an artificial reef at Texas Dock and Rail Company in Corpus Christi, Texas by Resolve Marine. The Navy is pursuing a risked-based disposal approval under 40 CFR 761 from the EPA before transferring the ship to the State of Florida for use as an artificial reef by the Florida Fish and Wildlife Conservation Commission. The following report provides estimates of PCB-containing material quantities found aboard the vessel to assist Navy and EPA authorities in determining that risk. *Oriskany* will eventually be sunk, and become part of the Escambia East Large Area Artificial Reef Site, off Pensacola.

Figure 1 *Oriskany* at Texas Dock & Rail

Methodology

PCB-containing materials were identified aboard *Oriskany* through PMS 333's routine sampling protocol for vessels during the inactivation process[5, 6]. Materials/components found to contain PCBs at some concentration include paints, rubber products, electrical cable insulation, bulkhead insulation, ventilation gaskets, and lubricants. Therefore, the scope of this study is limited to quantifying, by the best available means, the amount of these materials aboard *Oriskany* and calculating the PCBs available in these materials that could be potentially released into the environment if left aboard (the PCB source term).

Wherever possible, data from the *Oriskany* was used in the quantification process. PCB concentration data from samples collected aboard the ship were used exclusively[5, 6, and 7]. The ship was also visually inspected and onsite personnel involved in the preparation of the ship were interviewed by CACI personnel to verify the presence of targeted materials, define possible remediation/salvage scenarios, and to ensure no other materials historically found to contain PCBs on Navy ships (such as impregnated felt) were aboard *Oriskany*.

Where weight/quantity data was not directly available for *Oriskany*, data from surrogate vessels were used to approximate conditions found on *Oriskany* as closely as possible. Surrogate vessels were selected using the following criteria: 1. data readily available, 2. data from the same class (*Essex*/*Ticonderoga* Class), 3. data from another aircraft carrier, 4. data from a large combatant built in the same era. Fortunately, information unavailable for *Oriskany* necessary to quantify the material aboard was found for the

Essex (CV-9) and the *Lexington* (CV-16). Specifically, a microfiche copy of the Final Weight Report (FWR) for USS *Essex*[8] was acquired from NSWC Carderock Code 224, and the fan list for USS *Lexington* was acquired from John J. McMullen Associates. The use of these documents, along with other estimating assumptions will be discussed in greater detail in the Results section of this report.

After determining the initial (as built) quantity of a subject material, the material weight (in pounds) was adjusted by various factors to approximate as closely as possible the existing conditions aboard *Oriskany*. These correction factors include "growth rates" for materials that accumulate over the life cycle of the vessel, remediation (reduction) ratios for materials removed during preparation, or conservative multipliers to account for undocumented material quantities.

The total estimated existing material weights were then multiplied by the mean and 95% upper confidence limit (UCL) PCB concentration of all samples of a given material to derive the weight of PCBs attributable to each type of PCB-containing material within the scope of the study. These Source Terms were then totaled to derive the mean and 95% UCL of the mean Total Weight of PCBs.

Results

Bulkhead Insulation

PMS 333 collected thirty-two samples of bulkhead insulation for PCB analysis. All samples were analyzed by Puget Sound Naval Shipyard. Results reported as less than the method detection limit (MDL) were calculated as one half of the MDL for the purpose of determining the mean PCB concentration for the material.

Table 1 Bulkhead Insulation Sample Results

Sample #	MDL ppm	PCBs ppm	Calculated PCBs ppm
95PS00019-001	5	53	53
95PS00019-002	5	6100	6100
95PS00019-003	5	60	60
95PS00019-004	5	45	45
95PS00019-005	5	<5	2.5
95PS00019-006	5	5.9	5.9
95PS00019-007	5	<5	2.5
95PS00019-008	5	<5	2.5
95PS00019-009	5	<5	2.5
95PS00019-010	5	<5	2.5
95PS00019-011	5	11	11
95PS00019-012	5	<5	2.5
95PS00019-013	5	<5	2.5

95PS00019-014	5	18	18
95PS00019-015	5	7.4	7.4
95PS00019-016	5	<5	2.5
95PS00019-017	5	6.4	6.4
95PS00019-018	5	7.3	7.3
95PS00019-019	5	5.5	5.5
95PS00019-020	5	6.6	6.6
95PS00019-021	5	130	130
95PS00019-022	5	39	39
95PS00019-023	5	320	320
95PS00019-024	5	15	15
95PS00019-025	5	6.9	6.9
95PS00019-026	5	<5	2.5
95PS00019-027	5	11	11
95PS00019-028	5	<5	2.5
95PS00019-029	5	<5	2.5
95PS00019-030	5	<5	2.5
95PS00019-031	5	<5	2.5
95PS00019-032	5	<5	2.5
		Mean	215.1
		95% UCL	587.7

The estimated quantity of bulkhead insulation aboard *Oriskany* was determined from a review of the *Essex* FWR listing for Group 22 d-2 “Bulkheads” and 49 individual weight entries were summed to calculate a total weight of 115, 695 lbs of bulkhead insulation. This weight is assumed to be equivalent to the weight aboard *Oriskany* with no correction.

Figure 2 Typical space with peeling paint and bulkhead insulation.

Rubber Products

PMS 333 collected 30 samples of rubber products (door gaskets, pipe hangers, mounts, etc.) for PCB analysis. Twenty-nine samples were analyzed by Puget Sound Naval Shipyard and one sample was analyzed by Norfolk Naval Shipyard. Results reported as less than the method detection limit (MDL) were calculated as one half of the MDL for the purpose of determining the mean PCB concentration for the material.

Table 2 Rubber Products Sample Results

Sample #	MDL ppm	PCBs ppm	Calculated PCBs ppm
95PS00032-001	5	32	32
95PS00032-002	5	10	10
95PS00032-003	5	24	24
95PS00032-004	5	130	130
95PS00032-005	5	6.5	6.5
95PS00032-006	5	54	54
95PS00032-007	5	29	29
95PS00032-008	5	14	14
95PS00032-009	5	<5	2.5
95PS00032-010	5	19	19
95PS00032-011	5	8.9	8.9
95PS00035-015	5	12	12
95PS00035-016	5	58	58
95PS00035-017	5	<5	2.5
95PS00035-018	5	110	110
95PS00035-019	5	<5	2.5
95PS00035-020	5	17	17
95PS00035-021	5	46	46
95PS00035-022	5	13	13
95PS00035-023	5	<5	2.5
95PS00035-024	5	28	28
95PS00035-025	5	12	12
95PS00035-026	5	110	110
95PS00035-027	5	92	92
95PS00035-028	5	39	39
95PS00035-029	5	120	120
95PS00035-030	5	33	33
95PS00035-031	5	49	49
95PS00035-032	5	42	42
91NN00999-044	1	<1	0.5
		Mean	37.3
		95% UCL	50.9

The estimated quantity of rubber products aboard *Oriskany* was determined by a review of the *Essex* FWR listing for Group 36 "Doors and Hatches". These weights are assumed to be directly equivalent to *Oriskany*, with the following correction. There was no available weight data for other rubber products, so a conservative multiplier of two was applied to the calculated total weight of door/hatch gaskets (the most abundant source of rubber material) to account for unquantifiable rubber products.

The weight of door, hatch, manhole, and scuttle gaskets was derived by counting the quantity of each category from the Group 36 listing. An average weight of gasket for each category was derived by calculating the average perimeter of each closure size and multiplying that perimeter by 0.34 lb/ft, the weight of MIL-R-900 standard rubber gasket stock.

Table 3 Door Gasket Weights

Door Sizes				
L in	W in	Perim. In	ft	lbs
18	36	108	9.0	3.1
26	45	142	11.8	4.0
26	54	160	13.3	4.5
26	57	166	13.8	4.7
26	66	184	15.3	5.2
30	66	192	16.0	5.4
			Average	4.5

Table 4 Hatch Gasket Weights

Hatch Sizes				
L in	W in	Perim. In	ft	lbs
24	36	120	10.0	3.4
30	30	120	10.0	3.4
30	36	132	11.0	3.7
30	48	156	13.0	4.4
30	60	180	15.0	5.1
36	42	156	13.0	4.4
36	60	192	16.0	5.4
36	72	216	18.0	6.1
48	48	192	16.0	5.4
60	60	240	20.0	6.8
			Average	4.8

Table 5 Manhole Gasket Weights

Manhole Sizes				
L in	W in	Perim. In	ft	lbs
15	18	66	5.5	1.9
15	23	76	6.3	2.2
			Average	2.0

Table 6 Scuttle Gasket Weights

Scuttle Sizes				
Dia. In		Perim. In	ft	lbs
18		56.5	4.7	1.6
21		66.0	5.5	1.9
			Average	1.7

Table 7 Rubber Product Weight Summary

Weight Summary Rubber Products							
Gaskets	Doors	Hatches	M.H.	Scuttles	Multiplier		
Count	844	193	532	88			
Avg. Lb/gasket	4.5	4.8	2.0	1.7			
Total lbs	3794.2	931.8	1070.2	152.7	2	11898.0	Grand Total lbs

The result of the analysis showed 1,567 closures with a corresponding weight of gaskets of 5,949 lbs. The conservative multiplier of two resulted in a total estimated weight of rubber product aboard *Oriskany* of 11, 989 lbs.

Paints

PMS 333 collected five samples of paint products for PCB analysis. These samples were analyzed by Puget Sound Naval Shipyard. ESCO Marine collected two composite samples of removed paint chips from *Oriskany* that were analyzed by Analab. Results reported as less than the method detection limit (MDL) were calculated as one half of the MDL for the purpose of determining the mean PCB concentration for the material.

Table 8 Paint Sample Results

Sample #	MDL ppm	PCBs ppm	Calculated PCBs ppm
Analab 655039	1	24.4	24.4
Analab 655040	1	15.2	15.2
95PS0032-012	5	<5	2.5
95PS0032-013	5	<5	2.5
95PS0032-014	5	<5	2.5
95PS0032-015	5	28	28
95PS0032-016	5	5.8	5.8
		Mean	11.6
		95% UCL	19.7

The estimated quantity of paint aboard *Oriskany* was determined from a review of the *Essex* FWR listing for Group 24 a "Paints and Varnishes" and after non-paint entries were eliminated, the remaining entries were summed to calculate a total weight of 298,999 lbs of paint. This weight is assumed to be equivalent to the weight aboard *Oriskany* with no correction.

Electrical Cable Insulation

PMS 333 collected 59 samples of electrical cable/wire insulation for PCB analysis. Fifty samples were analyzed by Puget Sound Naval Shipyard and nine samples were analyzed by Norfolk Naval Shipyard. Results reported as less than the method detection limit (MDL) were calculated as one half of the MDL for the purpose of determining the mean PCB concentration for the material.

Figure 3 Cable trays in auxiliary machine room.

Table 9 Cable Insulation Sample Results

Sample #	MDL ppm	PCBs ppm	Calculated PCBs ppm
95PS00034-001	5	110	110
95PS00034-002	5	580	580
95PS00034-003	5	10	10
95PS00034-004	5	22	22
95PS00034-005	5	9.5	9.5
95PS00034-006	5	80	80
95PS00034-007	5	67	67
95PS00034-008	5	6.1	6.1
95PS00034-009	5	38	38
95PS00034-010	5	6.2	6.2
95PS00034-011	5	400	400
95PS00034-012	5	140	140
95PS00034-013	5	290	290
95PS00034-014	5	110	110
95PS00034-015	5	2200	2200
95PS00034-016	5	<5	2.5
95PS00034-017	5	56	56
95PS00034-018	5	12000	12000
95PS00034-019	5	94	94
95PS00034-020	5	85	85
95PS00034-021	5	37	37
95PS00034-022	5	24	24
95PS00034-023	5	23	23
95PS00034-024	5	12	12
95PS00034-025	5	11000	11000
95PS00034-026	5	63	63
95PS00034-027	5	100	100
95PS00034-028	5	13	13
95PS00034-029	5	45	45
95PS00034-030	5	29000	29000
95PS00034-031	5	80	80
95PS00034-032	5	150	150
95PS00035-001	5	42	42
95PS00035-002	5	290	290
95PS00035-003	5	19000	19000
95PS00035-004	5	71	71
95PS00035-005	5	30	30
95PS00035-006	5	38	38
95PS00035-007	5	85	85
95PS00035-008	5	180	180
95PS00035-009	5	95	95
95PS00035-010	5	67	67

95PS00035-011	5	59	59
95PS00035-012	5	18	18
95PS00035-013	5	65	65
95PS00035-014	5	110	110
95PS00032-017	5	580	580
95PS00032-018	5	150	150
95PS00032-019	5	140	140
95PS00032-020	5	10000	10000
91NN00999-046	1	<1	0.5
91NN00999-048	1	29	29
91NN00999-054	1	78	78
91NN00999-057	1	15	15
91NN00999-066	1	33	33
91NN00999-067	1	13	13
91NN00999-080	1	23	23
91NN00999-082	1	8	8
91NN00999-085	1	70	70
		Mean	1493.9
		95% UCL	2766.0

The estimated quantity of electrical cable insulation aboard *Oriskany* was determined from a review of the *Essex* FWR listing for Group 44 "Electrical Plant" The total reported weight of the electrical plant was listed as 1,551,498 lbs. NSWCCD Code 244 conducted a review of other CV/CVN weight reports and determined the cable to electrical plant weight ratio to be 36%. Using this ratio, the weight of cable from the FWR calculates to 558,539.3 lbs. A study of the Navy Cable Inventory conducted by Westinghouse MTD found that the percentage of insulation in any given quantity of bulk cable is 72.26% for a typical combatant. Multiplying the estimated weight of cable by the insulation percentage gives an estimated weight of cable insulation of 403,600.5 lbs. This weight is assumed to be equivalent to the weight aboard *Oriskany* with no additional correction.

Ventilation Gaskets

The visual inspection of the Oriskany in Corpus Christ, TX revealed that no ventilation gaskets were impregnated felt material. Of all gaskets observed, 95% were rubber, 5% were compressed hard fiber material. PMS 333 collected 34 samples of ventilation gasket material for PCB analysis. All samples were analyzed by Norfolk Naval Shipyard. Results reported as less than the method detection limit (MDL) were calculated as one half of the MDL for the purpose of determining the mean PCB concentration for the material.

Table 10 Ventilation Gasket Sample Results

Sample #	MDL ppm	PCBs ppm	Calculated PCBs ppm
91NN00999-045	1	<1	0.5
91NN00999-047	1	<1	0.5
91NN00999-049	1	7	7
91NN00999-050	1	<1	0.5
91NN00999-051	1	<1	0.5
91NN00999-052	1	<1	0.5
91NN00999-053	1	<1	0.5
91NN00999-055	1	49	49
91NN00999-056	1	<1	0.5
91NN00999-058	1	22	22
91NN00999-059	1	6	6
91NN00999-060	1	5	5
91NN00999-061	1	6	6
91NN00999-062	1	210	210
91NN00999-063	1	8	8
91NN00999-064	1	11	11
91NN00999-065	1	50	50
91NN00999-068	1	13	13
91NN00999-069	1	33	33
91NN00999-070	1	<1	0.5
91NN00999-071	1	<1	0.5
91NN00999-072	1	5	5
91NN00999-073	1	41	41
91NN00999-074	1	<1	0.5
91NN00999-075	1	78	78
91NN00999-076	1	<1	0.5
91NN00999-077	1	<1	0.5
91NN00999-078	1	63	63
91NN00999-079	1	<1	0.5
91NN00999-081	1	35	35
91NN00999-083	1	<1	0.5
91NN00999-084	1	<1	0.5
91NN00999-086	1	25	25
91NN00999-087	1	15	15
		Mean	20.3
		95% UCL	33.5

A review of the fan list of *Lexington* (CV 16) determined that, based on an algorithm developed by naval ventilation engineers using the number and size of fans, the ventilation system contains 6700 flanges. The average gasket weight per flange is 0.4

lbs. This results in a total ventilation gasket weight of 2680 lbs. This weight is assumed to be equivalent to the weight aboard *Oriskany* with no additional correction.

Lubricants

PMS 333 collected 11 samples of lube oils and greases for PCB analysis. Ten samples were analyzed by Puget Sound Naval Shipyard and one sample was analyzed by Norfolk Naval Shipyard. Results reported as less than the method detection limit (MDL) were calculated as one half of the MDL for the purpose of determining the mean PCB concentration for the material.

Table 11 Lubricant Sample Results

Sample #	MDL ppm	PCBs ppm	Calculated PCBs ppm
91NN00999-001	1	<1	0.5
95PS00029-001	1	150	150
95PS00029-002	1	230	230
95PS00029-003	1	<1	0.5
95PS00029-004	1	<1	0.5
95PS00029-005	1	4	4
95PS00029-006	1	<1	0.5
95PS00029-007	1	67	67
95PS00029-008	1	100	100
95PS00029-009	1	<1	0.5
95PS00029-010	1	110	110
		Mean	60.3
		95% UCL	106.8

The estimated quantity of lubricants aboard *Oriskany* was determined from a review of the *Essex* FWR listing for Group 53 "Fuel, Gasoline, and Lube" and, after fuels and gasoline entries were eliminated, the remaining entries were summed to calculate a total weight of 208,104 lbs of lube oil. The weight of miscellaneous lubricants (such as greases), are assumed to be an insignificant percentage of the total weight of other lube oil stores. This weight is assumed to be equivalent to the weight aboard *Oriskany* with no correction.

Baseline PCB Source Terms

Extending the as-built estimated weights for the subject materials to reflect present day conditions aboard *Oriskany* requires adjusting the as-built (FWR) derived estimates to reflect lifecycle increases in materials, where appropriate. If available, Navy standard growth rate have been applied.

For example, Navy material and weight experts estimate that the thickness of paint on vessels (and therefore weight), with repeated painting, stripping, and repainting activities, increases by a factor of 3 over a 30-year life cycle. This is in contrast with rubber products and bulkhead insulation, which is relatively static, being removed and replaced as necessary in a one for one changeout, with no net change in quantity. Electrical and ventilation systems can experience modest growth, but generally as a result of installation of new systems or modification/modernization programs. Accordingly, a 20% growth rate has been applied to the ventilation gasket and electrical cable insulation weights in proportion to the 20% increase in overall ship displacement as a result of SCB-27A modernization program. An additional 10% is included to the cable growth rate to account for the Naval Tactical Data System added in 1961. Lube oils are limited by the original design capacities of the systems they occupy.

The baseline PCB source terms, below, reflect lifecycle growth, but do not include any reductions as a result of the preparation of the vessel for use as an artificial reef.

Table 12 Baseline Source Terms

Material	FWR Wt (lbs)	30yr Growth	Avg.PCB Conc. ppm	95% UCL	Lbs PCB	95% UCL lbs
Paints	298999	3	11.6	19.7	10.4	17.7
Bulkhead Insulation	115695	1	215.1	587.7	24.9	68.0
Rubber Products	11898	1	37.3	50.9	0.4	0.6
Cable Insulation	403600	1.3	1493.9	2766.0	783.8	1451.3
Vent. Gaskets	2680	1.2	20.3	33.5	0.1	0.1
Lubricants	208140	1	60.3	106.8	12.6	22.2
				Total	832.2	1559.9

Preparation Scenario

The following source term table reflects possible reductions in PCB loading due to removal of items as part of the preparation process. The scenario assumes that 100% of all lubricants will be removed, 5% of the paint (flaking surfaces), 72.6% of the bulkhead insulation (Navy contracted to remove 42 tons of insulation), and 10% cable salvage. No significant removal of rubber products or ventilation gaskets is anticipated.

Table 13 Preparation Scenario Source Terms

Scenario- 100% Lubricants, 5% Paint, 72.6% BLKHD Ins. & 10% Cable Removal								
Material	**Est. Wt (lbs)**	**30yr Growth**	**Avg.PCB Conc. ppm**	**95% UCL ppm**	**Lbs PCB**	**Remaining**	**lbs PCB**	**95% UCL lbs**
Paints	298999	3	11.6	19.7	10.4	95%	9.8	16.8
Bulkhead Insulation	115695	1	215.1	587.7	24.9	27.4%	6.8	18.6
Rubber Products	11898	1	37.3	50.9	0.4	100%	0.4	0.6
Cable Insulation	403600	1.3	1493.9	2766.0	783.8	90%	705.5	1306.1
Vent. Gaskets	2680	1.2	20.3	33.5	0.1	100%	0.1	0.1
Lubricants	208140	1	60.3	106.8	12.6	0%	0.0	0.0
						Total	722.6	1342.3

The Preparation Scenario reflects the best available information to date with regard to the material expected to be removed in the preparation process. The EPA Best Management Practices guidance requires 100% removal of lube oils. Based on paint chip removal tonnage reported at the 50% conference[9] (9.38 LT removed prior to the conference date), it is estimated that at project completion 22 LT or 44, 000 lbs of paint chips (5% of the total weight) will have been removed. Contractor and SUPSHIP project personnel report 72.6% of the bulkhead insulation removed and estimate 10% of the electrical cable will be removed as a result of preparation activities.

Conclusions

The estimate shows the PCB source term related to electrical cable accounts for 95% of the total PCB loading of *Oriskany*. The next largest contributor, bulkhead insulation, only accounts for 3% of the total PCB load. Moreover, if paint, rubber products, and ventilation gaskets were addressed in terms of a bulk product disposal, they would be unregulated based on their mean concentration, and rubber would only be above regulatory limits at the very conservative 95% UCL of the mean concentration.

References

[1] Title 10 U.S.C § 7306b SEC. 1013. AUTHORIZE TRANSFER OF VESSELS STRICKEN FROM THE NAVAL VESSEL REGISTER FOR USE AS ARTIFICIAL REEFS.

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Appendix E

FFWCC Documentation on Choice of Escambia Reefing Site

APPENDIX E

In August of 1993, Florida state representative Bo Johnson asked the Florida Department of Environmental Protection's (DEP) agency secretary Virginia Wetherall to investigate a means of assisting the Florida panhandle charter fishing industry to provide locations where this group could legally deploy artificial reefs. The state's artificial reef program, at that time housed within the Division of Marine Resources, of the DEP began work on determining possible large area artificial reef sites suitable for the deployment public reefs as well as small artificial reefs by local individuals associated with the charter boat industry. Following a series of three September 1993 public meetings in Pensacola, Shalimar, and Panama City, FL, where charter fishermen stressed the importance of continued individual construction of numerous small artificial reefs as being important to their livelihood, DEP's state artificial reef program personnel spent many hours working on identification and evaluation of large artificial reef sites (LAARS) in NW Florida panhandle waters of the Exclusive Economic Zone (EEZ) that might be candidates for Army Corps of Engineers permitted artificial reef sites. Escambia County Commissioners passed a resolution requesting that the state assume the responsibility (and liability) for these large areas and to make formal application to the Army Corps of Engineers for permits.

Following two rounds of public comment on a large area permit application that was submitted by DEP to the U.S. Army Corps of Engineers (USACE) in the spring of 1994, a five year permit 199402365 (IP-SS) was issued by the USACE to DEP on October 12, 1994. Two of the three large areas included in the permit were off Escambia County. These sites were Escambia West (43.3 sq. nautical miles) and Escambia East (77.4 sq. nautical miles). In the southeast Corner of the latter site is the proposed sinking site of the ex Navy vessel *ORISKANY.*

Site selection involved an exclusionary mapping process. The location, depth and maximum size of the sites were ultimately dictated by the following requirements: 1) exclusion of all active oil and gas lease blocks as requested by the U.S. Dept. 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) DEP requirements to avoid known hard/live bottom areas and sea grass beds. 5) the shrimping industry's requirements to avoid historic shrimp trawling areas.; 6) provide reasonable accessibility to the recreational fishing public.

The state artificial reef program transferred from the Department of Environmental Protection on July 1, 1999 to a newly constitutionally created state fish and wildlife agency known as the Florida Fish and Wildlife Conservation Commission. Liabiility for the Escambia LAARS sites was transferred from DEP to the FWC on September 22, 1999.

Following a confirmation of the original decision of Escambia County Board of County Commissioners not to accept the permit liability and responsibility from the FWC, a five year reauthorization request for the Escambia LAARS sites was submitted to the USACE by FWC on June 19, 2000. The boundaries of the Escambia LAARS sites were unchanged from 1994. The application went out on public notice for comment on August 17, 2000. Four six month extensions beginning in September 1999 were granted on the original permit prior to and during the reauthorization review process. Following review of FWC responses to public comment, on July 25, 2001 the USACE issued modification #5 to permit 199402365 (IP-CP). Reef construction work on the permit was authorized through September 22, 2006. One of the authorized reef materials types to be used in this permit are "steel hull vessels ballasted (where necessary) and thoroughly clean in accordance with U.S. Coast Guard and U.S. Environmental Protection Agency (EPA standards).

Once again after the public review and comment process it was re-confirmed that within Escambia LAARS sites, no commercial fishing/trawling grounds, military restricted/testing areas, marine parks, marine reserves, aquatic preserves, and marine sanctuaries, were present within 10 nautical miles of the border of either sites. No known oil or gas submerged transmission crossings exist in these sites according to U.S. Department of Interior's Minerals Management Service. These sites were initially permitted to be over 2 nautical miles from the charted commercial fairways into Pensacola Bay. Although extensive side-scan sonar mapping has not taken place in the area has no direct evidence from the literature or through historic knowledge of local charter fishermen that any extensive hard bottom exists within these permitted sites. Based on the literature searches The only submerged grasses in this part of the Gulf of Mexico are found within Escambia Bay, more than 23 nautical miles shoreward of the proposed sinking location. Small areas of isolated low relief, ephemeral hard bottom may exist within Escambia East; however this type of live bottom is not well developed, contains no hard corals, is ephemeral and is subject to burial and re-emergence as part of natural storm driven cycles.

Prior to sinking the ORISKANY, drop down cameras and utilization of Ponar grabs will be used to double check the bottom substrate at the proposed sink site. Extensive use of a bottom machine (depth recorder) in the area has revealed no bottom relief indicative of any developed reef structure. Both FWC and County divers evaluating other reef sites in Escambia East LAARS describe the bottom as composed of light brown sandy sediment with no hard/live bottom observed. Little subsidence of artificial reef materials has been noted on multiple dives in the area in recent years in the 80-110 feet depth range.

Reef building activity in the Escambia East LAARS has been dominated by county, state, and federally funded public reef building efforts that have developed 27 sites dominated by concrete materials and modules but also including several steel hulled vessels, and a decommissioned energy platform.

Source: 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)

Appendix F

Escambia County 2003 Fish Consumption Survey

APPENDIX F

METHODS USED IN CONDUCTING A FISH CONSUMPTION SURVEY OF WESTERN FLORIDA MARINE ANGLERS THAT FISHED SELECTED ARTIFICIAL REEFS IN 2003

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11 June 2004

BACKGROUND

Florida is one of several coastal states interested in acquiring decommissioned U.S. Naval vessels for use in building artificial reefs. The anticipated benefits of building offshore reefs with former Naval vessels (REEFEX) include enhancing ecological resources by increasing the amount of productive hard-bottom habitat, using artificial reefs as marine protected and conservation areas, and using artificial reefs to provide alternative reefs for enhanced recreational fishing and diving opportunities so that natural hard-bottom reef communities can be better protected and conserved.

In November, 2003 the State of Florida, represented by the Florida Fish and Wildlife Conservation Commission (FWCC)[3], on behalf of Escambia County, Florida, submitted an application to the Department of Transportation, Maritime Administration, to transfer an obsolete ship, the ex-ORISKANY, to the State of Florida for use as an artificial reef.[4] If the application is approved, the ex-ORISKANY will be deployed in federal waters of the Exclusive Economic Zone in the northeast Gulf of Mexico. The vessel will be placed within the Escambia East Large Area Artificial Reef Site (LAARS), a site permitted for artificial reef construction by the United States Department of the Army, Corps of Engineers. The location of the proposed *USS ORISKANY Memorial Reef* site is approximately 23 miles from Pensacola Pass and 33 miles from Destin Pass. If transfer to the State of Florida is approved, the sinking of the ship will abide by all established environmental policies of the United States and the State of Florida.

Studies of decommissioned Naval vessels indicate that residual levels of polychlorinated biphenyls (PCBs) are likely to be present in some ship components. In order to address the feasibility of using these vessels in reef-building programs, in 2001 an interagency REEFEX Technical Working Group (TWG) was established, consisting of representatives from the U.S. Environmental Protection Agency (EPA), the U.S. Navy (Navy), and the South Carolina Department of Natural Resources (SCDNR). Potential

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[1] Capt. Robert Turpin, Chief, Escambia County Marine Resources Division (ECMRD)
[2] Andrea Lunsford, Atlantic Environmental Consultants (AEC), Subcontractor to URS
[3] Jon Dodrill, Natural Science Manager, Florida Fish and Wildlife Conservation Commission (FWCC)
[4] *Letter of Application to the DOT, Maritime Administration, for Transfer of an Obsolete Ship Pursuant to Public Law 92-402 (16 U.S.C.) 1220 et. Seq.) approved August 22, 1972, as amended by H.R. 4546 Section 3504(a) to the State of Florida for Use as an Artificial Reef*, dated November 20, 2003.

risks associated with PCB contamination was one of the critical issues addressed by the TWG; specifically, whether use of decommissioned Navy vessels for reef-building could pose potentially unacceptable risks.

Approval to sink the ex-ORISKANY within the LAARS will be contingent upon a number of factors, including the issuance of a risk-based PCB disposal approval by the EPA.[5] To address the potential human health risks associated with the proposed *USS ORISKANY Memorial Reef*, an interagency ex-ORISKANY Working Group (WG) has been established, consisting of representatives from the EPA, the Navy, and the State of Florida (the FWCC and the ECMRD). The Navy (NEHC) is conducting a Human Health Risk Assessment (HHRA) for the ex-ORISKANY site, which will be reviewed by the ex-ORISKANY WG.

A key parameter for the ex-ORISKANY HHRA will be the fraction ingested (FI) value to be used in the calculation of potential risk to marine anglers from ingestion of fish that will be caught on or near the reef. In order to derive an appropriate FI value for the risk assessment, information about the fish consumption habits of marine anglers in Escambia County is needed. In May, 2004 the ECMRD conducted fish consumption surveys of marine anglers fishing in Escambia County. Electronic copies of all of the completed fish consumption surveys, and a summary of results from all the surveys were forwarded to the NEHC for review and analysis. This document provides a description of the survey tool, and the methods used by ECMRD in conducting the angler surveys.

In addition to the survey methods described below, the ECMRD also contacted the Florida FWCC regarding the possibility of posting the Escambia County Fish Consumption Survey on the FWCC website. The FWCC subsequently posted the survey on their website during May, 2004, and received numerous responses. The surveys completed on-line by respondents to the FWCC posting will be described elsewhere and evaluated separately.

FISH CONSUMPTION SURVEY TOOL

In January 2003, the NEHC developed a Draft Fish Consumption Survey Form that was intended to be used to capture specific data recommended by the EPA, i.e., fish consumption information for marine anglers who fished artificial reefs. The Fish Consumption Survey Form was reviewed and approved by the EPA[6], and initially used by the State of South Carolina in a survey of recreational marine anglers who were known to have fished the ex-Vermillion artificial reef located offshore of the state.

ECMRD anticipated that similar fish consumption data would also be needed to assess the potential human health risks associated with marine anglers and divers who might catch and consume fish at the proposed *USS ORISKANY Memorial Reef* site, if and when

[5] Naval Sea Systems Command letter, 4770, Ser 333/125, dated April 28, 2004 to USEPA, Region IV.
[6] Laura Casey, EPA OPPTS. Email message dated January 16, 2003; "REEFEX HHRA – Proposed Fish Consumption Survey".

it becomes an established reef. Since the Fish Consumption Survey tool had been used successfully in the South Carolina reef study, ECMRD personnel decided to use the same Fish Consumption Survey template, with adaptations to make the survey questions applicable to marine anglers who fish in Escambia County. Essentially, only place names and dates were changed, to make the survey tool applicable to marine anglers who fished in Florida during calendar year 2003. Survey questions regarding fish consumption habits are identical to those included on the SC survey. The Fish Consumption Survey Form used in Escambia County (see attached Escambia County Fish Consumption Survey form – Attachment 1) includes a question to verify that the angler being surveyed sport-fished in Florida marine waters during 2003. For respondents that answered in the affirmative, i.e., that they had indeed fished in Florida marine waters during 2003, additional questions were included on the survey to determine:

(1) Whether the angler had fished on or near 4 selected artificial reef sites (referred to as "Section I reefs") during 2003;
(2) The types or methods of fishing conducted when fishing on or near the Section I reefs;
(3) The types (species) of fish caught; and
(4) The anglers' consumption of fish over the specified period (consumption of fish obtained from the Section I reefs and consumption of fish and shellfish from other sources).

"Section I Reefs"

A significant difference between the Fish Consumption Survey used in SC and the Fish Consumption Survey used in Escambia County is embedded in question (1)(b), which asks the angler if they sometimes fished on a particular reef. In the case of the SC survey, the ex-Vermillion reef was an established reef; the ship had been deployed as a reef some 20+ years ago. In the case of the Escambia County survey, the *USS ORISKANY Memorial Reef* is currently a proposed reef; the ex-ORISKANY will not be deployed as a reef until EPA and DOT approval has been granted, and then it will likely take several years for it to become a viable reef which can be fished.

Because it would make no sense to ask anglers if they had fished a reef which does not yet exist, ECMRD personnel selected several existing artificial reefs within the LAARS, to use as surrogate reefs for the purpose of collecting fish consumption data that could be applicable to the proposed *USS ORISKANY Memorial Reef.* In choosing the surrogate reefs, ECMRD recognized that none of the artificial reefs which are currently in the Escambia County Artificial Reef inventory are the size of the proposed ex-ORISKANY reef (the ex-ORISKANY is an obsolete aircraft carrier, which will provide a large vertical and surface area profile). Because a larger-profile reef can be anticipated to provide more fish habitat, and therefore potentially support greater fish harvests than any single smaller reef, a decision was made to include four artificial reef sites, as opposed to just one site, in question (1)(b). Together, the four separate artificial reef sites are referred to as "Section I reefs" in the survey.

The four artificial reef sites that are listed in the Escambia Fish Consumption Survey, question (1)(b) are: (1) the Chevron Rig; (2) the ex-Antares; (3) the ex-Avocet; and (4) the ex-Navy Tugs. In completing the surveys, the survey-taker asked each angler being surveyed whether they had fished on or near any one of these four sites during 2003 (i.e., "yes" and "no" blocks are provided by each of the four sites to record responses). Then, in subsequent questions, regarding types of fishing conducted, etc., these four sites were referred to as Section I reefs. For example, question (II)(a) asked, "When you fished on the **Section I Reefs**, did you usually bottom-fish, troll, or both?"

The four artificial reef sites included on the Escambia County Fish Consumption Survey were selected on the basis that they might exhibit similar fish harvests and fish consumption patterns as those that could be expected at the ex-ORISKANY site. A number of criteria were considered, including these:

- Visitation: visual observance of marine anglers frequently fishing the site
- Proximity to the proposed ex-ORISKANY reef site
- Offshore location similar to the proposed ex-ORISKANY reef site
- Were they former Navy ships
- Were they former ships
- Size of the reef

The four artificial reef sites selected for inclusion on the Escambia County Fish Consumption Survey are briefly described below:

(1) The Chevron Rig:

The Chevron Rig was a retired oil field production platform. Prior to being deployed, the rig was cut into two pieces. The two pieces are deployed side-by-side in 140 feet of water. The Chevron Rig is located approximately two nautical miles from the proposed ex-ORISKANY site.

(2) The ex-Antares:

The ex-Antares was formerly a freighter. It is approximately 387 feet long, and was deployed as a reef in 1998. It is located in 130 feet of water. The ex-Antares is the largest ship in the Escambia County Artificial Reef inventory, and it is located approximately 20 miles offshore from Pensacola. This location is a similar distance offshore as the proposed ex-ORISKANY site.

(3) The ex-Avocet:

The ex-Avocet was formerly a dredge. It is approximately 247 feet long, and was deployed as a reef in the late 1980s. The ex-Avocet sits in 120 feet of water. The ex-Avocet is also located approximately 20 miles offshore from Pensacola, a similar distance offshore as the proposed ex-ORISKANY site.

(4) The ex-Navy Tugs:

This site is comprised of two former Navy tugs, the ex-YTD-14 and the ex-YTD-15 Both of the vessels are 132 feet long. The two vessels sit approximately 400 feet apart from each other on the ocean floor, in 100 feet of water. The two retired vessels are located approximately 15 miles offshore. ECMRD personnel have visually observed frequent visitation by marine anglers to this site.

METHODS USED IN CONDUCTING THE SURVEYS

ECMRD personnel[7] conducted the surveys during May of 2004. Three approaches were used to identify recreational marine angler populations that were considered likely to include anglers that may have fished the selected artificial reefs: [8] (1) a popular Sportfishing Club was visited during a scheduled club meeting; (2) intercept surveys were conducted during the 2004 Red Snapper World Championship Fishing Tournament held in Pensacola, Florida on 14-16 May; (3) popular County Park Boat Ramps were visited to conduct intercept surveys; and (4) several public marinas, used extensively by marine anglers, were visited to conduct intercept surveys with the fishermen as they left for, or returned from, fishing trips.

To conduct the surveys, ECMRD interviewed anglers and recorded the responses. Each question on the Fish Consumption Survey form was asked, and the response given by the angler was recorded. The date of the survey interview, the initials of the ECMRD recorder, and the initials of the interviewed angler were recorded on the top right corner of the first sheet of the survey form. A summary of the results of the "Escambia County Marine Resources 2003 Fish Consumption Survey" is provided as Attachment (2).

Surveys Conducted at the Pensacola Recreational Fishermen's Association on 11 May 2004

On May 11th, Capt. Robert Turpin, ECMRD, attended the Pensacola Recreational Fishermen's Association meeting in Pensacola, FL. Capt. Turpin believed that members of this club would likely have a high number of anglers who might fish the selected artificial reefs. At this meeting Capt. Turpin surveyed 24 anglers who indicated they had fished in Florida marine waters during 2003. Fourteen (14) of the 24 anglers surveyed indicated they had fished the "Site 1" artificial reefs in 2003. Capt. Turpin completed 24 survey interviews, including surveys of the 14 anglers who indicated they had fished the Section 1 artificial reefs, and surveys of the 10 anglers who indicated they had not fished the Section 1 artificial reefs during 2003.

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[7] Captain Robert Turpin, Chief, Escambia County Marine Resources Division; and Donald Clemens and Gus Canero, volunteer assistants to the Escambia County Marine Resources Division.

[8] Captain Robert Turpin, ECMRD. Telephone discussion of June 8, 2004, with Andrea Lunsford, AEC, and email message from R. Turpin dated June 8, 2004 which provided a summary table entitled "Escambia County Marine Resources 2003 Fish Consumption Survey."

Surveys Conducted at the Navy Point Boat Ramp on 15 May and 24 May, 2004:

"Navy Point" is the name of a public (county) park in Escambia County. The boat ramp at the Navy Point county park is highly utilized by marine anglers. The boat ramp is used to launch recreational boats from trailers. On 15 May, and again on 29 May, 2004 Mr. Donald Clemens, a volunteer assistant to the Escambia County Marine Resources Division, conducted intercept surveys of marine anglers that were departing from or arriving at the Navy Point boat ramp. Of the 27 marine anglers surveyed by Mr. Clemens on 15 and 29 May, 15 responded affirmatively that they had fished the Section 1 artificial reefs during 2003; 12 respondents indicated that they had not fished the Section 1 artificial reefs during 2003.

Surveys Conducted during the 2004 Red Snapper World Championship Fishing Tournament, 14 to 16 May, 2004:

The 2004 Red Snapper World Championship Fishing Tournament was held in Pensacola, FL on 14-16 May, 2004. The Weigh-In point for this tournament was the Daybreak Marina, in Pensacola, FL. Capt. Robert Turpin was the Weigh Master for this tournament, and therefore was stationed at the Daybreak Marina during the tournament. Interludes between weigh-in activities provided Capt. Turpin an opportunity to conduct intercept interviews of sports fishermen who were present at the Daybreak Marina. CAPT Turpin completed 5 surveys of marine anglers during 14-16 May. Of the 5 marine anglers surveyed, all 5 anglers indicated that they had fished the Section 1 reefs during 2003.

Surveys Conducted at the Galvez Landing Boat Ramp on 15-16 May and on 29 May, 2004:

"Galvez Landing" is the name of a public boat ramp in Escambia County. The boat ramp at the Galvez Landing is highly utilized by marine anglers. The boat ramp is used to launch recreational boats from trailers. On 15 and 16 May, and again on 28 May, 2004 Mr. Gus Canero, a volunteer assistant to the Escambia County Marine Resources Division, conducted intercept surveys of marine anglers that were departing from or arriving at the Galvez Landing boat ramp. Of the 10 marine anglers surveyed by Mr. Canero on 15, 16, and 28 May, nine (9) responded affirmatively that they had fished the Section 1 reefs during 2003; one respondent indicated that he had not fished the Section 1 artificial reefs during 2003.

Surveys Conducted at the Holiday Harbor Marina on 28 May and 31 May, 2004:

On 28 May and 31 May, 2004 Mr. Gus Canero visited the Holiday Harbor Marina located on Big Lagoon, in Escambia County. The Holiday Harbor Marina is a large private marina used by the general public and frequented by marine anglers. Mr. Canero conducted intercept surveys with 6 marine anglers that were present at the Holiday Harbor Marina on 28 and 31 May. Of the 6 marine anglers surveyed by Mr. Canero on

these dates, 5 indicated that they had fished the Section 1 reefs during 2003; one respondent indicated that he had not fished the Section 1 artificial reefs during 2003.

Surveys Conducted at the Oyster Bar Marina on 31 May, 2004:

On 31 May, 2004 Mr. Gus Canero also visited the Oyster Bar Marina located on Big Lagoon, in Escambia County. The Oyster Bar Marina is a large private marina used by the general public and frequented by marine anglers. Mr. Canero conducted intercept surveys with 5 marine anglers that were present at the Oyster Bar Marina on 31 May. All five of the five marine anglers surveyed by Mr. Canero indicated that they had fished the Section 1 reefs during 2003.

Survey Effort Results

By attending the Pensacola Recreational Fishermen's Association meeting, the 2004 Red Snapper World Championship Fishing Tournament, visiting the Navy Point boat ramp and Galvez Landing boat ramp, and visiting the Holiday Harbor Marina and Oyster Bar Marina, ECMRD personnel attempted to target sports fishermen who were most likely to fish the Section I artificial reefs. Of the 77 Fish Consumption Surveys completed at these locations, 53 respondents indicated that they had fished the Section I artificial reefs in 2003. All of the completed surveys (77) were forwarded to NEHC for review and evaluation of the data.[9]

[9] In addition to conducting the 77 surveys described above, ECMRD conducted three additional surveys, via telephone interviews. These 3 surveys are not described above, and are not included in the summary table, "Escambia County Marine Resources 2003 Fish Consumption Survey" provided in Attachment 1. However, copies of these 3 surveys were also provided to NEHC for review and evaluation, thus the total number of surveys used to derive the Site-Specific Fraction Ingested value (see Appendix L) was 80.

Escambia County Division of Marine Resources

Artificial Reef User Survey

Date:_____ Location:_____

1. Florida resident?____

2. County residence:_____

3. Boat registration location (County/ State):_____

4. Fishing?__ Diving?__ Both?__ Other:_____

5. Do you know what structure(s) you fished?__ List:_____

_____

6. Target species:_____

7. Importance of artificial reefs to your fishing/diving (scale:1-10): _____

8. How many days per year do you fish/dive artificial reefs?_____

9. How many fish caught/kept during your last trip:

Red snapper	_____/_____
"Mingo" snapper	_____/_____
Triggerfish	_____/_____
Gag (all grouper)	_____/_____
Amberjack	_____/_____
Other:	_____/_____

10. How many other boats were on the same artificial reefs with you today (last trip)? _____

11. Rate your satisfaction with the Escambia County Artificial Reef Program (scale: 1-10):___

12. Suggestions/comments:_____

_____

_____

_____

13. (Optional) Name:_____
Address:_____
Phone:_____

Survey #_____
Date:_____
Initials of Surveyor/ Questioner:_____
Initials of Survey Participant_____
Location Survey Conducted_____

ESCAMBIA COUNTY FISH CONSUMPTION SURVEY

I. Verification Questions

a. Did you sport-fish in Florida marine waters during 2003?
- ☐ YES
- ☐ NO

b. Did you sometimes fish on the:

1) Chevron Rig ☐YES ☐NO
2) Antares ☐YES ☐NO
3) Avocet ☐YES ☐NO
4) Navy Tugs (one or both) ☐YES ☐NO

[The 4 Artificial Reefs listed above will be called ***Section I Reefs*** for the rest of the survey]

II. Types of Fishing Conducted

a. When you fished on the ***Section 1 Reefs***, did you usually bottom-fish, troll, or both?
- ☐ Usually only BOTTOM- fished
- ☐ Usually only TROLLED
- ☐ Usually we both BOTTOM- fished *and* TROLLED
- ☐ I really can't remember whether I bottom-fished, trolled, or did both while fishing the ***Section I Reefs***

III. Types of Fish Caught

a. When you bottom-fished at the ***Section I Reefs***, what types of fish did you usually catch? **(Please check all that apply)**

- ☐ Red Snapper
- ☐ Grouper
- ☐ White Grunt
- ☐ Triggerfish
- ☐ Vermillion Snapper
- ☐ Amberjack
- ☐ King Mackerel
- ☐ Other **(please list other fish usually caught)**

_____
_____

☐ I really can't remember what types of fish I caught when I bottom-fished the ***Section I Reefs***

IV. Fish Consumption Questions

a. Do you ***usually keep*** the legal- sized, edible fish that you catch, ***to eat yourself (or for your family to eat)?***

☐ YES-- I usually keep the edible fish I catch, for me/ my family to eat.
☐ NO-- I don't usually keep the edible fish I catch for myself/ my family to eat.

(Example of no- Rather, for example, I usually give it away to others; catch fish just for the sport of it, and throw them back; etc.)

b. What ***proportion*** of the edible saltwater fish that you catch ***do you estimate you or your family eats?*** *(Please check the box below that **best describes** the proportion of fish that you/ your family eats of the edible fish that you catch yourself.)*

☐ ALMOST ALL	(I/my family eat ***almost all*** of the edible fish/ almost every edible fish that I catch.)
☐ MOST	(I/my family probably ***eats ½ to two- thirds*** of the edible fish I catch.)
☐ SOME	(I/my family probably ***eats less than one- half*** of all the edible fish I catch
☐ NOT MUCH	(I/my family probably ***eats less than one-quater*** of all the edible fish I catch

[Examples: Some people only eat the biggest, or the most favorite type of fish, and give the rest away. Or they don't like cleaning or cooking fish themselves, etc.]

c. During the year, do you/your family typically eat ***any*** fish/shellfish meals at restaurants, or from take-outs, or from commercial sources such as grocery stores?

☐ YES
☐ NO

d. ***How many fish/shellfish meals*** / (how often) do you estimate you/your family ate ***at restaurants or take-outs, or bought from other sources*** during 2003?

☐ 1 to 2	(About 1 or 2 meals a year)
☐ 3 to 5	(About 1 meal every 3 or 4 months)
☐ 5 to 7	(About once every 2 months)
☐ 10 to 13	(About once a month)
☐ 13 to 16	(More than once a month)
☐ 16 to 24	(About 2 meals every month)

e. ***How many home-cooked fish meals*** / (how often) do you estimate you/your family ate during 2003

☐ 1 to 2	(About 1 or 2 meals a year)
☐ 3 to 5	(About 1 meal every 3 or 4 months)
☐ 5 to 7	(About once every 2 months)
☐ 10 to 13	(About once a month)
☐ 13 to 16	(More than once a month)
☐ 16 to 24	(About 2 meals every month)

f. ***How many of the home-cooked fish meals*** that you/your family ate during 2003 do you estimate ***were made up of fish that you caught from the Section 1 Reefs?***

☐ 1 to 2	(About 1 or 2 meals a year)
☐ 3 to 5	(About 1 meal every 3 or 4 months)
☐ 5 to 7	(About once every 2 months)
☐ 10 to 13	(About once a month)
☐ 13 to 16	(More than once a month)
☐ 16 to 24	(About 2 meals every month

APPENDIX F

Escambia County Marine Resources 2003 Fish Consumption Survey

Location	Pens. Rec. Fish Assoc. Mtg.	Navy Pt. Ramp	Red Snapper Tourney	Galvez Boat Ramp	Holiday Harbor Marina	Oyster Bar Marina				Total
Responses: Site 1 Reefs/ Total	14/24	15/27	5/5	9/10	5/6	5/5				53/77
Date	11 May '04	15May'04	14-16 May '04	15-16 May '04	28 May '04	31 May '04				
		29May'04		28 May '04	31 May '04					
RESULTS FROM ALL COMPLTED SURVEYS:										
Sport-Fished in Florida Waters in 2003?	Yes	No								
	71	6								77
Reefs Fished (Section 1 Reefs)	Chevron Rig	Antares	Avocet	Navy Tugs						
	28	31	34	32						
Method of Fishing	Bottom	Trolled	Both	Can't Remember	*Not Answered*					
	26	3	23	0	1					53
Species of Fish Caught	Red Snapper	Grouper	White Grunt	Trigger	Vermillion Snapper	Amberjack	King Mackerel	Other	Can't Remember	
	43	40	3	24	14	30	5	8		
Are Legal-Sized, Edible Fish Kept to Eat?	Yes	No								
	53	0								53
What Portion of Edible Fish Kept is Eaten?	Almost All	Most	Some	Not Much						
	35	13	4	1						53
Fish/Shellfish Bought/Eaten Outside Home?	Yes	No	*Not Answered*							
	51	1	1							53
# Of Fish/S.F. Meals Bought/Eaten outside Home in 2003	1 to 2	3 to 5	5 to 7	10 to 13	13 to 16	16 to 24	*Own Answer*			
	1	7	5	12	4	17	7			53
# of Home-Cooked Fish Meals Eaten in 2003	1 to 2	3 to 5	5 to 7	10 to 13	13 to 16	16 to 24	*Own Answer.*			
	1	2	1	8	5	30	6			53
# of Home-Cooked Fish Meals That Came From Section 1 Reefs in 2003	1 to 2	3 to 5	5 to 7	10 to 13	13 to 16	16 to 24	*No/ Answer*			
	14	16	7	8	3	4	1			53

Escambia County Marine Resources 2003 Fish Consumption Survey	
Notes	
Survey #4- Question III a. For Other, Listed "White Snapper, Lane Snapper"	Survey #40- Question IV c. Checked YES and Added "Mullet"
Survey # 5- Question IV e. Checked 16 to 24, Wrote "MORE"	Survey #40- Question IV e. Checked 16 to 24, Wrote, "if not more"
Survey # 6- Question I b. Circled "both" for Navy Tugs	Survey #43- Queston IV e. Didn't Check an Answer, Wrote, "more than 24"
Survey # 7- Question IV f. Wrote Zero, "0".	Survey #44- Question III a. For Other, Listed "Red Fish"
Survey #11- Question II a. Diving Response; We Marked *BOTTOM- fished*	Survey #44- Question IV d. Wrote, "about 96 per year (About 8 times a month)"
Survey # 12- Question IV b. Multiple Response- Almost All & Some	Survey #48- Question IV e. Didn't Check an Answer, Wrote "40"
Survey #14- Question I a. Misunderstood- Changed to Sport Fishing = ~ Recreational Fisherman.	Survey #51- Question IV d. Didn't Check an Answer, Wrote "40-50"
Survey #21- Question I a. Misunderstood- Changed to Sport Fishing = ~ Recreational Fisherman.	Survey #52- Question I b. Thinks Navy Tugs Goes by Different Name
Survey #36- Question IV d. Checked 16 to 24, Wrote "+"	Survey #52- Question III a. For Other, Listed "Wahoo"

Appendix G

Derivation of Site-Specific Fraction Ingested (FI) Term

APPENDIX G

Derivation of a Marine Finfish-Specific Fraction Ingested (FI_{MFF}) Term for Use in Evaluating Prospective Health Risks at the Proposed ex-ORISKANY Memorial Reef Site

Prepared for
Navy Environmental Health Center
by URS Corporation
June 14, 2004

INTRODUCTION

Since the exposure scenario of primary concern in the human health risk assessment (HHRA) is the ingestion of *marine finfish* that will be caught at the ex-ORISKANY artificial reef site, the use of a Fraction Ingested (FI) term specific to marine anglers who are likely to fish the ex-ORISKANY site, and an Ingestion Rate (IR) value which is specific for the consumption of marine finfish in the Gulf Coast Region, are considered appropriate. Therefore, we have derived a site-specific FI term, specific to ingestion of marine finfish (FI_{MFF}), based on the results of a fish consumption survey conducted by the Escambia County Marine Resources Division[1] (ECMRD) in May, 2004. The survey obtained fish consumption information from marine anglers who fished four artificial reef sites (i.e. surrogate sites) thought to most closely reflect the fish harvests and recreational utilization that can be anticipated to occur at the ex-ORISKANY reef site, when that site becomes a viable reef. A summary of the results of the survey is provided in Table 1. Note that a discussion of the survey methodology and a sample survey form are presented in Appendix G of the HHRA.

To derive the site-specific FI_{MFF} term, we based the numerator (the amount of marine finfish caught on the Section 1 reefs [i.e., the four surrogate reefs identified as "Section 1 reefs" in the Fish Consumption Survey] and consumed by Florida [FL] recreational marine anglers) on fish consumption survey data collected by ECMRD. We based the denominator (the amount of marine finfish consumed per year by FL marine anglers from all sources) on U.S. Environmental Protection Agency (USEPA) published values.

The following steps were used to derive the FI_{MFF} term:

- Identify IR values for fish from EPA Exposure Factors Handbook, Table 10-52, for the Gulf Region.

- Identify mean and 95th percentile fish meal sizes for the general U.S. population (EPA Exposure Factors Handbook, Section 10.10.1, p. 10-26).

[1] Capt. Robert Turpin, Chief, Escambia County Marine Resources Division (ECMRD), and voluntary assistants to the ECMRD (Donald Clemens and Gus Canero), conducted the fish consumption surveys.

- Calculate the total number of marine finfish meals per year from all sources by multiplying 365 days per year times the mean and 95th percentile daily ingestion rate (g/day) for the Gulf region (Table 10-52), divided by mean and 95th percentile meal sizes for the U.S. population (g/meal), respectively (Section 10.10.1).

- Derive the FI_{MFF} term using the amount of fish consumed from the four surrogate reefs and the above amount of fish consumed from all sources, using deterministic and probabilistic methods.

ESTIMATION OF A MARINE FINFISH-SPECIFIC FRACTION-INGESTED TERM (FI_{MFF})

Use of Mid-Range FI Estimate

The USEPA Guidance for Exposure Assessment (57 FR 22888) recommends against the use of high-end values for each exposure parameter used in a risk assessment because the compounding effect of multiple upperbound values would place the estimated exposure in the realm of Theoretical Upper-bound Exposure (TUBE). These guidelines recommend that while high-end exposure estimates should be greater than the 90th percentile of the total exposure, it should not be at the extreme upper end of the range. The USEPA Risk Assessment Guidance for Superfund[2] (RAGS) recommends using two to three exposure parameters that are high end, including the Ingestion Rate, and using central tendency values (mean values) for the remaining parameters when estimating Reasonable Maximum Exposure (RME). This approach has been incorporated into the HHRA. Consistent with this approach, central tendency exposure (CTE) and reasonable maximum exposure (RME) FI_{MFF} terms have been derived. The CTE term uses mean values for the number of meals of fish from the Section 1 reefs, and mean values for the total yearly number of marine finfish meals consumed.

Deterministic Estimate of Fraction Ingested Term for Section 1 Reefs Marine Finfish Consumption

The FI_{MFF} is derived deterministically by taking the ratio of the number of Section 1 reef-fish meals consumed per year by marine anglers who fish the Section 1 reefs to the estimated total number of marine finfish meals consumed in the Gulf Region.

To estimate the total number of marine finfish meals per year consumed by FL marine anglers, the mean and 95th percentile meal sizes, and the mean and 95th percentile marine finfish ingestion rates for the Gulf Coast region based on EPA[3] were employed. Given a mean daily marine finfish ingestion rate (e.g., 7.2g/day, mean value) and a mean fish meal size (e.g., 129g), a yearly marine finfish meal consumption value can be calculated

[2] United States Environmental Protection Agency (USEPA). 1989. *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A).* Office of Emergency and Remedial Response, Washington, DC.
[3] United States Environmental Protection Agency (USEPA). 1997. Exposure Factors Handbook. Office of Health and Environmental Assessment, Washington, DC, EPA/600/P-95/002F, August 1997.

as follows: 365 days per year times 7.2g per day, divided by 129g per meal. This yields a mean value of 20.4 meals of marine finfish per year. Using the 95th percentile values for daily marine finfish ingestion (26.1g/day) and meal size (326g), a 95th percentile for the total number of marine finfish meals per year is calculated to be 29.2.

These values are used in the denominator in calculating a point estimate for the FI_{MFF} term in Table 2. The numerator is the mid-point of each individual respondent's number of meals consumed per year from the four surrogate reef sites. These calculations result in two ratios for each respondent in the survey, based on the mean and on the 95th percentile total meals consumed for the Gulf region. The means for each of these two sets of ratios determines the mean value (CTE) for the FI_{MFF} term, of 0.251, and the 95th percentile value (RME) for the FI_{MFF} term of 0.175.

Probabilistic Estimate of Fraction Ingested Term for Section 1 Reefs Marine Finfish Consumption

To describe and quantify the variability inherent within the deterministic FI_{MFF} term estimates, we employ the bootstrap analysis. The Section 1 reefs marine finfish-specific FI term distributions, based on the mean and 95th percentile yearly marine finfish meals, are presented in Figure 1. The top chart represents the bootstrapped FI term based on the number of Section 1 reef-associated fish meals per year and the number of marine finfish meals derived from the mean ingestion rate for marine finfish in the Gulf region (7.2g/day), and mean fish meal size (129g). The lower chart is based on the upper limit (95th percentile) ingestion rate for marine finfish in the Gulf Coast Region (26.1g/day) and the upper limit fish meal size (326g). The entire range of possible outcomes for the FI_{MFF} term, based on the EPA derived yearly finfish meals, is from 0.113 to 0.372.

The 50th percentile (most likely outcome) of the bootstrap of the FI_{MFF} term, based on the mean number of yearly finfish meals, is 0.251. The 5th and the 95th percentiles of the bootstrap distribution (representing the 5% lower and 95% upper limits) are 0.197 and 0.308, respectively. In other words, there is only a 10% probability that the FI_{MFF} is either higher or lower than these values.

The bootstrapped FI_{MFF} distribution, based on the upper limit for the number of yearly finfish meals derived from the EPA Exposure Handbook, reveals a 50th percentile, or most likely value, of 0.174. The 5th and the 95th percentiles of the bootstrap distribution are 0.138 and 0.216, respectively. There is only a 10% probability that the FI_{MFF} is either higher or lower than these values.

SUMMARY OF FINDINGS

By calculating the FI_{MFF} term using deterministic and probabilistic methods, the potential range in values can be illustrated. The following summarizes the results of these calculations as presented above:

Based on Survey Results and Mean EPA Marine Finfish Ingestion Rate (for Gulf Coast) and Meal Size	
Point Estimate	0.251
Probabilistic Estimate Median	0.251
Probabilistic 5th Percentile	0.197
Probabilistic 95th Percentile	0.308
Based on Survey Results and 95th Percentile EPA Marine Finfish Ingestion Rate (for Gulf Coast) and Meal Size	
Point Estimate	0.175
Probabilistic Estimate Median	0.174
Probabilistic 5th Percentile	0.138
Probabilistic 95th Percentile	0.216

DISCUSSION AND RECOMMENDATIONS

The FI_{MFF} terms discussed in this document were derived using survey data collected by ECMRD for the Section 1 reefs, as well as from numerous published studies cited in the Exposure Factors Handbook (EPA, 1997). The deterministic-derived values for the FI_{MMF} term range from 0.175 (based on the 95th percentile marine finfish consumption rate) to 0.251 (based on the mean marine finfish consumption rate). The probabilistic distributions present central tendency FI_{MMF} values in terms of the median (50th percentile) estimates. The median probabilistic FI_{MFF} estimates range from 0.174 (based on the 95th percentile marine finfish consumption rate) to 0.251 (based on the mean marine finfish consumption rate).

TABLE 1
SUMMARY OF ANGLER SURVEY RESULTS FOR THE EX-VERMILLION REEF

	I. Reefs Fished				II. Types of Fishing Conducted			III. Types of Fish Caught									IV. Fish Consumption (Parts a, b, and c)							
																	Keep fish to eat?		How much caught fish are eaten?				Eat fish not prepared at home? [2]	
Survey Number	Chevron	Antares	Avocet	Navy Tugs	Bottom fished	Trolled	Bottom & Trolled	Red Snapper	Grouper	White grunt	Triggerfish	Vermillion Snapper	Amberjack (not reef-associated)	King Mackerel	Other Species	Additional Species taken while fishing the Section I Reefs[1]	YES - Usually Keep fish to eat	NO - Do not usually keep to eat	Almost all eaten	Most fish eaten (1/2 to 2/3)	Some fish eaten (<1/2)	NOT much (< 1/4)	YES	NO
1	X	X	X	X			X	X	X		X	X	X	X			X		X				X	
2	X	X	X		X			X	X		X						X		X				X	
3	X	X	X	X	X			X	X		X		X				X		X				X	
4	X	X	X	X	X			X	X	X	X	X	X	X	X	White Snapper, Lane Snapper	X			X			X	
5	X	X	X		X			X	X		X						X			X				X
6				X	X			X			X						X				X		X	
7																	X					X	X	
8			X	X	X			X	X		X		X				X		X				X	
9	X	X	X		X			X	X				X				X			X			X	
10	X	X	X				X	X	X		X	X	X				X			X			X	
11	X	X	X	X	X				X				X				X		X				X	
12				X	X			X	X		X						X		X				X	
13				X	X			X	X		X	X	X				X				X		X	
14	X	X	X	X	X			X	X	X	X	X	X	X			X			X			X	
15																	X		X				X	
16							X											X			X		X	
17																	X		X				X	
18																		X				X	X	
19																	X		X				X	
20																		X				X	X	
21					X			X			X						X		X				X	
22																	X			X			X	
23					X				X		X		X	X	X	Dolphin	X		X				X	
24																	X				X		X	
25																							X	
26		X		X			X	X	X								X		X				X	
27					X			X	X		X	X					X		X				X	
28				X	X			X	X		X						X			X			X	
29																	X			X				X
30						X											X		X				X	
31					X			X	X		X						X		X				X	
32		X		X	X			X	X					X			X		X				X	
33					X			X	X		X		X	X			X			X			X	
34																							X	
35		X		X			X	X	X		X						X		X				X	
36			X				X	X			X	X					X			X			X	
37	X	X	X	X			X	X	X		X		X				X			X			X	
38	X	X	X	X	X			X	X		X		X				X			X			X	
39	X		X				X	X	X				X				X		X				X	
40		X	X	X	X			X	X		X		X				X		X				X	
41	X	X	X		X			X	X		X	X					X		X				X	
42	X	X		X			X	X	X	X			X				X		X				X	
43	X	X	X	X	X				X				X				X		X				X	
44				X			X		X						X	Red Fish	X		X				X	
45																	X		X				X	
46	X						X	X	X				X				X		X				X	
47			X				X	X	X								X			X			X	
48		X			X			X	X				X				X		X				X	
49		X		X			X	X	X								X		X				X	
50		X					X		X								X			X			X	
51	X		X				X	X	X				X				X		X				X	
52	X			X		X		X					X		X	Wahoo	X			X			X	
53			X				X	X	X				X				X		X				X	
54	X			X			X		X				X				X		X				X	
55																	X		X				X	
56			X		X			X				X	X		X	Black Snapper, Cobia	X		X				X	
57		X			X			X	X				X				X		X				X	
58			X				X	X	X		X	X	X	X			X			X			X	
59			X				X										X			X			X	
60			X	X	X			X				X			X	Mingo	X		X				X	
61		X	X	X	X			X	X		X	X	X	X			X			X			X	
62	X	X	X		X			X	X		X	X	X	X	X	Ling	X		X				X	
63			X		X				X				X		X	Mingo	X			X			X	
64				X	X			X									X		X				X	
65	X		X	X	X			X			X	X	X				X		X				X	
66						X	X								X	Red Drum		X				X	X	
67					X	X		X	X		X			X			X		X				X	
68																	X			X			X	
69																	X		X				X	
70																	X			X			X	
71	X	X	X	X			X	X					X				X		X				X	
72		X	X			X											X				X		X	
73	X	X	X	X			X	X	X				X				X				X		X	
74	X					X											X		X				X	
75	X	X	X	X			X	X	X		X				X	Mingo	X		X				X	
76			X	X			X	X	X								X		X				X	
77				X			X	X			X	X		X			X		X				X	

If the response to Survey Question I regarding whether the Section I reefs were fished in the past year was negative then the survey was excluded from any subequent calculati

1 = Of the additional fish caught while fishing the Section 1 reefs, only the red porgy is associated with reef habita
2 = This refers fish eaten at restaurants, as take out, or bought pre-prepared at grocery store
3 = This refers to fish caught angling and fish bought unprepared from market
4 = This refers to just those fish caught in the vicinity of the Section 1 reefs and includes both oceanic and reef-associated speci

Survey #4- Q III a. For**Other**, Listed White Snapper, Lane Snapper
Survey # 5- Q IV e. Checked 16 to 24, Wrote "MORE"
Survey # 6- Q I b. Circled "both" for Navy Tugs
Survey # 7- Q IV f. Wrote Zero, "0".
Survey #11- Q I b. Circled "both" for Navy Tugs, Q II a. "Diving" Response; We Marked BOTTOM-fis
Survey # 12- Q IV b. Multiple Response- Almost All & Some
Survey #14- Q I a. Misunderstood- Changed to "Sport Fishing" = ~ Recreational Fisherman.
Survey #21- Q I a. Misunderstood- Changed to "Sport Fishing" = ~ Recreational Fisherman.
Survey #36- Q IV d. Checked 16 to 24, Wrote "+"

Survey #40- Q IV c. Checked "YES" and Added "Mullet"
Survey #40- Q IV e. Checked 16 to 24, Wrote, "if not more"
Survey #43- Didn't Check an Answer, Wrote, "more than 24"
Survey #44- Q III a. For Other, Listed "Red Fish"
Survey #44- Q IV d. Wrote, "about 96 per year (About 8 times a month)"
Survey #48- Didn't Check an Answer, Wrote "40"
Survey #51- Q IV d. Wrote, "40-50"
Survey #53- Q IV d. and IV e. Wrote, ">50"
Survey #55- Q IV d. Wrote, ">30"

TABLE 1 (CONTINUED)
SUMMARY OF ANGLER SURVEY RESULTS FOR THE EX-VERMILLION REEF

	IV. Fish Consumption (Parts d, e, and f)																							
	How many fish meals eaten that were no								How many home-cooked fish meals?[3]								How many home-meals of Section 1 fish?							
Survey Number	0 meals per year	1 - 2 meals per year	3 - 5 meals per year	5 - 7 meals per year	10-13 meals per year	13-16 meals per year	16-24 meals per year	>24 meals per year	0 meals per year	1 - 2 meals per year	3 - 5 meals per year	5 - 7 meals per year	10-13 meals per year	13-16 meals per year	16-24 meals per year	>24 meals per year	0 meals per year	1 - 2 meals per year	3 - 5 meals per year	5 - 7 meals per year	10-13 meals per year	13-16 meals per year	16-24 meals per year	>24 meals per year
1			X												X					X				
2							X								X			X						
3							X								X			X						
4					X										X					X				
5		X														X				X				
6			X									X							X					
7											X						X							
8							X								X			X						
9				X										X							X			
10							X						X						X					
11					X										X			X						
12							X								X				X					
13						X								X				X						
14					X										X				X					
15							X						X				X							
16							X								X		X							
17					X								X				X							
18							X						X				X							
19							X								X		X							
20							X								X		X							
21							X							X					X					
22			X										X											
23							X								X					X				
24							X								X		X							
25							X								X		X							
26							X								X						X			
27			X										X											
28							X								X					X				
29			X												X								X	
30					X						X						X							
31							X						X								X			
32			X								X							X						
33					X									X						X				
34							X								X								X	
35							X								X								X	
36								X							X						X			
37					X					X								X						
38							X								X								X	
39					X								X							X				
40				X												X					X			
41			X												X								X	
42						X									X							X		
43			X													X				X				
44								X							X				X					
45				X										X			X							
46							X								X			X						
47						X									X				X					
48							X									X					X			
49				X									X						X					
50					X									X				X						
51								X					X								X			
52						X							X					X						
53								X								X			X					
54						X										X			X					
55								X						X			X							
56			X											X								X		
57					X									X					X					
58							X								X				X					
59					X								X					X						
60				X											X			X						
61							X								X							X		
62							X								X								X	
63					X										X				X					
64					X								X					X						
65							X									X			X					
66			X							X								X						
67			X										X										X	
68							X							X					X					
69								X							X		X							
70				X						X														
71							X								X						X			
72				X									X					X						
73					X										X				X					
74								X								X			X					
75								X							X					X				
76								X								X			X					
77								X								X						X		

1 = Of the additional fish caught while fishing the Section 1 reefs, only the red porgy is associated with reef habita
2 = This refers fish eaten at restaurants, as take out, or bought pre-prepared at grocery store
3 = This refers to fish caught angling and fish bought unprepared from market
4 = This refers to just those fish caught in the vicinity of the Section 1 reefs and includes both oceanic and reef-associated speci

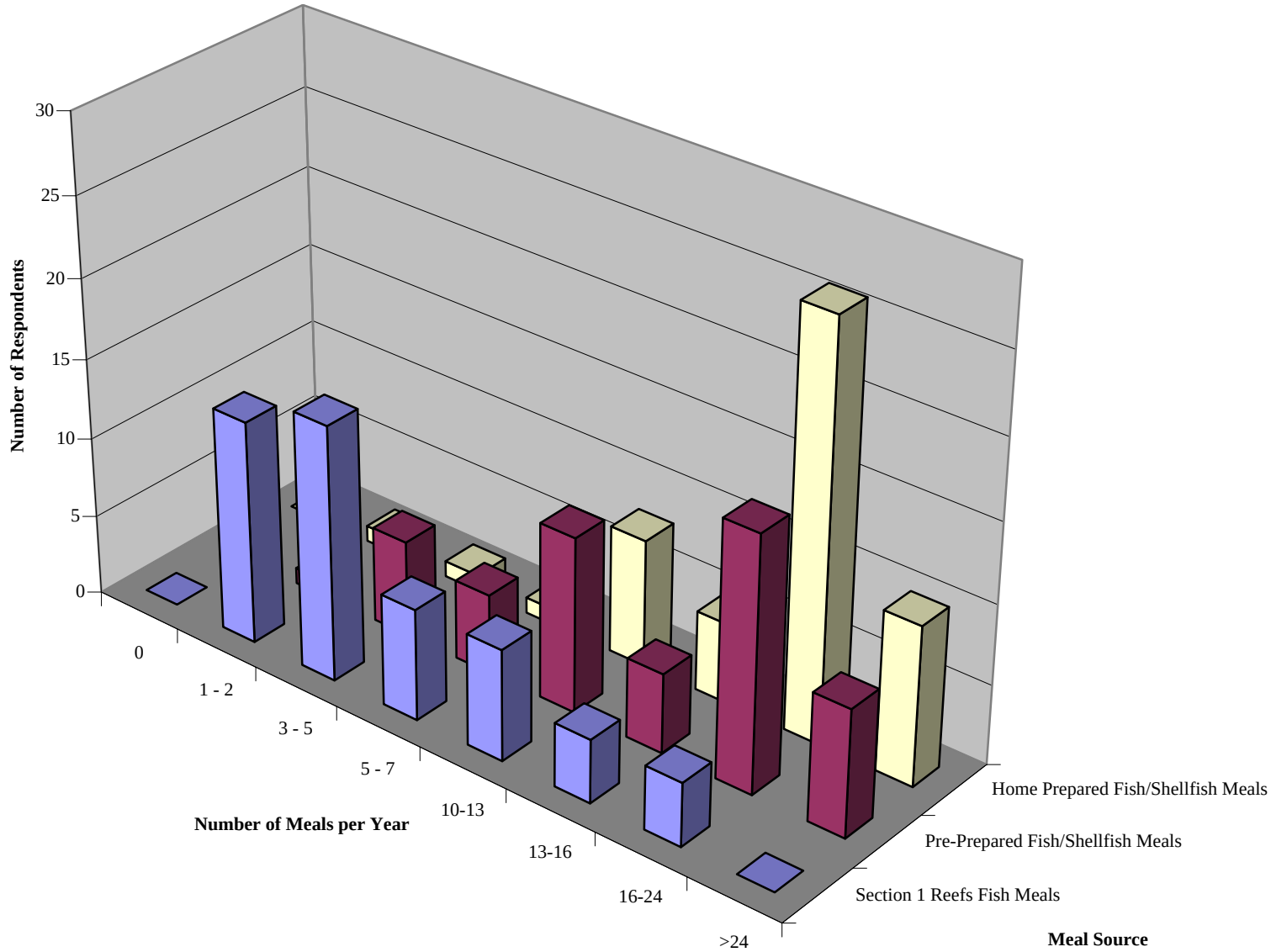
Survey #59- Provided no answer for Section III, zero reef-associated species have been assumed
Survey #65- Q IV e. Wrote, "more"
Survey #69- Q IV d. Wrote, "more"
Survey #72- Section III wrote "Did not Bottom Fish", zero reef-associated species have been assumed
Survey #74- Section III wrote "Did not Bottom Fish", zero reef-associated species have been assumed
Survey #74- Q IV d. Wrote "60-70" and IV e. Wrote, "100-200"
Survey #75- Q IV d. Wrote, ">30"
Survey #76- Q IV d. Wrote "50-75" and IV e. Wrote, "50 to 60"
Survey #77- Q IV d. Wrote "50-70" and IV e. Wrote, "50"

			Ingestion Rate g/day		Meal Size (g/meal)		Finfish Meals per year					FI			Usable FI Only			
Survey Number	Usable?	Fraction Reef-associated Fish Caught	Mean	95th Percentile	Mean	95th Percentile	Mean	95th Percentile	mid-point non-home meals	mid-point home meals	mid-point reef meals	Mean	95th Percentile		Mean	Transformed (added one to previous column)	95th Percentile	Transformed (added one to previous column)
1	YES	0.833333	7.2	26.1	129	326	20.37209	29.222393	4	20	6	0.245434	0.171102		0.245434	1.245434	0.171102	1.171102
2	YES	1	7.2	26.1	129	326	20.37209	29.222393	20	20	1.5	0.07363	0.05133		0.07363	1.07363	0.05133	1.05133
3	YES	0.75	7.2	26.1	129	326	20.37209	29.222393	20	20	1.5	0.055223	0.038498		0.055223	1.055223	0.038498	1.038498
4	YES	0.666667	7.2	26.1	129	326	20.37209	29.222393	11.5	20	6	0.196347	0.136881		0.196347	1.196347	0.136881	1.136881
5	YES	1	7.2	26.1	129	326	20.37209	29.222393	1.5	30	6	0.294521	0.205322		0.294521	1.294521	0.205322	1.205322
6	YES	1	7.2	26.1	129	326	20.37209	29.222393	4	6	4	0.196347	0.136881		0.196347	1.196347	0.136881	1.136881
7	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	0	4	0	NA	NA		0.055223	1.055223	0.038498	1.038498
8	YES	0.75	7.2	26.1	129	326	20.37209	29.222393	20	20	1.5	0.055223	0.038498		0.376332	1.376332	0.262356	1.262356
9	YES	0.666667	7.2	26.1	129	326	20.37209	29.222393	6	14.5	11.5	0.376332	0.262356		0.157078	1.157078	0.109505	1.109505
10	YES	0.8	7.2	26.1	129	326	20.37209	29.222393	20	11.5	4	0.157078	0.109505		0.036815	1.036815	0.025665	1.025665
11	YES	0.5	7.2	26.1	129	326	20.37209	29.222393	11.5	20	1.5	0.036815	0.025665		0.196347	1.196347	0.136881	1.136881
12	YES	1	7.2	26.1	129	326	20.37209	29.222393	20	20	4	0.196347	0.136881		0.058904	1.058904	0.041064	1.041064
13	YES	0.8	7.2	26.1	129	326	20.37209	29.222393	14.5	14.5	1.5	0.058904	0.041064		0.168297	1.168297	0.117327	1.117327
14	YES	0.857143	7.2	26.1	129	326	20.37209	29.222393	11.5	20	4	0.168297	0.117327		0.564498	1.564498	0.393534	1.393534
15	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	20	11.5	0	NA	NA		0.294521	1.294521	0.205322	1.205322
16	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	20	20	0	NA	NA		0.07363	1.07363	0.05133	1.05133
17	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	11.5	11.5	0	NA	NA		0.981735	1.981735	0.684407	1.684407
18	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	20	11.5	0	NA	NA		0.564498	1.564498	0.393534	1.393534
19	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	20	20	0	NA	NA		0.055223	1.055223	0.038498	1.038498
20	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	20	20	0	NA	NA		0.736301	1.736301	0.513305	1.513305
21	NO	1	7.2	26.1	129	326	20.37209	29.222393	20	14.5	4	NA	NA		0.196347	1.196347	0.136881	1.136881
22	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	4	11.5	0	NA	NA		0.423373	1.423373	0.29515	1.29515
23	NO	0.6	7.2	26.1	129	326	20.37209	29.222393	20	20	6	NA	NA		0.981735	1.981735	0.684407	1.684407
24	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	20	20	0	NA	NA		0.533818	1.533818	0.372146	1.372146
25	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	20	20	0	NA	NA		0.14726	1.14726	0.102661	1.102661
26	YES	1	7.2	26.1	129	326	20.37209	29.222393	20	20	11.5	0.564498	0.393534		0.098174	1.098174	0.068441	1.068441
27	NO	1	7.2	26.1	129	326	20.37209	29.222393	4	11.5	0	NA	NA		0.049087	1.049087	0.03422	1.03422
28	YES	1	7.2	26.1	129	326	20.37209	29.222393	20	20	6	0.294521	0.205322		0.196347	1.196347	0.136881	1.136881
29	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	4	20	20	NA	NA		0.376332	1.376332	0.262356	1.262356
30	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	11.5	4	0	NA	NA		0.196347	1.196347	0.136881	1.136881
31	NO	1	7.2	26.1	129	326	20.37209	29.222393	20	11.5	11.5	NA	NA		0.07363	1.07363	0.05133	1.05133
32	YES	1	7.2	26.1	129	326	20.37209	29.222393	4	4	1.5	0.07363	0.05133		0.376332	1.376332	0.262356	1.262356
33	NO	0.8	7.2	26.1	129	326	20.37209	29.222393	11.5	14.5	6	NA	NA		0.024543	1.024543	0.01711	1.01711
34	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	20	20	20	NA	NA		0.130898	1.130898	0.091254	1.091254
35	YES	1	7.2	26.1	129	326	20.37209	29.222393	20	20	20	0.981735	0.684407		0.098174	1.098174	0.068441	1.068441
36	YES	1	7.2	26.1	129	326	20.37209	29.222393	30	20	11.5	0.564498	0.393534		0.284703	1.284703	0.198478	1.198478
37	YES	0.75	7.2	26.1	129	326	20.37209	29.222393	11.5	1.5	1.5	0.055223	0.038498		0.130898	1.130898	0.091254	1.091254
38	YES	0.75	7.2	26.1	129	326	20.37209	29.222393	20	20	20	0.736301	0.513305		0.163623	1.163623	0.114068	1.114068
39	YES	0.666667	7.2	26.1	129	326	20.37209	29.222393	11.5	11.5	6	0.196347	0.136881		0	1	0	1
40	YES	0.75	7.2	26.1	129	326	20.37209	29.222393	6	30	11.5	0.423373	0.29515		0.049087	1.049087	0.03422	1.03422
41	YES	1	7.2	26.1	129	326	20.37209	29.222393	4	20	20	0.981735	0.684407		0.593132	1.593132	0.413496	1.413496
42	YES	0.75	7.2	26.1	129	326	20.37209	29.222393	14.5	20	14.5	0.533818	0.372146		0.701239	1.701239	0.488862	1.488862
43	YES	0.5	7.2	26.1	129	326	20.37209	29.222393	4	30	6	0.14726	0.102661		0.065449	1.065449	0.045627	1.045627
44	YES	0.5	7.2	26.1	129	326	20.37209	29.222393	30	20	4	0.098174	0.068441		0.07363	1.07363	0.05133	1.05133
45	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	6	14.5	0	NA	NA		0.14726	1.14726	0.102661	1.102661
46	YES	0.666667	7.2	26.1	129	326	20.37209	29.222393	20	20	1.5	0.049087	0.03422		0.282249	1.282249	0.196767	1.196767
47	YES	1	7.2	26.1	129	326	20.37209	29.222393	14.5	20	4	0.196347	0.136881		0	1	0	1
48	YES	0.666667	7.2	26.1	129	326	20.37209	29.222393	20	30	11.5	0.376332	0.262356		0.130898	1.130898	0.091254	1.091254
49	YES	1	7.2	26.1	129	326	20.37209	29.222393	6	11.5	4	0.196347	0.136881		0	1	0	1
50	YES	1	7.2	26.1	129	326	20.37209	29.222393	11.5	14.5	1.5	0.07363	0.05133		0.22089	1.22089	0.153991	1.153991
51	YES	0.666667	7.2	26.1	129	326	20.37209	29.222393	30	11.5	11.5	0.376332	0.262356		0.196347	1.196347	0.136881	1.136881
52	YES	0.333333	7.2	26.1	129	326	20.37209	29.222393	14.5	11.5	1.5	0.024543	0.01711		0.711758	1.711758	0.496195	1.496195
53	YES	0.666667	7.2	26.1	129	326	20.37209	29.222393	30	30	4	0.130898	0.091254					
54	YES	0.5	7.2	26.1	129	326	20.37209	29.222393	14.5	30	4	0.098174	0.068441					
55	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	30	14.5	0	NA	NA					
56	YES	0.4	7.2	26.1	129	326	20.37209	29.222393	4	14.5	14.5	0.284703	0.198478					
57	YES	0.666667	7.2	26.1	129	326	20.37209	29.222393	11.5	14.5	4	0.130898	0.091254					
58	YES	0.833333	7.2	26.1	129	326	20.37209	29.222393	20	20	4	0.163623	0.114068					
59	YES	0	7.2	26.1	129	326	20.37209	29.222393	11.5	11.5	1.5	0	0					
60	YES	0.666667	7.2	26.1	129	326	20.37209	29.222393	6	20	1.5	0.049087	0.03422					
61	YES	0.833333	7.2	26.1	129	326	20.37209	29.222393	20	20	14.5	0.593132	0.413496					
62	YES	0.714286	7.2	26.1	129	326	20.37209	29.222393	20	20	20	0.701239	0.488862					
63	YES	0.333333	7.2	26.1	129	326	20.37209	29.222393	11.5	20	4	0.065449	0.045627					
64	YES	1	7.2	26.1	129	326	20.37209	29.222393	11.5	11.5	1.5	0.07363	0.05133					
65	YES	0.75	7.2	26.1	129	326	20.37209	29.222393	20	30	4	0.14726	0.102661					
66	NO	0	7.2	26.1	129	326	20.37209	29.222393	4	1.5	1.5	NA	NA					
67	NO	1	7.2	26.1	129	326	20.37209	29.222393	4	11.5	20	NA	NA					
68	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	20	14.5	4	NA	NA					
69	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	30	20	0	NA	NA					
70	NO	#DIV/0!	7.2	26.1	129	326	20.37209	29.222393	6	1.5	0	NA	NA					
71	YES	0.5	7.2	26.1	129	326	20.37209	29.222393	20	20	11.5	0.282249	0.196767					
72	YES	0	7.2	26.1	129	326	20.37209	29.222393	6	11.5	1.5	0	0					
73	YES	0.666667	7.2	26.1	129	326	20.37209	29.222393	11.5	20	4	0.130898	0.091254					
74	YES	0	7.2	26.1	129	326	20.37209	29.222393	30	30	4	0	0					
75	YES	0.75	7.2	26.1	129	326	20.37209	29.222393	30	20	6	0.22089	0.153991					
76	YES	1	7.2	26.1	129	326	20.37209	29.222393	30	30	4	0.196347	0.136881					
77	YES	1	7.2	26.1	129	326	20.37209	29.222393	30	30	14.5	0.711758	0.496195					

Data Analysis Wizard - Descriptive Statistics
Output

Mean		*95th Percentile*	
Mean	0.250662743	Mean	0.174746975
Standard Error	0.033808744	Standard Error	0.023569421
Median	0.182322244	Median	0.127104093
Mode	0.196347032	Mode	0.136881331
Standard Deviation	0.243798317	Standard Deviation	0.169961511
Sample Variance	0.059437619	Sample Variance	0.028886915
Kurtosis	1.731395243	Kurtosis	1.731395243
Skewness	1.493007537	Skewness	1.493007537
Range	0.98173516	Range	0.684406655
Minimum	0	Minimum	0
Maximum	0.98173516	Maximum	0.684406655
Sum	13.03446265	Sum	9.086842717
Count	52	Count	52
Confidence Level(95.0%)	0.067873833	Confidence Level(95.0%)	0.04731755
Upper 95% Confidence Limit for the Mean	0.318536576	Upper 95% Confidence Limit for the Mean	0.222064526

FIGURE 1
DISTRIBUTION OF THE NUMBER OF FISH AND SHELLFISH MEALS CONSUMED PER YEAR



Section 1 Reef Fish meals represents a subset of the home prepared fish meals. These Section 1 meals are not corrected for that fraction of fish associated with the reef and includes oceanic species. Total fish meals per year equals the sum of the pre-prepared meals and the home prepared meals.

TABLE 2
DETERMINISTIC ESTIMATE OF THE FRACTION INGESTED TERM FOR SECTION 1 REEFS FISH BASED ON THE TOTAL NUMBER OF FINFISH MEALS PER YEAR

Survey Number	fraction Section 1 reef-associated fish caught	Mean Finfish Meals per Year [(7.2 g/d * 365d/y)/129g/meal]	95th Percentile Finfish Meals per Year [(26.1g/d * 365d/y)/326g/meal]	mid-point Section 1 meals	fraction-Section 1 Meals / Σ - meals (mean)	fraction-Section 1 meals / Σ - meals (95th percentile)	FI - Section 1 reef fish for only finfish (mean)	FI - ex-Section 1 reef fish for only finfish (95th percentile)
1	83%	20.4	29.2	6	6.0 / 20.4	6.0 / 29.2	0.245	0.171
2	100%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0.074	0.051
3	75%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0.055	0.038
4	67%	20.4	29.2	6	6.0 / 20.4	6.0 / 29.2	0.196	0.137
5	100%	20.4	29.2	6	6.0 / 20.4	6.0 / 29.2	0.295	0.205
6	100%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.196	0.137
8	75%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0.055	0.038
9	67%	20.4	29.2	11.5	11.5 / 20.4	11.5 / 29.2	0.376	0.262
10	80%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.157	0.110
11	50%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0.037	0.026
12	100%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.196	0.137
13	80%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0.059	0.041
14	86%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.168	0.117
26	100%	20.4	29.2	11.5	11.5 / 20.4	11.5 / 29.2	0.564	0.394
28	100%	20.4	29.2	6	6.0 / 20.4	6.0 / 29.2	0.295	0.205
32	100%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0.074	0.051
35	100%	20.4	29.2	20	20.0 / 20.4	20.0 / 29.2	0.982	0.684
36	100%	20.4	29.2	11.5	11.5 / 20.4	11.5 / 29.2	0.564	0.394
37	75%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0.055	0.038
38	75%	20.4	29.2	20	20.0 / 20.4	20.0 / 29.2	0.736	0.513
39	67%	20.4	29.2	6	6.0 / 20.4	6.0 / 29.2	0.196	0.137
40	75%	20.4	29.2	11.5	11.5 / 20.4	11.5 / 29.2	0.423	0.295
41	100%	20.4	29.2	20	20.0 / 20.4	20.0 / 29.2	0.982	0.684
42	75%	20.4	29.2	14.5	14.5 / 20.4	14.5 / 29.2	0.534	0.372
43	50%	20.4	29.2	6	6.0 / 20.4	6.0 / 29.2	0.147	0.103
44	50%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.098	0.068
46	67%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0.049	0.034
47	100%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.196	0.137
48	67%	20.4	29.2	11.5	11.5 / 20.4	11.5 / 29.2	0.376	0.262
49	100%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.196	0.137
50	100%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0.074	0.051
51	67%	20.4	29.2	11.5	11.5 / 20.4	11.5 / 29.2	0.376	0.262
52	33%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0.025	0.017
53	67%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.131	0.091
54	50%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.098	0.068
56	40%	20.4	29.2	14.5	14.5 / 20.4	14.5 / 29.2	0.285	0.198
57	67%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.131	0.091
58	83%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.164	0.114
59	0%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0	0
60	67%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0.049	0.034
61	83%	20.4	29.2	14.5	14.5 / 20.4	14.5 / 29.2	0.593	0.413
62	71%	20.4	29.2	20	20.0 / 20.4	20.0 / 29.2	0.701	0.489
63	33%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.065	0.046
64	100%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0.074	0.051
65	75%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.147	0.103
71	50%	20.4	29.2	11.5	11.5 / 20.4	11.5 / 29.2	0.282	0.197
72	0%	20.4	29.2	1.5	1.5 / 20.4	1.5 / 29.2	0	0
73	67%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.131	0.091
74	0%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0	0
75	75%	20.4	29.2	6	6.0 / 20.4	6.0 / 29.2	0.221	0.154
76	100%	20.4	29.2	4	4.0 / 20.4	4.0 / 29.2	0.196	0.137
77	100%	20.4	29.2	14.5	14.5 / 20.4	14.5 / 29.2	0.712	0.496

TABLE 2 (CONTINUED)
DETERMINISTIC ESTIMATE OF THE FRACTION INGESTED TERM FOR SECTION 1 REEFS FISH BASED ON THE TOTAL NUMBER OF FINFISH MEALS PER YEAR

Point Estimates of Fraction Ingested (FI) term for Section 1 reef fish

	Mean FI Term	95th Percentile FI Term
Mean	0.251	0.175
Upper 95% Confidence Limit for the Mean	0.319	0.222
Standard Error	0.034	0.024
Median	0.182	0.127
Mode	0.196	0.137
Standard Deviation	0.244	0.170
Sample Variance	0.059	0.029
Kurtosis	1.731	1.731
Skewness	1.493	1.493
Range	0.982	0.684
Minimum	0	0
Maximum	0.982	0.684
Sum	13.034	9.087
Count	52	52

FIGURE 1

PROBABILISTIC ESTIMATES OF THE FRACTION INGESTED TERM FOR SECTION 1 FISH BASED ON THE TOTAL NUMBER OF FINFISH MEALS PER YEAR

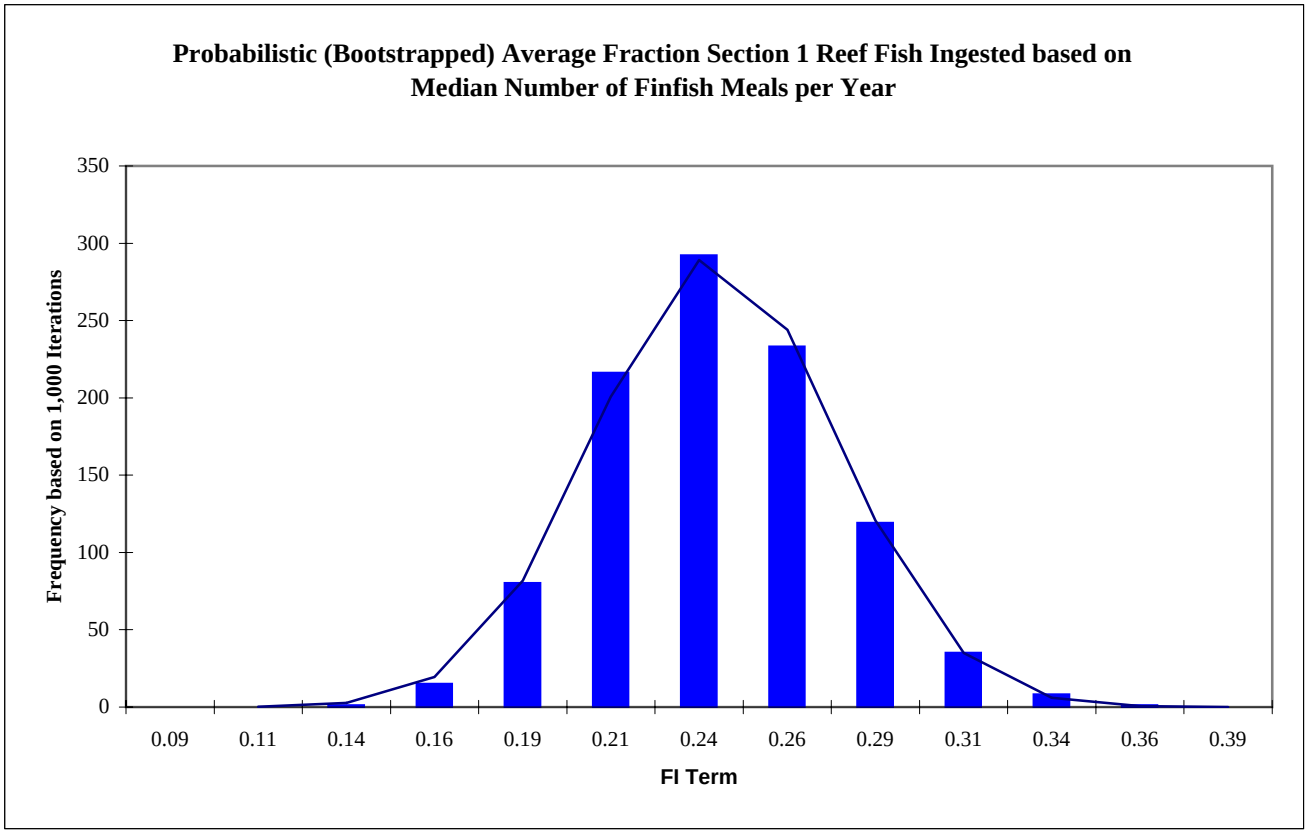
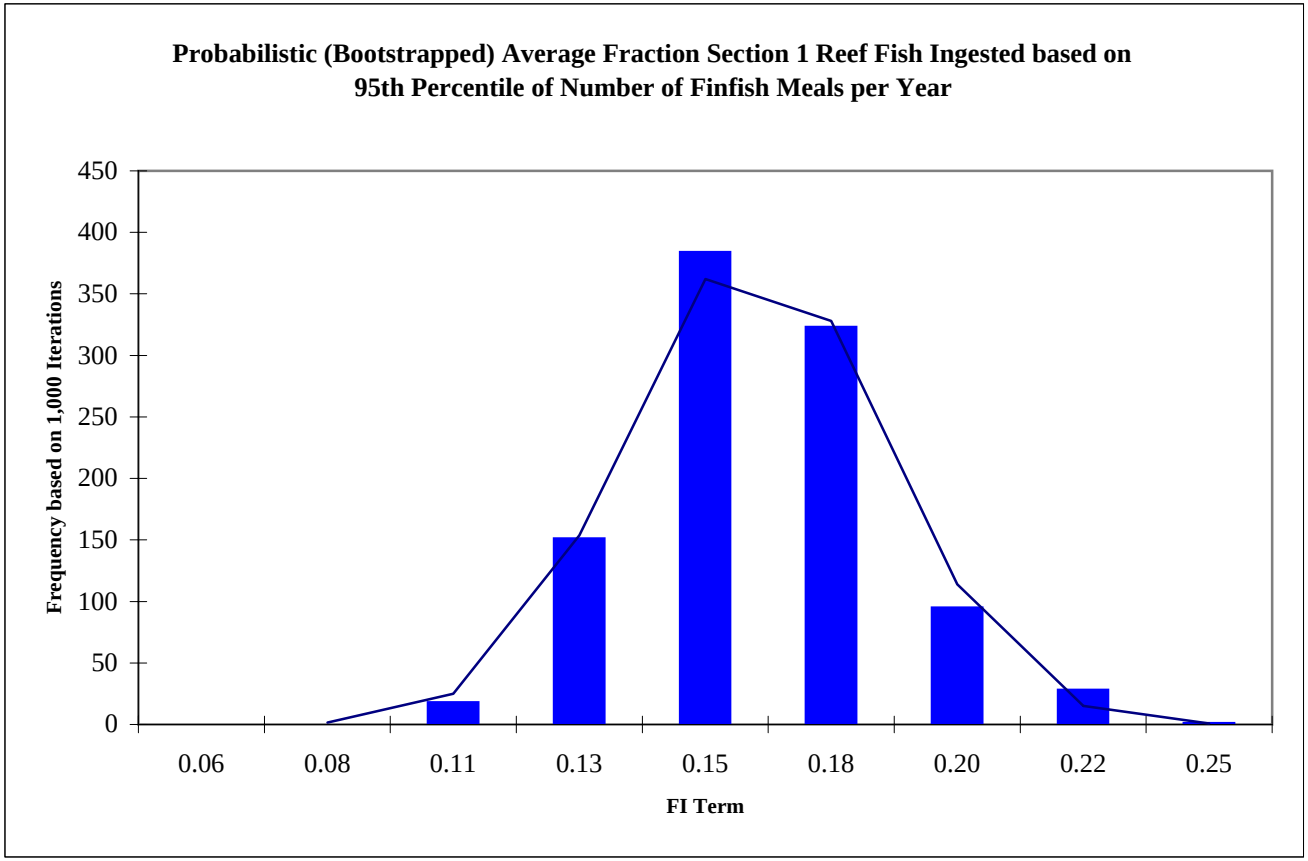


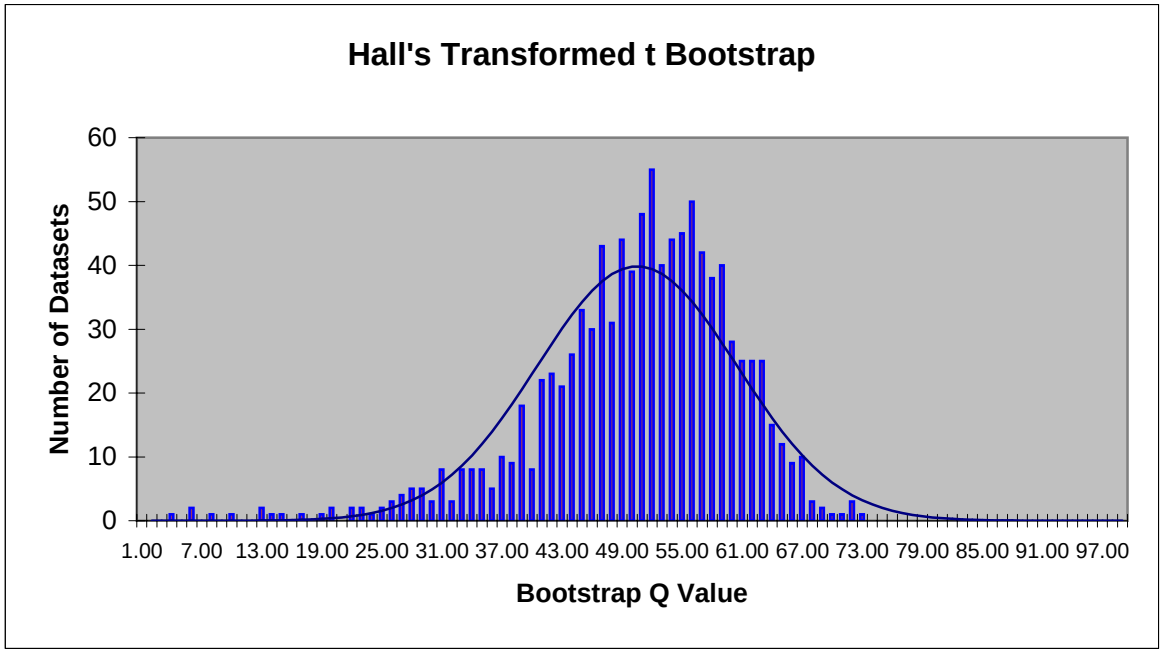
FIGURE 1

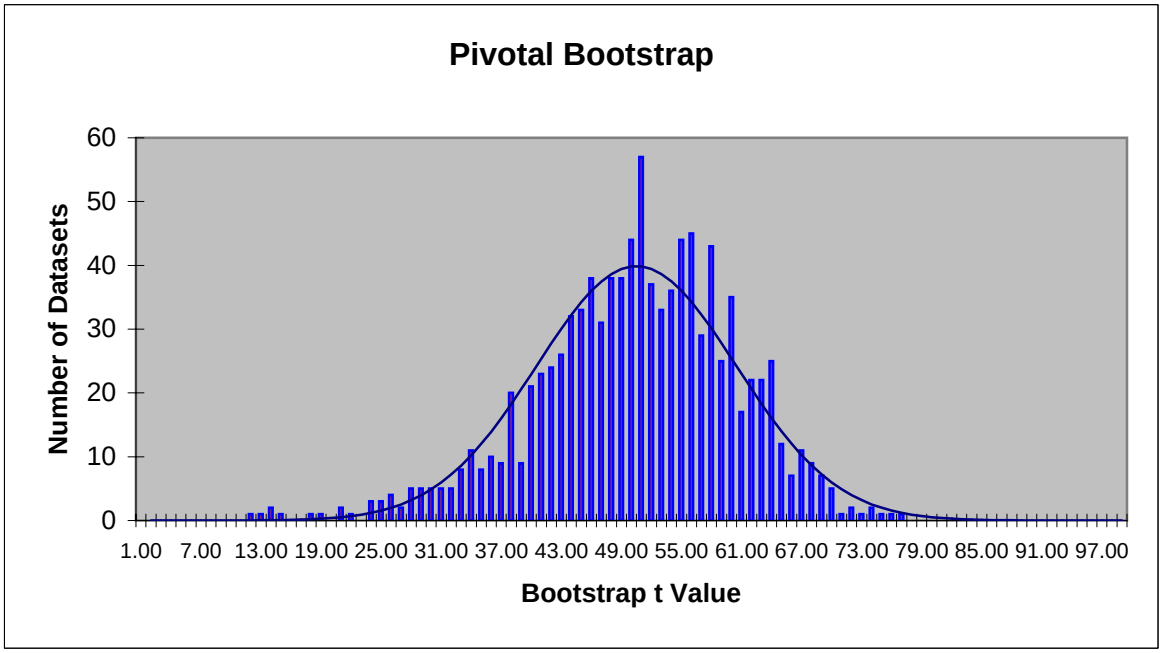
PROBABILISTIC ESTIMATES OF THE FRACTION INGESTED TERM FOR SECTION 1 FISH BASED ON THE TOTAL NUMBER OF FINFISH MEALS PER YEAR



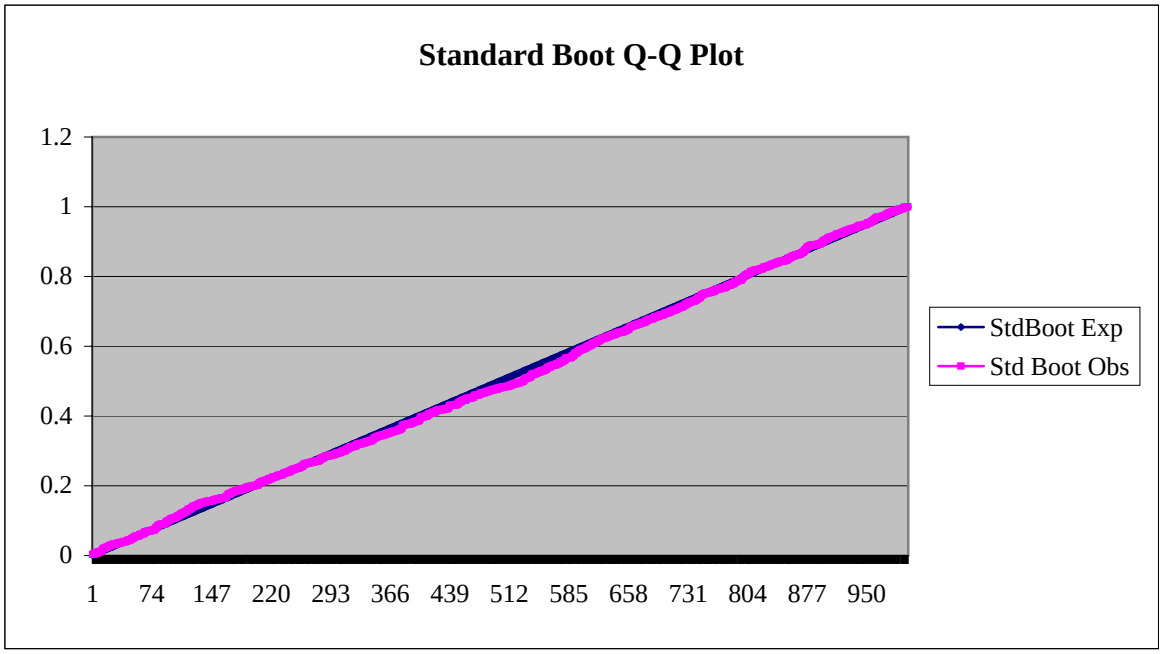
TEXT TABLE

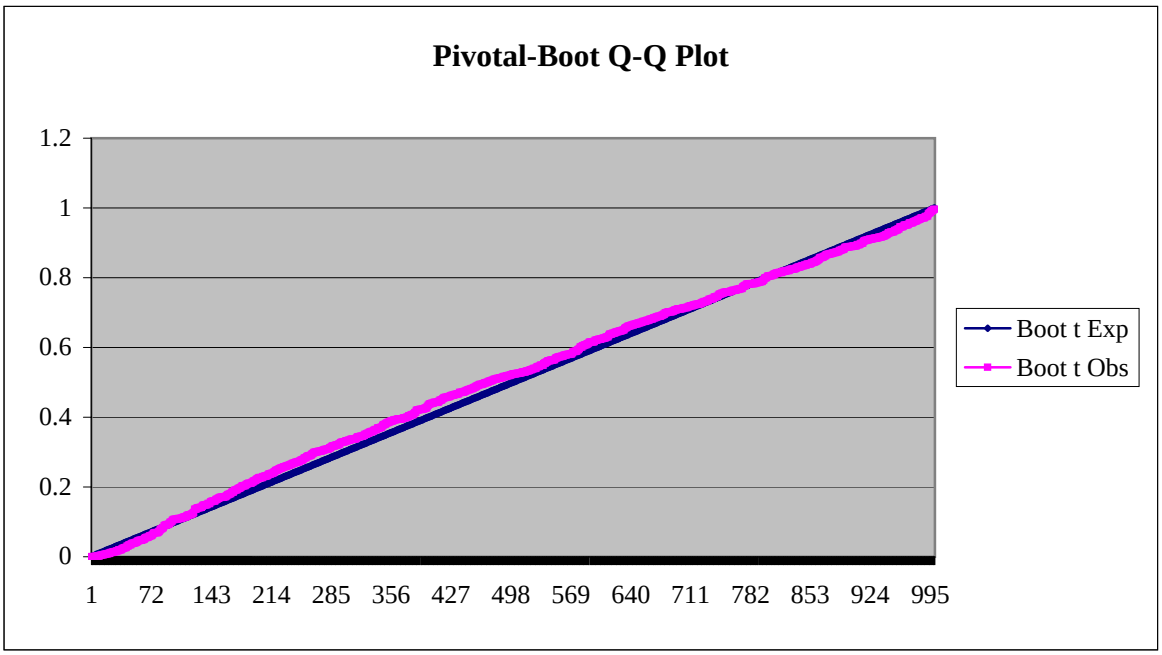
Based on Survey Results and Mean EPA Marine Finfish Ingestion Rate (for Gulf Coast) and Meal Size	
Point Estimate	0.251
Probabilistic Estimate Median	0.251
Probabilistic 5th Percentile	0.197
Probabilistic 95th Percentile	0.308
Based on Survey Results and 95th Percentile EPA Marine Finfish Ingestion Rate (for Gulf Coast) and Meal Size	
Point Estimate	0.175
Probabilistic Estimate Median	0.174
Probabilistic 5th Percentile	0.138
Probabilistic 95th Percentile	0.216


Hall's Transformed t Bootstrap
Number of Datasets
0
10
20
30
40
50
60
1.00 7.00 13.00 19.00 25.00 31.00 37.00 43.00 49.00 55.00 61.00 67.00 73.00 79.00 85.00 91.00 97.00
Bootstrap Q Value

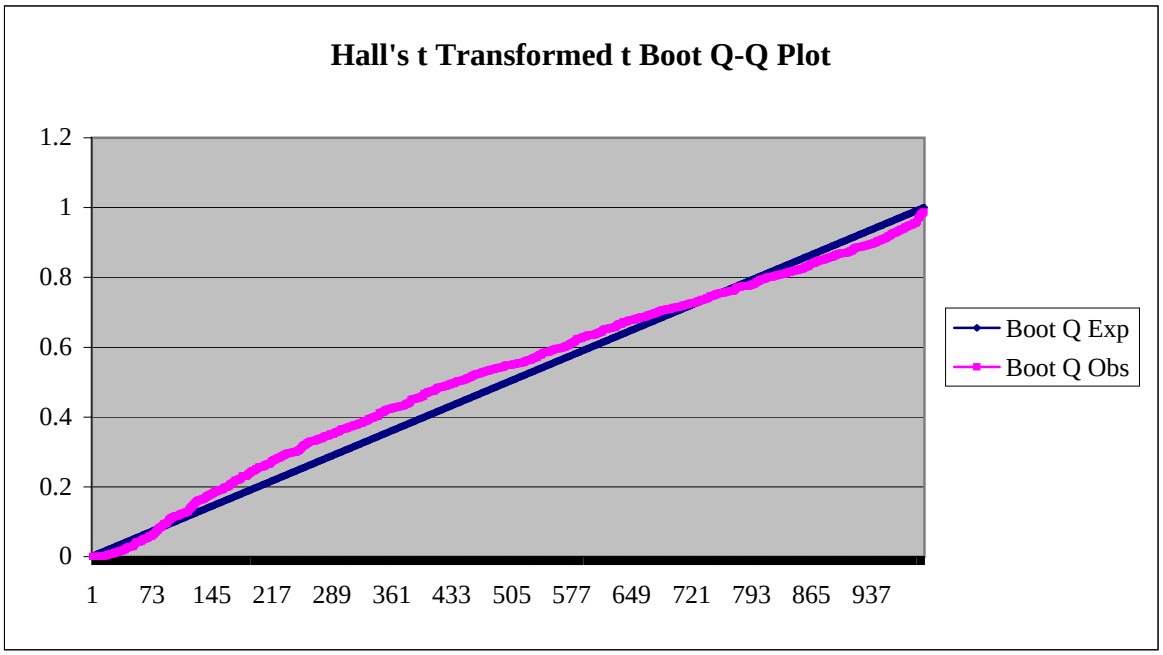

Pivotal Bootstrap
Number of Datasets
0
10
20
30
40
50
60
1.00 7.00 13.00 19.00 25.00 31.00 37.00 43.00 49.00 55.00 61.00 67.00 73.00 79.00 85.00 91.00 97.00
Bootstrap t Value

MEAN BOOT DETAIL





MEAN BOOT DETAIL



RECOMMENDED ENVIRONMENTAL EXPOSURE POINT CONCENTRATIONS (EPCs)

Column
Water

There is a sufficient number of values for statistical analysis - the data were found to be non-normally distributed with high skewness - use the Standard Bootstrap mean and Hall's Adjusted Bootstrap UCLs as the EPCs

(Nondetect data presented as 1/2 the DL)

Units = PPM

Sample#	Value	Qualifier	Sample#	Value	Qualifier
1	1.24543		46	1.28225	
2	1.07363		47	1	
3	1.05522		48	1.1309	
4	1.19635		49	1	
5	1.29452		50	1.22089	
6	1.19635		51	1.19635	
7	1.05522		52	1.71176	
8	1.37633				
9	1.15708				
10	1.03682				
11	1.19635				
12	1.0589				
13	1.1683				
14	1.5645				
15	1.29452				
16	1.07363				
17	1.98174				
18	1.5645				
19	1.05522				
20	1.7363				
21	1.19635				
22	1.42337				
23	1.98174				
24	1.53382				
25	1.14726				
26	1.09817				
27	1.04909				
28	1.19635				
29	1.37633				
30	1.19635				
31	1.07363				
32	1.37633				
33	1.02454				
34	1.1309				
35	1.09817				
36	1.2847				
37	1.1309				
38	1.16362				
39	1				
40	1.04909				
41	1.59313				
42	1.70124				
43	1.06545				
44	1.07363				
45	1.14726				

Low-End EPC	Bootstrap Mean	1.25265734
High-End EPC	Hall Adjusted Bootstrap	1.315874216

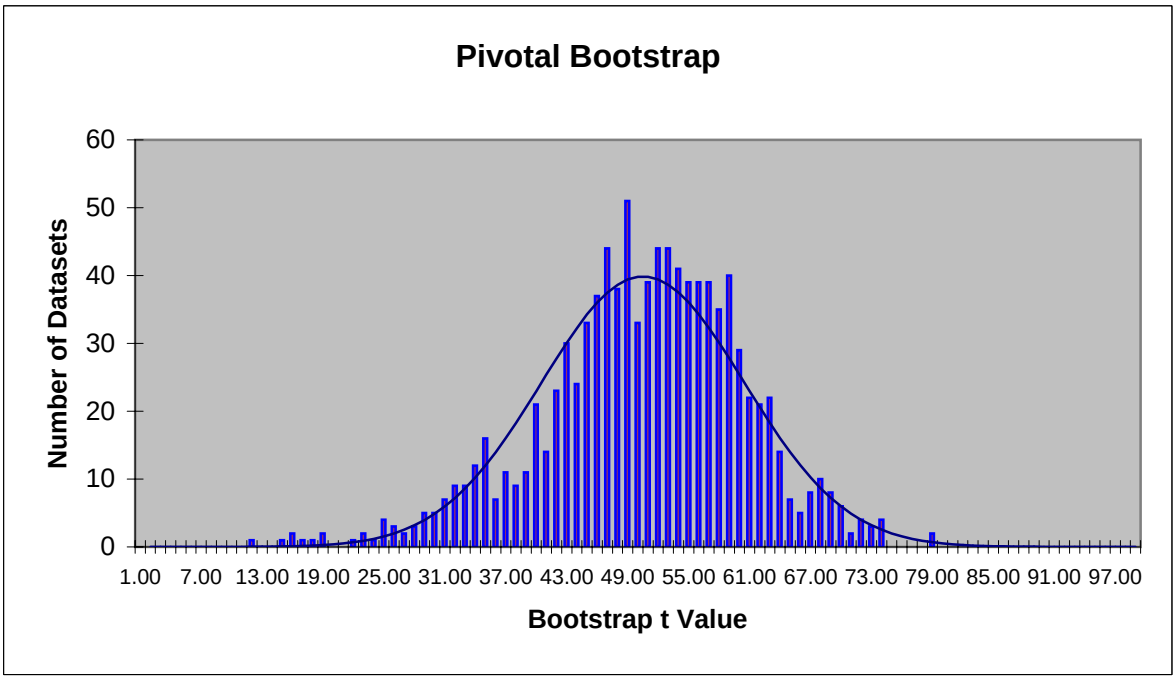
Raw Data Results					
Number of Samples	52				
Percent Detection	100%	52 of 52	Percent Detects J-coded		0%
Maximum Detection	1.98E+00		Minimum Detection		1.00E+00
Maximum Non-detection[1]	All Detects		Minimum Non-detection[1]		All Detects
Normal (Non-transformed) Results					
Normal Mean	1.25E+00		Mean Standard Error		3.38E-02
Standard Deviation	2.44E-01		Coefficient of Variance (%)		19%
Dataset Skewness	Fail	1.41E+00	Dataset Kurtosis	Pass	4.29E+00
Tested for Normality	D-Test		NormalityResult (a = 0.05)		Fail
Critical Value	-2.746 or 1.053		Calculated Value for dataset		-6.23E+00
90% UCL using t-statistic	1.29E+00		95% UCL using -t-statistic		1.31E+00
Natural Log-Transformed Results					
MVUE of the log-mean	1.25E+00		Standard error of the log-mean		3.08E-02
Standard Deviation	1.76E-01		Coefficient of Variance (%)		85%
Dataset Skewness	Fail	1.09E+00	Dataset Kurtosis	Pass	3.33E+00
Tested for Normality	D-Test		Normality Result (a = 0.05)		Fail
Critical Value	-2.746 or 1.053		Calculated Value for dataset		-3.60E+00
Anderson Darling (AD) A^2	2.15E+00		AD Probability	Fail	7.61E-02
90% UCL of the MVUE	1.29E+00		95% UCL of the MVUE		1.30E+00
EPA Concentration Term	1.30E+00		Chebychev 95% UCL		1.39E+00
Jackknife Results					
Jackknifed Mean	1.25E+00		Jackknifed Standard Error		3.38E-02
90% UCL of the mean	1.29E+00		95% UCL of the mean		1.31E+00
90% UCL of the MVUE[2]	1.29E+00		95% UCL of the MVUE[2]		1.31E+00

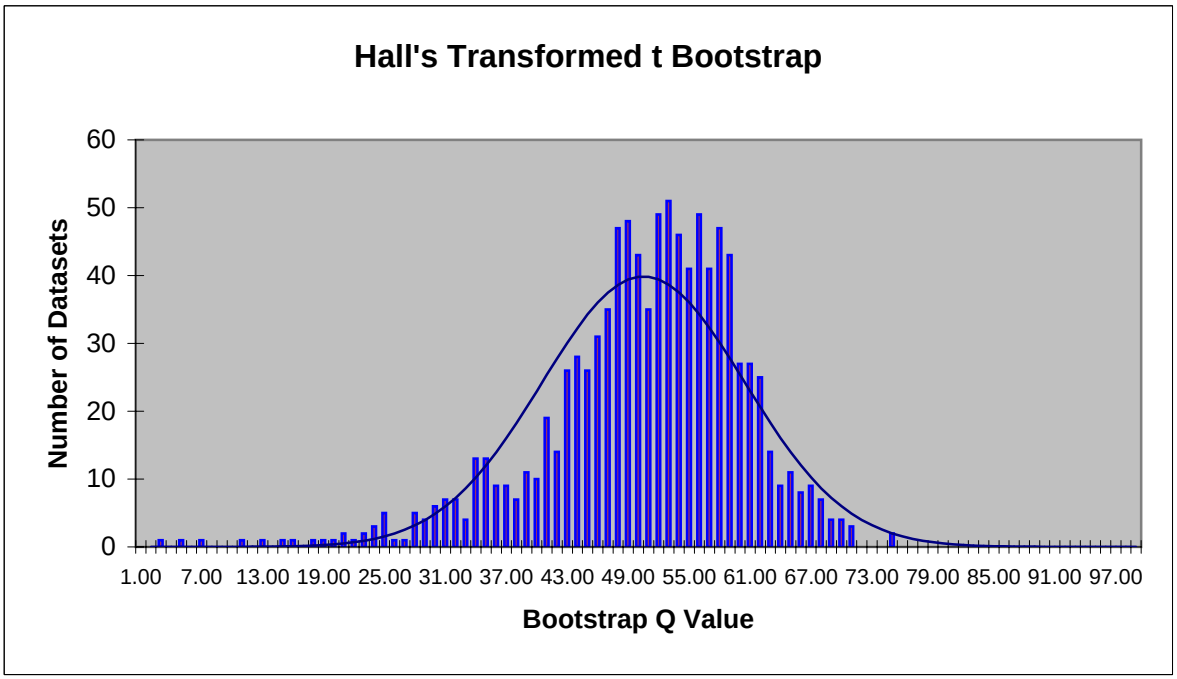
Bootstrap Results (Raw Data)						
Standard Bootstrap	Mean	1.25E+00	90% UCL	1.30E+00	95% UCL	1.31E+00
Skewness	1.62E-01		Kurtosis	3.03E+00		
Quantile fit is good - Bootstrap Output is Normal or nearly so						
Pivitol (t) Bootstrap	90% UCL	1.30E+00	95% UCL	1.32E+00		
Skewness	-5.27E-01		Kurtosis	3.68E+00		
Quantile fit is good - Bootstrap Output is Normal or nearly so						
Hall's t Bootstrap	90% UCL	1.30E+00	95% UCL	1.32E+00		
Skewness	-1.14E+00		Kurtosis	5.62E+00		
Quantile fit is good - Bootstrap Output is Normal or nearly so						

1= Equals 1/2 of the reporting limit
2= Using the Jackknife

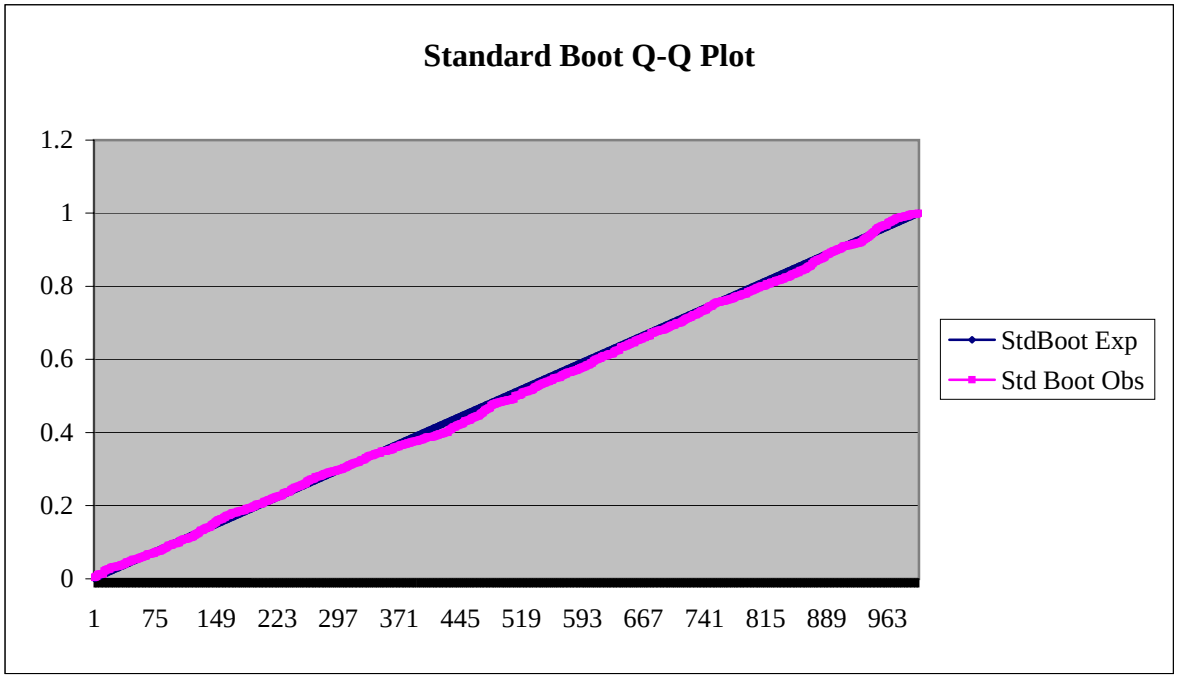
EPC= Environmental Exposure Concentration
MVUE= Minimum Variance Unbiased Estimator
UCL= Upper Confidence Interval

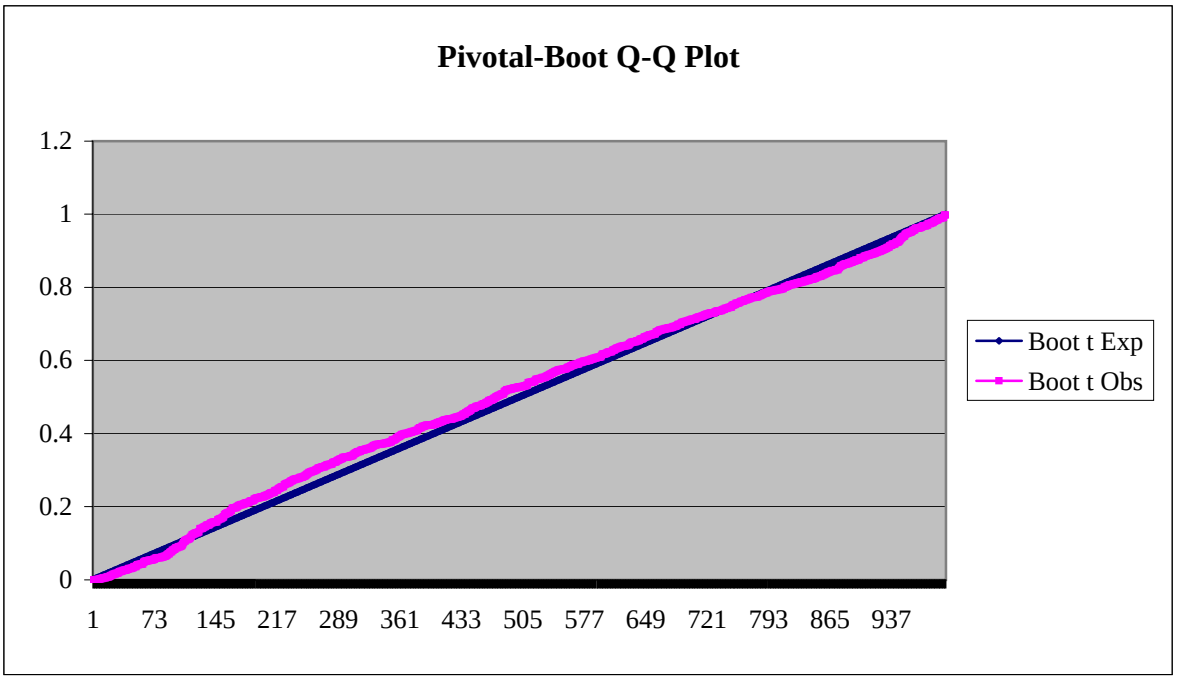
95th Boot Detail



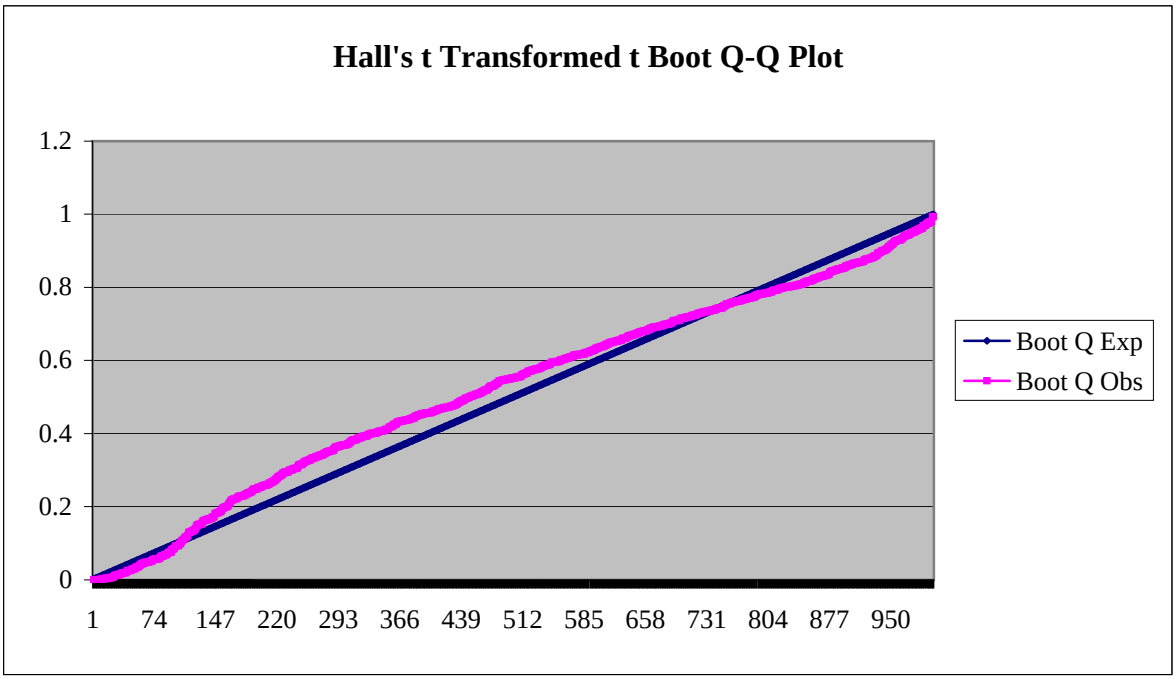


95th Boot Detail





95th Boot Detail



RECOMMENDED ENVIRONMENTAL EXPOSURE POINT CONCENTRATIONS (EPCs)

Column
Water

There is a sufficient number of values for statistical analysis - the data were found to be non-normally distributed with high skewness - use the Standard Bootstrap mean and Hall's Adjusted Bootstrap UCLs as the EPCs

(Nondetect data presented as 1/2 the DL)

Units = PPM

Sample#	Value	Qualifier	Sample#	Value	Qualifier
1	1.1711		46	1.19677	
2	1.05133		47	1	
3	1.0385		48	1.09125	
4	1.13688		49	1	
5	1.20532		50	1.15399	
6	1.13688		51	1.13688	
7	1.0385		52	1.49619	
8	1.26236				
9	1.10951				
10	1.02567				
11	1.13688				
12	1.04106				
13	1.11733				
14	1.39353				
15	1.20532				
16	1.05133				
17	1.68441				
18	1.39353				
19	1.0385				
20	1.5133				
21	1.13688				
22	1.29515				
23	1.68441				
24	1.37215				
25	1.10266				
26	1.06844				
27	1.03422				
28	1.13688				
29	1.26236				
30	1.13688				
31	1.05133				
32	1.26236				
33	1.01711				
34	1.09125				
35	1.06844				
36	1.19848				
37	1.09125				
38	1.11407				
39	1				
40	1.03422				
41	1.4135				
42	1.48886				
43	1.04563				
44	1.05133				
45	1.10266				

Low-End EPC	Bootstrap Mean	1.174601446
High-End EPC	Hall Adjusted Bootstrap	1.220792005

Raw Data Results					
Number of Samples	52				
Percent Detection	100%	52 of 52	Percent Detects J-coded		0%
Maximum Detection	1.68E+00		Minimum Detection		1.00E+00
Maximum Non-detection[1]	All Detects		Minimum Non-detection[1]		All Detects
Normal (Non-transformed) Results					
Normal Mean	1.17E+00		Mean Standard Error		2.36E-02
Standard Deviation	1.70E-01		Coefficient of Variance (%)		14%
Dataset Skewness	Fail	1.41E+00	Dataset Kurtosis	Pass	4.29E+00
Tested for Normality	D-Test		NormalityResult (a = 0.05)		Fail
Critical Value	-2.746 or 1.053		Calculated Value for dataset		-6.23E+00
90% UCL using t-statistic	1.21E+00		95% UCL using -t-statistic		1.21E+00
Natural Log-Transformed Results					
MVUE of the log-mean	1.17E+00		Standard error of the log-mean		2.18E-02
Standard Deviation	1.34E-01		Coefficient of Variance (%)		88%
Dataset Skewness	Fail	1.16E+00	Dataset Kurtosis	Pass	3.52E+00
Tested for Normality	D-Test		Normality Result (a = 0.05)		Fail
Critical Value	-2.746 or 1.053		Calculated Value for dataset		-4.18E+00
Anderson Darling (AD) A^2	2.37E+00		AD Probability	Fail	5.84E-02
90% UCL of the MVUE	1.20E+00		95% UCL of the MVUE		1.21E+00
EPA Concentration Term	1.21E+00		Chebychev 95% UCL		1.27E+00
Jackknife Results					
Jackknifed Mean	1.17E+00		Jackknifed Standard Error		2.36E-02
90% UCL of the mean	1.21E+00		95% UCL of the mean		1.21E+00
90% UCL of the MVUE[2]	1.20E+00		95% UCL of the MVUE[2]		1.21E+00

Bootstrap Results (Raw Data)						
Standard Bootstrap	Mean	1.17E+00	90% UCL	1.20E+00	95% UCL	1.21E+00
Skewness	2.35E-01		Kurtosis	3.13E+00		
	Quantile fit is good - Bootstrap Output is Normal or nearly so					
Pivitol (t) Bootstrap	90% UCL	1.21E+00	95% UCL	1.22E+00		
Skewness	-4.62E-01		Kurtosis	3.65E+00		
	Quantile fit is good - Bootstrap Output is Normal or nearly so					
Hall's t Bootstrap	90% UCL	1.21E+00	95% UCL	1.22E+00		
Skewness	-1.04E+00		Kurtosis	5.27E+00		
	Quantile fit is good - Bootstrap Output is Normal or nearly so					

1= Equals 1/2 of the reporting limit
2= Using the Jackknife

EPC= Environmental Exposure Concentration
MVUE= Minimum Variance Unbiased Estimator
UCL= Upper Confidence Interval

Appendix H

Example PRAM Calculations and Model Output

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

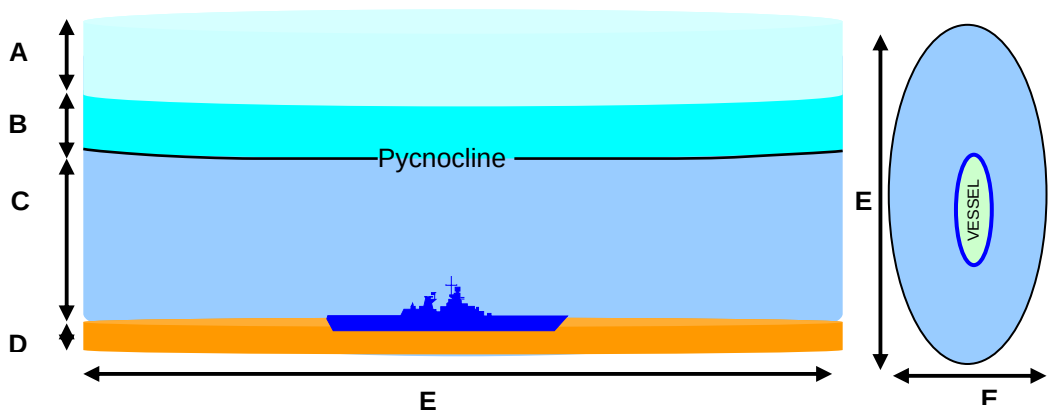
RISK INPUTS - Adult	RME	CTE
Body Weight (BWa) (kg)	70	70
Exposure Frequency (EFa) (days)	365	365
Exposure Duration (EDa) (years)	24	3
Ingestion Rate (IRa) (kg/day)	0.0261	0.0072
Averaging Time for cancer (ATc)	25550	25550
Averaging Time for noncancer (ATnc-adult)	8760	1095
Slope Factor (mg/kg-day)	2	1
Reference dose for PCBs (RfD) (mg/kg-day)	2.00E-05	4.50E-05
Fractional Ingestion factor (FI)	0.17	0.25
Ingestion Rates Based on Data from	Gulf Coast	

RISK INPUTS - Child	RME	CTE
Body Weight (BWc) (kg)	15	15
Exposure Frequency (EFc) (days)	365	365
Exposure Duration (EDc) (years)	6	6
Ingestion Rate (IRc) (kg/day)	0.0092916	0.0025632
Averaging Time for cancer (ATc)	25550	25550
Averaging Time for noncancer (ATnc-child)	2190	2190
Slope Factor (mg/kg-day)	2	1
Reference dose for PCBs (RfD) (mg/kg-day)	2.00E-05	4.50E-05
Fractional Ingestion factor (FI)	0.17	0.25
Child - Adult IR scaling factor	0.356	

Zone of Influence Multiplier	2
Scenario run on	5/11/05 13:36

PCB-LADEN MATERIAL INPUTS	Fraction PCB	Release Rate (ng/g-d)	kg Material Onboard	PCB Release (ng/day)
Ventilation Gaskets	3.14E-05	1.58E+03	1.46E+03	7.23E+04
Lubricants	1.03E-04	2.20E+03	0.00E+00	0.00E+00
Foam Rubber Material	7.60E-03	2.62E+00	0.00E+00	0.00E+00
Black Rubber Material	5.29E-05	1.58E+03	5.40E+03	4.50E+05
Electrical Cable	1.85E-03	2.79E+02	2.96E+05	1.53E+08
Bulkhead Insulation Material	5.37E-04	6.76E+04	1.44E+04	5.22E+08
Aluminum Paint	2.00E-05	1.11E+04	3.87E+05	8.62E+07
Total				7.62E+08

Ex-Oriskany CV34	
Displacement (tons)	27100
Length (ft)	888
Beam (ft)	120



ZOI =	2	
Spatial Footprint on Ocean Floor		
	1.56E+04	m2
	6.00E-03	mile2
Modeled Dimensions Outside the Vessel		
A	1.00E+01	m
B	1.50E+01	m
C	5.00E+01	m
D	1.00E-01	m
E	3.00E+02	m
F	6.60E+01	m
Volumes		
Air Column		
Air	1.56E+05	m3
Upper Water Column		
Water	2.33E+05	m3
TSS	1.56E+00	m3
Lower Water Column		
Water	7.24E+05	m3
TSS	4.82E+00	m3
Inside Vessel		
Water	5.38E+04	m3
TSS	3.59E-01	m3
Sediment Bed		
Sediment	7.78E+02	m3

Abiotic Inputs	
Air Column	
Active air space height above water column (m)	10
Air current (m/h)	13677
Upper Water Column	
Temperature (°C)	24.5
Water depth (m)	15
Total suspended solids (mg/L)	10
Dissolved organic carbon (mg/L)	0.6
Dissolved oxygen (mg/L)	6.12
Lower Water Column	
Temperature (°C)	19.5
Water depth (m)	50
Total suspended solids (mg/L)	10
Dissolved organic carbon (mg/L)	0.6
Dissolved oxygen (mg/L)	4.59
Inside Vessel	
Temperature (°C)	19.5
Total suspended solids (mg/L)	10
Dissolved organic carbon (mg/L)	0.6
Dissolved oxygen (mg/L)	4.59
Sediment Bed	
Sediment density (g/cm3)	1.5
Active sediment depth (m)	0.1
Sediment fraction organic carbon	0.01
All Regions	
Suspended solids density (g/cm3)	1.5
Suspended solids fraction organic carbon	0.15
Dissolved organic carbon density (g/cm3)	1
Water current - to out of the ZOI (m/h)	926
Water current - inside to outside the vessel (m/h)	9.26

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 High-End Weight of PCB-Laden Materials

Supplemental Information

Scenario Run on 10/21/2004 14:10

PCB Homolog	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Molecular Weight (g/mol)	1.89E+02	2.23E+02	2.58E+02	2.92E+02	3.26E+02	3.61E+02	3.95E+02	4.30E+02	4.64E+02	4.99E+02
Solubility (mg/L)	2.91E+00	6.78E-01	8.14E-02	6.67E-02	2.61E-02	9.50E-04	2.30E-04	2.11E-08	4.02E-09	1.69E-10
Solubility (mol/m^3)	1.54E-02	3.04E-03	3.16E-04	2.28E-04	8.00E-05	2.63E-06	5.82E-07	4.91E-11	8.65E-12	3.38E-13
Vapor Pressure (Pa)	6.32E-01	1.41E-01	5.11E-02	2.08E-02	2.96E-03	3.43E-03	2.56E-04	8.65E-05	2.77E-05	1.41E-05
Henry's (Pa-m^3/mol)	4.10E+01	4.65E+01	1.62E+02	9.10E+01	3.70E+01	1.30E+03	4.40E+02	1.76E+06	3.20E+06	4.18E+07
$\log_{10}K_{ow}$ =	4.47	5.24	5.52	5.92	6.50	6.98	7.19	7.70	8.35	9.60
$\log_{10}K_{oc}$ =	3.66	4.06	4.63	4.65	4.94	6.08	6.34	6.46	6.97	7.94
$\log_{10}K_{doc}$ =	3.34	4.11	4.39	4.79	5.51	5.85	6.06	6.57	7.22	8.47
Chemical emission rate (g/day)	1.37E-05	1.12E-01	9.95E-03	1.69E-01	3.20E-01	7.57E-02	7.37E-02	0.00E+00	8.28E-04	4.62E-04
Chemical emission rate (mol/hr)	3.03E-09	2.09E-05	1.61E-06	2.42E-05	4.08E-05	8.74E-06	7.77E-06	0.00E+00	7.43E-08	3.86E-08
Biodegradation in sediment (1/hr)	0	0	0	0	0	0	0	0	0	0
Biodegradation in water (1/hr)	0	0	0	0	0	0	0	0	0	0

	Ventilation Gaskets	Lubricants	Foam Rubber Material	Black Rubber Material	Electrical Cable	Bulkhead Insulation Material	Aluminized Paint
Fraction PCB in Material (wt/wt)	0.0000314	0.000103	0.76%	0.0000529	0.00185	0.000537	0.00002
Material Mass Onboard (kg)	1459	0	0	5397	296419	14379	386528
Total PCBs (kg)	0.0458126	0	0	0.2855013	548.37515	7.721523	7.73056
Total PCB Release rate (ng/g-PCB per day)	1.58E+03	2.20E+03	2.62E+00	1.58E+03	2.79E+02	6.76E+04	1.11E+04

Release Rates in nanograms PCB per gram of PCB within the Material	Ventilation Gaskets	Lubricants	Foam Rubber Material	Black Rubber Material	Electrical Cable	Bulkhead Insulation Material	Aluminized Paint
Monochlorobiphenyl	4.14E+01	3.47E+01	0.00E+00	4.14E+01	0.00E+00	0.00E+00	0.00E+00
Dichlorobiphenyl	1.27E+03	1.72E+02	3.08E-02	1.27E+03	2.03E+02	5.36E+00	0.00E+00
Trichlorobiphenyl	5.66E+01	8.97E+01	7.63E-02	5.66E+01	1.14E+00	9.44E+02	2.61E+02
Tetrachlorobiphenyl	1.44E+02	1.08E+03	1.29E+00	1.44E+02	1.57E+01	2.07E+04	1.23E+02
Pentachlorobiphenyl	6.31E+01	6.60E+02	3.90E-02	6.31E+01	1.80E+01	3.79E+04	2.24E+03
Hexachlorobiphenyl	0.00E+00	9.42E+01	5.34E-01	0.00E+00	2.41E+01	6.76E+03	1.33E+03
Heptachlorobiphenyl	5.04E+00	7.17E+01	6.46E-01	5.04E+00	1.47E+01	1.30E+03	7.19E+03
Octachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nonachlorobiphenyl	0.00E+00	0.00E+00	1.72E-03	0.00E+00	1.51E+00	0.00E+00	0.00E+00
Decachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.43E-01	0.00E+00	0.00E+00
Total	**1.58E+03**	**2.20E+03**	**2.62E+00**	**1.58E+03**	**2.79E+02**	**6.76E+04**	**1.11E+04**

Release Rates in nanograms PCB per Day	Ventilation Gaskets	Lubricants	Foam Rubber Material	Black Rubber Material	Electrical Cable	Bulkhead Insulation Material	Aluminized Paint	Total
Monochlorobiphenyl	1.90E+03	0.00E+00	0.00E+00	1.18E+04	0.00E+00	0.00E+00	0.00E+00	1.37E+04
Dichlorobiphenyl	5.80E+04	0.00E+00	0.00E+00	3.62E+05	1.11E+08	4.14E+04	0.00E+00	1.12E+08
Trichlorobiphenyl	2.59E+03	0.00E+00	0.00E+00	1.62E+04	6.25E+05	7.29E+06	2.02E+06	9.95E+06
Tetrachlorobiphenyl	6.60E+03	0.00E+00	0.00E+00	4.11E+04	8.61E+06	1.60E+08	9.51E+05	1.69E+08
Pentachlorobiphenyl	2.89E+03	0.00E+00	0.00E+00	1.80E+04	9.87E+06	2.93E+08	1.73E+07	3.20E+08
Hexachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E+07	5.22E+07	1.03E+07	7.57E+07
Heptachlorobiphenyl	2.31E+02	0.00E+00	0.00E+00	1.44E+03	8.06E+06	1.01E+07	5.56E+07	7.37E+07
Octachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nonachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.28E+05	0.00E+00	0.00E+00	8.28E+05
Decachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.62E+05	0.00E+00	0.00E+00	4.62E+05
Total	7.23E+04	0.00E+00	0.00E+00	4.50E+05	1.53E+08	5.22E+08	8.62E+07	7.62E+08

PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION
Risk Estimates for Ex-ORISKANY CV34 High-End Weight of PCB-Laden Materials
Supplemental Information

Air	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Fugacity (Pa)	3.22E-20	1.98E-16	1.30E-17	1.74E-16	1.91E-16	6.72E-18	2.40E-18	0.00E+00	8.51E-22	2.74E-24
Air concentration (g/m3)	2.47E-21	1.80E-17	1.37E-18	2.07E-17	2.54E-17	9.88E-19	3.86E-19	0.00E+00	1.61E-22	5.56E-25

Upper Water Column	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Fugacity (Pa)	6.67E-18	5.04E-14	1.22E-14	9.85E-14	4.71E-14	5.99E-14	7.57E-15	0.00E+00	2.11E-14	9.20E-16
Water concentration (mg/L)	3.07E-17	2.42E-13	1.95E-14	3.16E-13	4.15E-13	1.66E-14	6.80E-15	0.00E+00	3.06E-18	1.10E-20
Suspended solids concentration (mg/kg)	2.12E-14	4.15E-10	1.23E-10	2.14E-09	5.36E-09	2.99E-09	2.23E-09	0.00E+00	4.24E-12	1.44E-13
Dissolved organic carbon (mg/kg)	6.77E-14	3.09E-09	4.79E-10	1.95E-08	1.35E-07	1.16E-08	7.79E-09	0.00E+00	5.09E-11	3.25E-12

Lower Water Column	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Fugacity (Pa)	2.35E-14	1.81E-10	4.61E-11	3.80E-10	2.18E-10	6.75E-10	1.31E-10	0.00E+00	1.83E-09	9.95E-10
Water concentration (mg/L)	1.08E-13	8.67E-10	7.34E-11	1.22E-09	1.92E-09	1.87E-10	1.18E-10	0.00E+00	2.65E-13	1.19E-14
Suspended solids concentration (mg/kg)	7.47E-11	1.48E-06	4.64E-07	8.25E-06	2.48E-05	3.37E-05	3.87E-05	0.00E+00	3.68E-07	1.55E-07
Dissolved organic carbon (mg/kg)	2.38E-10	1.11E-05	1.80E-06	7.54E-05	6.26E-04	1.31E-04	1.35E-04	0.00E+00	4.41E-06	3.52E-06

Inside the Vessel	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Fugacity (Pa)	9.67E-12	7.43E-08	1.89E-08	1.56E-07	8.96E-08	2.77E-07	5.40E-08	0.00E+00	7.51E-07	4.09E-07
Water concentration (mg/L)	4.45E-11	3.57E-07	3.02E-08	5.02E-07	7.90E-07	7.68E-08	4.85E-08	0.00E+00	1.09E-10	4.88E-12
Suspended solids concentration (mg/kg)	3.07E-08	6.11E-04	1.91E-04	3.39E-03	1.02E-02	1.39E-02	1.59E-02	0.00E+00	1.51E-04	6.38E-05
Dissolved organic carbon (mg/kg)	9.80E-08	4.54E-03	7.41E-04	3.10E-02	2.57E-01	5.38E-02	5.56E-02	0.00E+00	1.81E-03	1.45E-03

Sediment Bed	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Fugacity (Pa)	2.35E-14	1.81E-10	4.61E-11	3.80E-10	2.18E-10	6.75E-10	1.31E-10	0.00E+00	1.83E-09	9.95E-10
Pore Water concentration (mg/L)	1.08E-13	8.67E-10	7.34E-11	1.22E-09	1.92E-09	1.87E-10	1.18E-10	0.00E+00	2.65E-13	1.19E-14
Sediment concentration (mg/kg)	4.98E-12	9.90E-08	3.09E-08	5.50E-07	1.65E-06	2.25E-06	2.58E-06	0.00E+00	2.45E-08	1.03E-08

Bioenergetic Inputs

	Species	Body Weight	Lipid	Moisture	Caloric Density	GE to ME	Met Energy	Caloric Density	Production	Respiration	Excretion	Caloric Density	Met Energy
		(kg)	(%-dw)	(%)	(kcal/g-dry weight)	Fraction	(kcal/kg-lipid)	(kcal/kg-lipid)	(% of total)	(% of total)	(% of total)	(kcal/g-wt weight)	(kcal/g-wt weight)
Pelagic Community													
Phytoplankton (TL-I)	Algae		10%	84%	2.36	0.6	13748	22913				0.3776	0.22656
Zooplankton (TL-II)	copepods	0.000005	22%	76%	3.6	0.65	10636	16364	18%	24%	58%	0.864	0.5616
Planktivore (TL-III)	herring	0.05	28%	75%	4.9	0.7	12206	17438	20%	60%	20%	1.225	0.8575
Piscivore (TL-IV)	jack	0.5	28%	75%	4.9	0.7	12206	17438	20%	60%	20%	1.225	0.8575
Reef / Vessel Community													
Attached Algae (TL-I)	Algae		10%	84%	2.36	0.6	13748	22913				0.3776	0.22656
Sessile filter feeder (TL-II)	bivalves (w/o shell)	0.05	5%	82%	4.6	0.65	59800	92000	28%	31%	41%	0.828	0.5382
Invertebrate Omnivore (TL-II)	urchin	0.05	29%	82%	4.6	0.65	10310	15862	7%	25%	68%	0.828	0.5382
Invertebrate Forager (TL-III)	crab	1	9%	74%	2.7	0.65	19118	29412	28%	59%	13%	0.702	0.4563
Vertebrate Forager (TL-III)	triggerfish	1	28%	75%	4.9	0.7	12206	17438	20%	60%	20%	1.225	0.8575
Predator (TL-IV)	grouper	1.5	28%	75%	4.9	0.7	12206	17438	20%	60%	20%	0.2	0.14
Benthic Community													
Infaunal invert. (TL-II)	polychaete	0.01	6%	84%	4.6	0.65	50000	76923	71%	26%	3%	0.736	0.4784
Epifaunal invert. (TL-II)	nematode	0.01	6%	82%	4.6	0.65	50000	76923	31%	19%	50%	0.828	0.5382
Forager (TL-III)	lobster	2	9%	74%	2.7	0.65	19118	29412	28%	59%	13%	0.702	0.4563
Predator (TL-IV)	flounder	3	22%	75%	4.9	0.7	15591	22273	20%	60%	20%	1.225	0.8575

Bioenergetic Inputs		Respiration Rate Allometric Regression Parameters			Resp. Rate	Resp. Rate	Consumption	Growth Rate	Consumption	Consumption	
		a	b1	b2	1 / day	gO2 / kg-lipid-day	kcal / kg-lipid-day	1 / day	g-wt weight / g-wt weight-d	kcal / wet weight-da	As a % of body weight
Pelagic Community											
Phytoplankton (TL1)	Algae										
Zooplankton (TL-II)	copepods	0.006375522	0	0.039935335	0.015425453	84.24400867	1286.168071	0.014147849	0.32636028	0.06790967	32.6%
Planktivore (TL-III)	herring	0.0033	-0.227	0.0548	0.004949927	21.1649	129.2512977	0.001482433	0.01616792	0.0090799	1.6%
Piscivore (TL-IV)	jack	0.001118602	-0.55	0.12	0.000630951	2.697821256	16.47524431	0.000188961	0.00139796	0.00115739	0.1%
Reef / Vessel Community											
Attached Algae	Algae										
Sessile filter feeder (TL-II)	bivalves (w/o shell)	0.012	0	0.036	0.024213411	581.8482643	6877.300342	0.020930914	0.24377539	0.0618957	24.4%
Invertebrate Omnivore (TL-II)	urchin	0.000675466	0	0.079181846	0.003163548	13.1069075	192.1012396	0.000847751	0.03471132	0.01002768	3.5%
Invertebrate Forager (TL-III)	crab	0.001158234	0	0.071193202	0.004642088	60.75673491	377.3221989	0.003592107	0.01678102	0.00900593	1.7%
Vertebrate Forager (TL-III)	triggerfish	0.015181024	-0.415	0.061	0.002837229	12.13142452	74.08503521	0.00084971	0.00907693	0.00520447	0.9%
Predator (TL-IV)	grouper	0.00279	-0.355	0.0811	0.001011362	4.324384181	26.40845301	0.000302889	0.00264734	0.00185519	0.3%
Benthic Community											
Infaunal invert. (TL-II)	polychaete	0.001682129	0	0.071034762	0.006721006	135.0382801	1903.064429	0.017565285	0.09800757	0.01820852	9.8%
Epifaunal invert. (TL-II)	nematode	0.001682129	0	0.071034762	0.006721006	135.0382801	2604.19343	0.0104949	0.09262416	0.02803154	9.3%
Forager (TL-III)	lobster	0.0035	-0.13	0.066	0.00471923	61.76639253	383.5925529	0.003651801	0.01899736	0.00915559	1.9%
Predator (TL-IV)	flounder	0.0046	-0.24	0.067	0.002486878	13.58174479	82.94195291	0.000744785	0.00974341	0.00456181	1.0%

Dietary Preferences	Suspended Solids (Epilimnion)	Suspended Solids (Hypolimnion)	Sediment	Phytoplankton	Zooplankton	Pelagic Plankitivore	Attached Algae	Reef Sessile Filter Feeder	Invertebrate Omnivore	Reef Invertebrate Forager	Reef Vertebrate Forager	Infaunal Benthos	Epifaunal Benthos	Benthic Forager
Pelagic Community														
Phytoplankton (TL1)														
Zooplankton (TL-II)	15%	15%		70%										
Planktivore (TL-III)					100%									
Piscivore (TL-IV)					10%	90%								
Reef / Vessel Community														
Attached Algae														
Sessile filter feeder (TL-II)		10%		80%	10%									
Invertebrate Omnivore (TL-II)							80%	20%						
Invertebrate Forager (TL-III)		5%			5%	5%		35%	50%					
Vertebrate Forager (TL-III)						19%		19%	15%	22%		12.5%	12.5%	
Predator (TL-IV)										15%	60%	8%	8%	8%
Benthic Community														
Infaunal invert. (TL-II)			50%	30%	20%									
Epifaunal invert. (TL-II)			25%	30%	20%							25%		
Forager (TL-III)			5%									50%	45%	
Predator (TL-IV)			2%									20%	20%	58%

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

Energy Estimates for Suspended Sediment and Bedded Sediment	GE	ME	ME	as kcal/g-ww
Sediment (kcal/kg-oc)	11456	6873.6	0.6	0.01099776
Suspended Sediment (kcal/kg-oc)	11456	6873.6	0.6	0.1649664

Respiratory Efficiencies	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Low body weight (<100g)	4.335E-01	8.000E-01	8.000E-01	8.000E-01	4.492E-01	2.582E-01	2.018E-01	1.127E-01	5.303E-02	1.255E-02
High body weight (>100g)	5.000E-01	5.000E-01	5.000E-01	5.000E-01	3.769E-01	2.857E-01	2.526E-01	1.888E-01	1.295E-01	6.299E-02
Dietary Assimilation Efficiencies	27%	46%	53%	62%	69%	69%	68%	59%	44%	16%

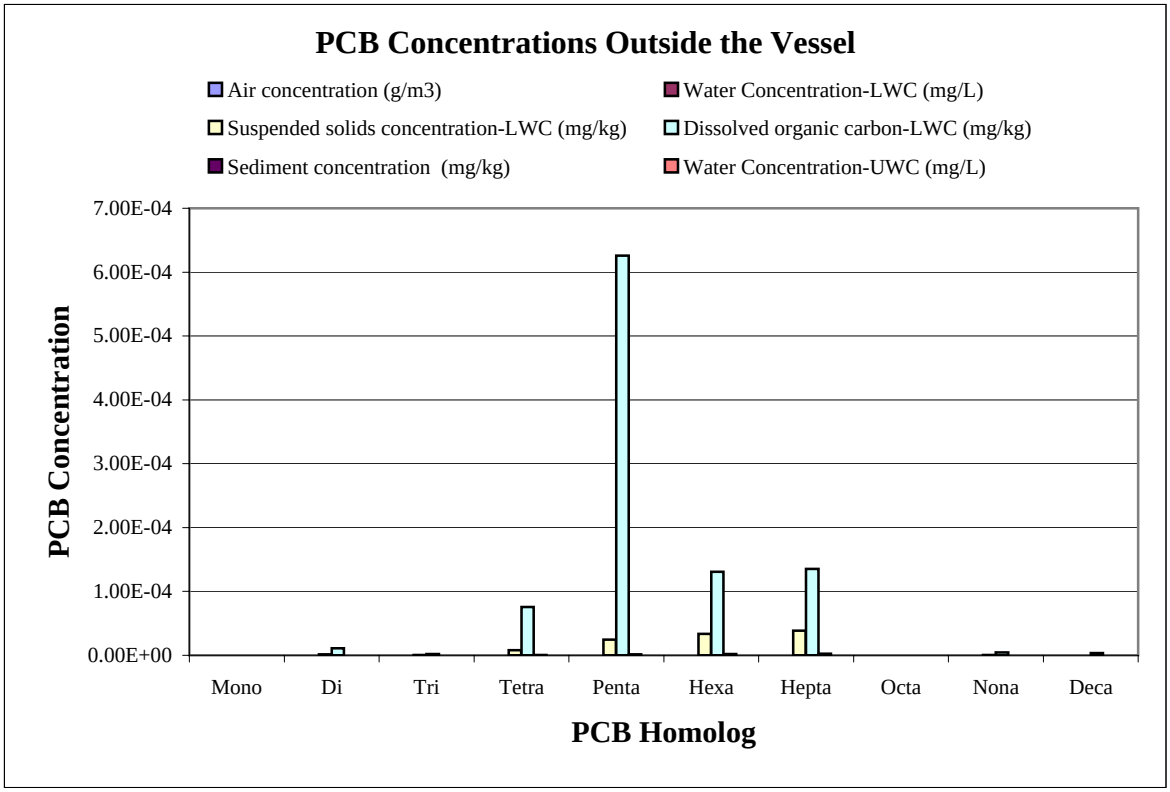
Tissue Conc. (mg/kg-lipid)	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Pelagic Community										
Phytoplankton (TL1)	9.143E-13	2.422E-08	1.948E-09	3.159E-08	4.150E-08	1.659E-09	6.797E-10	0.000E+00	3.062E-13	1.097E-15
Zooplankton (TL-II)	7.287E-09	2.706E-04	2.729E-05	5.151E-04	5.109E-04	7.310E-05	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

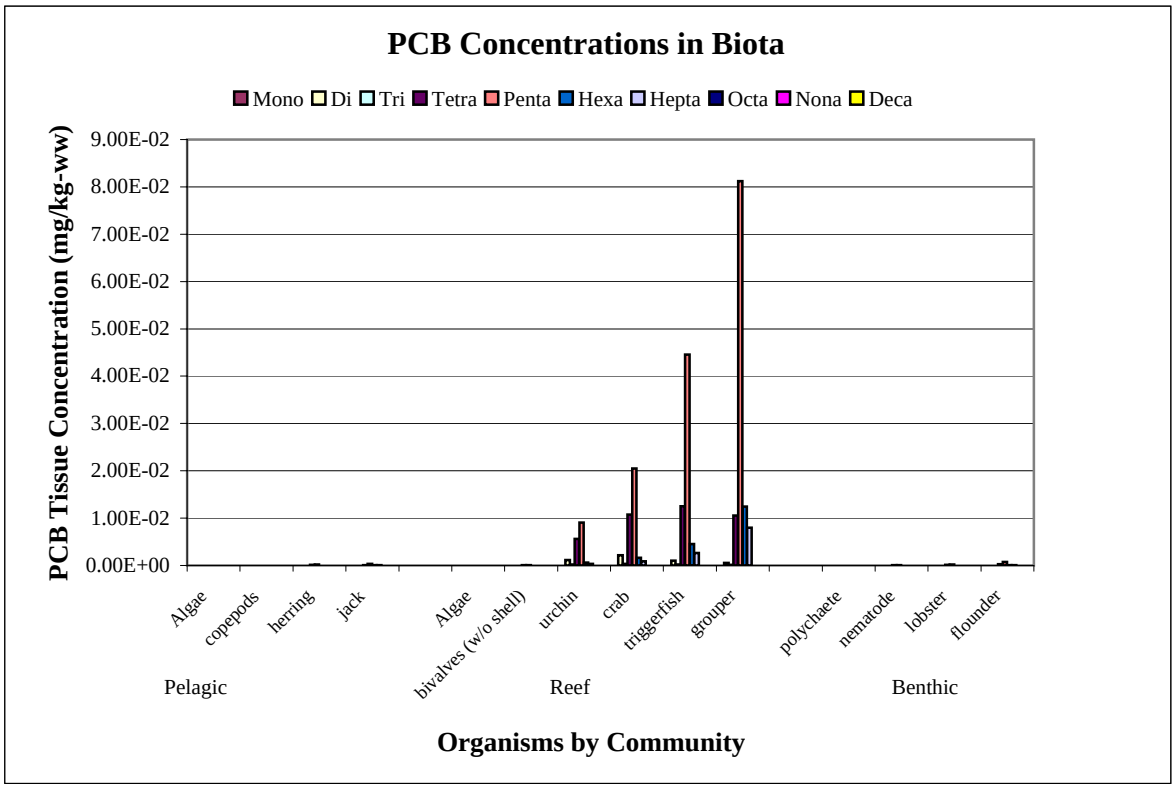
Tissue Conc. (mg/kg-WW)	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total PCB
Pelagic Community											
Phytoplankton (TL1)	1.507E-14	3.991E-10	3.211E-11	5.207E-10	6.838E-10	2.735E-11	1.120E-11	0.000E+00	5.047E-15	1.807E-17	1.674E-09
Zooplankton (TL-II)	3.847E-10	1.429E-05	1.441E-06	2.720E-05	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

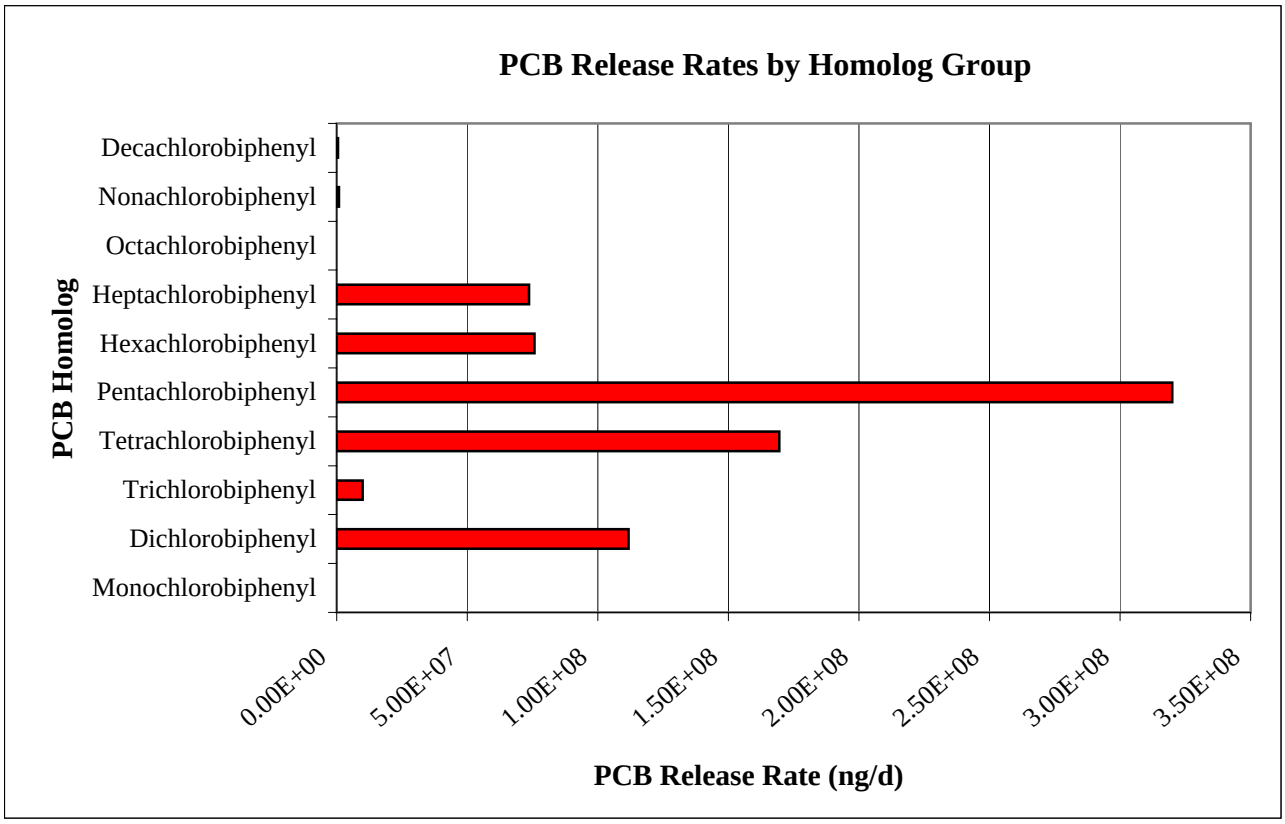
BAFs (L/kg-lipid)	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Pelagic Community										
Phytoplankton (TL1)	2.979E+04	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.000E+05	0.000E+00	1.000E+05	1.000E+05
Zooplankton (TL-II)	1.347E+05	6.238E+05	7.436E+05	8.445E+05	5.320E+05	7.826E+05	1.103E+06	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

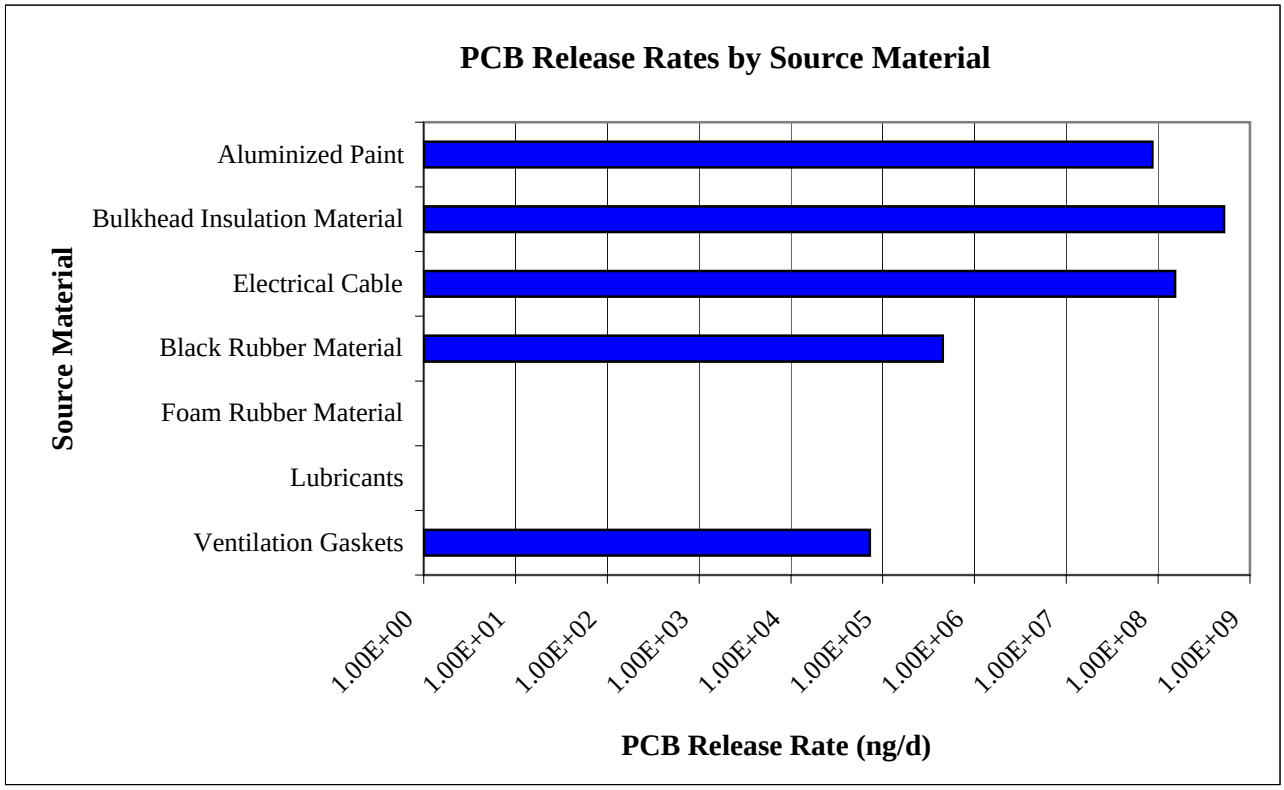
Notes:
Kow = octanol to water partitioning coefficient, Koc = organic carbon partitioning coefficient, Kdoc = dissolved organic carbon partitioning coefficient
TL = trophic level, ww = wet weight

APPENDIX H


PCB Concentrations Outside the Vessel
Air concentration (g/m3)
Water Concentration-LWC (mg/L)
Suspended solids concentration-LWC (mg/kg)
Dissolved organic carbon-LWC (mg/kg)
Sediment concentration (mg/kg)
Water Concentration-UWC (mg/L)
PCB Concentration
7.00E-04
6.00E-04
5.00E-04
4.00E-04
3.00E-04
2.00E-04
1.00E-04
0.00E+00
Mono
Di
Tri
Tetra
Penta
Hexa
Hepta
Octa
Nona
Deca
PCB Homolog


PCB Concentrations in Biota
Mono
Di
Tri
Tetra
Penta
Hexa
Hepta
Octa
Nona
Deca
PCB Tissue Concentration (mg/kg-ww)
9.00E-02
8.00E-02
7.00E-02
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
Algae
copepods
herring
jack
Algae
bivalves (w/o shell)
urchin
crab
triggerfish
grouper
polychaete
nematode
lobster
flounder
Pelagic
Reef
Benthic
Organisms by Community


PCB Release Rates by Homolog Group
PCB Homolog
Decachlorobiphenyl
Nonachlorobiphenyl
Octachlorobiphenyl
Heptachlorobiphenyl
Hexachlorobiphenyl
Pentachlorobiphenyl
Tetrachlorobiphenyl
Trichlorobiphenyl
Dichlorobiphenyl
Monochlorobiphenyl
0.00E+00
5.00E+07
1.00E+08
1.50E+08
2.00E+08
2.50E+08
3.00E+08
3.50E+08
PCB Release Rate (ng/d)


PCB Release Rates by Source Material
Source Material
Aluminized Paint
Bulkhead Insulation Material
Electrical Cable
Black Rubber Material
Foam Rubber Material
Lubricants
Ventilation Gaskets
1.00E+00
1.00E+01
1.00E+02
1.00E+03
1.00E+04
1.00E+05
1.00E+06
1.00E+07
1.00E+08
1.00E+09
PCB Release Rate (ng/d)

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

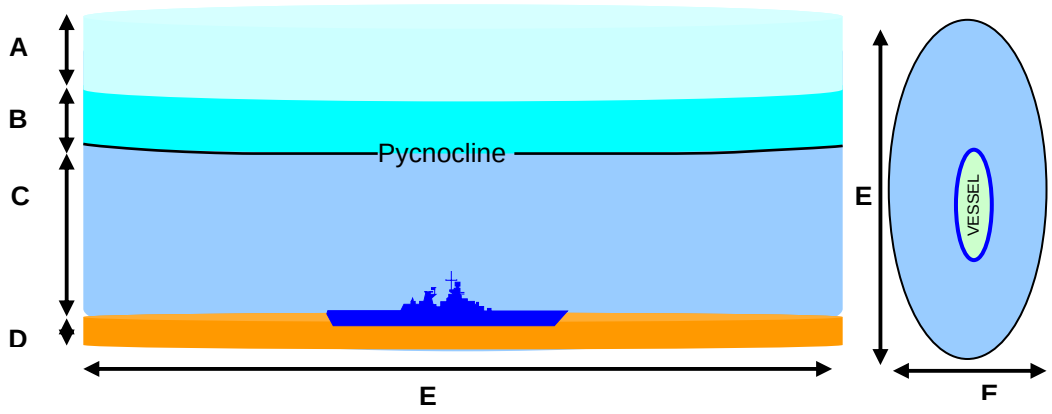
RISK INPUTS - Adult	RME	CTE
Body Weight (BWa) (kg)	70	70
Exposure Frequency (EFa) (days)	365	365
Exposure Duration (EDa) (years)	24	3
Ingestion Rate (IRa) (kg/day)	0.0261	0.0072
Averaging Time for cancer (ATc)	25550	25550
Averaging Time for noncancer (ATnc-adult)	8760	1095
Slope Factor (mg/kg-day)	2	1
Reference dose for PCBs (RfD) (mg/kg-day)	2.00E-05	4.50E-05
Fractional Ingestion factor (FI)	0.17	0.25
Ingestion Rates Based on Data from	Gulf Coast	

RISK INPUTS - Child	RME	CTE
Body Weight (BWc) (kg)	15	15
Exposure Frequency (EFc) (days)	365	365
Exposure Duration (EDc) (years)	6	6
Ingestion Rate (IRc) (kg/day)	0.0092916	0.0025632
Averaging Time for cancer (ATc)	25550	25550
Averaging Time for noncancer (ATnc-child)	2190	2190
Slope Factor (mg/kg-day)	2	1
Reference dose for PCBs (RfD) (mg/kg-day)	2.00E-05	4.50E-05
Fractional Ingestion factor (FI)	0.17	0.25
Child - Adult IR scaling factor	0.356	

Zone of Influence Multiplier	5
Scenario run on	5/11/05 13:38

PCB-LADEN MATERIAL INPUTS	Fraction PCB	Release Rate (ng/g-d)	kg Material Onboard	PCB Release (ng/day)
Ventilation Gaskets	3.14E-05	1.58E+03	1.46E+03	7.23E+04
Lubricants	1.03E-04	2.20E+03	0.00E+00	0.00E+00
Foam Rubber Material	7.60E-03	2.62E+00	0.00E+00	0.00E+00
Black Rubber Material	5.29E-05	1.58E+03	5.40E+03	4.50E+05
Electrical Cable	1.85E-03	2.79E+02	2.96E+05	1.53E+08
Bulkhead Insulation Material	5.37E-04	6.76E+04	1.44E+04	5.22E+08
Aluminum Paint	2.00E-05	1.11E+04	3.87E+05	8.62E+07
Total				7.62E+08

Ex-Oriskany CV34	
Displacement (tons)	27100
Length (ft)	888
Beam (ft)	120



ZOI =	5	
Spatial Footprint on Ocean Floor		
	3.89E+04	m2
	1.50E-02	mile2
Modeled Dimensions Outside the Vessel		
A	1.00E+01	m
B	1.50E+01	m
C	5.00E+01	m
D	1.00E-01	m
E	3.68E+02	m
F	1.34E+02	m
Volumes		
Air Column		
Air	3.89E+05	m3
Upper Water Column		
Water	5.83E+05	m3
TSS	3.89E+00	m3
Lower Water Column		
Water	1.89E+06	m3
TSS	1.26E+01	m3
Inside Vessel		
Water	5.38E+04	m3
TSS	3.59E-01	m3
Sediment Bed		
Sediment	3.11E+03	m3

Abiotic Inputs	
Air Column	
Active air space height above water column (m)	10

Total PCB concentrations		
Air Column		
Air	9.68E-17	g/m3

Air current (m/h)	13677
Upper Water Column	
Temperature (°C)	24.5
Water depth (m)	15
Total suspended solids (mg/L)	10
Dissolved organic carbon (mg/L)	0.6
Dissolved oxygen (mg/L)	6.12
Lower Water Column	
Temperature (°C)	19.5
Water depth (m)	50
Total suspended solids (mg/L)	10
Dissolved organic carbon (mg/L)	0.6
Dissolved oxygen (mg/L)	4.59
Inside Vessel	
Temperature (°C)	19.5
Total suspended solids (mg/L)	10
Dissolved organic carbon (mg/L)	0.6
Dissolved oxygen (mg/L)	4.59
Sediment Bed	
Sediment density (g/cm3)	1.5
Active sediment depth (m)	0.1
Sediment fraction organic carbon	0.01
All Regions	
Suspended solids density (g/cm3)	1.5
Suspended solids fraction organic carbon	0.15
Dissolved organic carbon density (g/cm3)	1
Water current - to out of the ZOI (m/h)	926
Water current - inside to outside the vessel (m/h)	9.26

Upper Water Column		
Freely dissolved in water	9.32E-13	mg/L
Suspended solids	1.22E-08	mg/kg
Dissolved organic carbon	1.63E-07	mg/kg
Lower Water Column		
Freely dissolved in water	2.55E-09	mg/L
Suspended solids	6.27E-05	mg/kg
Dissolved organic carbon	5.74E-04	mg/kg
Inside Vessel		
Freely dissolved in water	1.80E-06	mg/L
Suspended solids	4.44E-02	mg/kg
Dissolved organic carbon	4.06E-01	mg/kg
Sediment Bed		
Freely dissolved in pore water	2.55E-09	mg/L
Bedded sediment	4.18E-06	mg/kg
Dissolved organic carbon in pore water	5.74E-04	mg/kg

Total PCB concentrations in biota			**Percent Exposures**	
Pelagic Community			Upper WC	Lower WC
Phytoplankton (TL-I)	1.54E-09	mg/kg	100%	0%
Zooplankton (TL-II)	4.48E-05	mg/kg	50%	50%
Planktivore (TL-III)	2.17E-04	mg/kg	80%	20%
Piscivore (TL-IV)	3.37E-04	mg/kg	80%	20%
Reef / Vessel Community			Lower WC	Vessel Int.
Attached Algae (TL-I)	4.20E-06	mg/kg	100%	0%
Sessile filter feeder (TL-II)	9.19E-05	mg/kg	100%	0%
Invertebrate Omnivore (TL-II)	1.67E-02	mg/kg	80%	20%
Invertebrate Forager (TL-III)	3.59E-02	mg/kg	70%	30%
Vertebrate Forager (TL-III)	6.47E-02	mg/kg	70%	30%
Predator (TL-IV)	1.11E-01	mg/kg	80%	20%
Benthic Community			Lower WC	Pore Water
Infaunal invert. (TL-II)	3.18E-05	mg/kg	20%	80%
Epifaunal invert. (TL-II)	8.74E-05	mg/kg	50%	50%
Forager (TL-III)	2.00E-04	mg/kg	75%	25%
Predator (TL-IV)	6.88E-04	mg/kg	90%	10%

PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION

Risk Estimates For Ex-ORISKANY CV34 High-End Weight of PCB-Laden Materials

Supplemental Information

Scenario Run on 10/21/2004 14:10

PCB Homolog	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Molecular Weight (g/mol)	1.89E+02	2.23E+02	2.58E+02	2.92E+02	3.26E+02	3.61E+02	3.95E+02	4.30E+02	4.64E+02	4.99E+02
Solubility (mg/L)	2.91E+00	6.78E-01	8.14E-02	6.67E-02	2.61E-02	9.50E-04	2.30E-04	2.11E-08	4.02E-09	1.69E-10
Solubility (mol/m^3)	1.54E-02	3.04E-03	3.16E-04	2.28E-04	8.00E-05	2.63E-06	5.82E-07	4.91E-11	8.65E-12	3.38E-13
Vapor Pressure (Pa)	6.32E-01	1.41E-01	5.11E-02	2.08E-02	2.96E-03	3.43E-03	2.56E-04	8.65E-05	2.77E-05	1.41E-05
Henry's (Pa-m^3/mol)	4.10E+01	4.65E+01	1.62E+02	9.10E+01	3.70E+01	1.30E+03	4.40E+02	1.76E+06	3.20E+06	4.18E+07
$\log_{10}K_{ow}$ =	4.47	5.24	5.52	5.92	6.50	6.98	7.19	7.70	8.35	9.60
$\log_{10}K_{oc}$ =	3.66	4.06	4.63	4.65	4.94	6.08	6.34	6.46	6.97	7.94
$\log_{10}K_{doc}$ =	3.34	4.11	4.39	4.79	5.51	5.85	6.06	6.57	7.22	8.47
Chemical emission rate (g/day)	1.37E-05	1.12E-01	9.95E-03	1.69E-01	3.20E-01	7.57E-02	7.37E-02	0.00E+00	8.28E-04	4.62E-04
Chemical emission rate (mol/hr)	3.03E-09	2.09E-05	1.61E-06	2.42E-05	4.08E-05	8.74E-06	7.77E-06	0.00E+00	7.43E-08	3.86E-08
Biodegradation in sediment (1/hr)	0	0	0	0	0	0	0	0	0	0
Biodegradation in water (1/hr)	0	0	0	0	0	0	0	0	0	0

	Ventilation Gaskets	Lubricants	Foam Rubber Material	Black Rubber Material	Electrical Cable	Bulkhead Insulation Material	Aluminized Paint
Fraction PCB in Material (wt/wt)	0.0000314	0.000103	0.76%	0.0000529	0.00185	0.000537	0.00002
Material Mass Onboard (kg)	1459	0	0	5397	296419	14379	386528
Total PCBs (kg)	0.0458126	0	0	0.2855013	548.37515	7.721523	7.73056
Total PCB Release rate (ng/g-PCB per day)	1.58E+03	2.20E+03	2.62E+00	1.58E+03	2.79E+02	6.76E+04	1.11E+04

Release Rates in nanograms PCB per gram of PCB within the Material	Ventilation Gaskets	Lubricants	Foam Rubber Material	Black Rubber Material	Electrical Cable	Bulkhead Insulation Material	Aluminized Paint
Monochlorobiphenyl	4.14E+01	3.47E+01	0.00E+00	4.14E+01	0.00E+00	0.00E+00	0.00E+00
Dichlorobiphenyl	1.27E+03	1.72E+02	3.08E-02	1.27E+03	2.03E+02	5.36E+00	0.00E+00
Trichlorobiphenyl	5.66E+01	8.97E+01	7.63E-02	5.66E+01	1.14E+00	9.44E+02	2.61E+02
Tetrachlorobiphenyl	1.44E+02	1.08E+03	1.29E+00	1.44E+02	1.57E+01	2.07E+04	1.23E+02
Pentachlorobiphenyl	6.31E+01	6.60E+02	3.90E-02	6.31E+01	1.80E+01	3.79E+04	2.24E+03
Hexachlorobiphenyl	0.00E+00	9.42E+01	5.34E-01	0.00E+00	2.41E+01	6.76E+03	1.33E+03
Heptachlorobiphenyl	5.04E+00	7.17E+01	6.46E-01	5.04E+00	1.47E+01	1.30E+03	7.19E+03
Octachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nonachlorobiphenyl	0.00E+00	0.00E+00	1.72E-03	0.00E+00	1.51E+00	0.00E+00	0.00E+00
Decachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.43E-01	0.00E+00	0.00E+00
Total	**1.58E+03**	**2.20E+03**	**2.62E+00**	**1.58E+03**	**2.79E+02**	**6.76E+04**	**1.11E+04**

Release Rates in nanograms PCB per Day	Ventilation Gaskets	Lubricants	Foam Rubber Material	Black Rubber Material	Electrical Cable	Bulkhead Insulation Material	Aluminized Paint	Total
Monochlorobiphenyl	1.90E+03	0.00E+00	0.00E+00	1.18E+04	0.00E+00	0.00E+00	0.00E+00	1.37E+04
Dichlorobiphenyl	5.80E+04	0.00E+00	0.00E+00	3.62E+05	1.11E+08	4.14E+04	0.00E+00	1.12E+08
Trichlorobiphenyl	2.59E+03	0.00E+00	0.00E+00	1.62E+04	6.25E+05	7.29E+06	2.02E+06	9.95E+06
Tetrachlorobiphenyl	6.60E+03	0.00E+00	0.00E+00	4.11E+04	8.61E+06	1.60E+08	9.51E+05	1.69E+08
Pentachlorobiphenyl	2.89E+03	0.00E+00	0.00E+00	1.80E+04	9.87E+06	2.93E+08	1.73E+07	3.20E+08
Hexachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E+07	5.22E+07	1.03E+07	7.57E+07
Heptachlorobiphenyl	2.31E+02	0.00E+00	0.00E+00	1.44E+03	8.06E+06	1.01E+07	5.56E+07	7.37E+07
Octachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nonachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.28E+05	0.00E+00	0.00E+00	8.28E+05
Decachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.62E+05	0.00E+00	0.00E+00	4.62E+05
Total	7.23E+04	0.00E+00	0.00E+00	4.50E+05	1.53E+08	5.22E+08	8.62E+07	7.62E+08

PCB MODELING RESULTS - PROSPECTIVE RISK EVALUATION

Risk Estimates For Ex-ORISKANY CV34 High-End Weight of PCB-Laden Materials

Supplemental Information

Air	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Fugacity (Pa)	4.65E-20	2.86E-16	1.89E-17	2.52E-16	2.76E-16	9.75E-18	3.48E-18	0.00E+00	1.23E-21	3.97E-24
Air concentration (g/m3)	3.58E-21	2.60E-17	1.98E-18	3.00E-17	3.67E-17	1.43E-18	5.60E-19	0.00E+00	2.33E-22	8.06E-25

Upper Water Column	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Fugacity (Pa)	6.12E-18	4.63E-14	1.12E-14	9.04E-14	4.32E-14	5.50E-14	6.95E-15	0.00E+00	1.94E-14	8.44E-16
Water concentration (mg/L)	2.82E-17	2.22E-13	1.79E-14	2.90E-13	3.81E-13	1.52E-14	6.24E-15	0.00E+00	2.81E-18	1.01E-20
Suspended solids concentration (mg/kg)	1.95E-14	3.80E-10	1.13E-10	1.96E-09	4.92E-09	2.75E-09	2.05E-09	0.00E+00	3.89E-12	1.32E-13
Dissolved organic carbon (mg/kg)	6.21E-14	2.83E-09	4.39E-10	1.79E-08	1.24E-07	1.07E-08	7.15E-09	0.00E+00	4.67E-11	2.99E-12

Lower Water Column	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Fugacity (Pa)	1.37E-14	1.05E-10	2.67E-11	2.21E-10	1.27E-10	3.92E-10	7.63E-11	0.00E+00	1.06E-09	5.78E-10
Water concentration (mg/L)	6.28E-14	5.03E-10	4.26E-11	7.08E-10	1.11E-09	1.08E-10	6.85E-11	0.00E+00	1.54E-13	6.89E-15
Suspended solids concentration (mg/kg)	4.34E-11	8.62E-07	2.69E-07	4.79E-06	1.44E-05	1.96E-05	2.25E-05	0.00E+00	2.13E-07	9.01E-08
Dissolved organic carbon (mg/kg)	1.38E-10	6.41E-06	1.05E-06	4.38E-05	3.63E-04	7.60E-05	7.85E-05	0.00E+00	2.56E-06	2.04E-06

Inside the Vessel	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Fugacity (Pa)	9.67E-12	7.43E-08	1.89E-08	1.56E-07	8.96E-08	2.77E-07	5.40E-08	0.00E+00	7.51E-07	4.09E-07
Water concentration (mg/L)	4.45E-11	3.57E-07	3.02E-08	5.02E-07	7.90E-07	7.68E-08	4.85E-08	0.00E+00	1.09E-10	4.88E-12
Suspended solids concentration (mg/kg)	3.07E-08	6.11E-04	1.91E-04	3.39E-03	1.02E-02	1.39E-02	1.59E-02	0.00E+00	1.51E-04	6.38E-05
Dissolved organic carbon (mg/kg)	9.80E-08	4.54E-03	7.41E-04	3.10E-02	2.57E-01	5.38E-02	5.56E-02	0.00E+00	1.81E-03	1.45E-03

Sediment Bed	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Fugacity (Pa)	1.37E-14	1.05E-10	2.67E-11	2.21E-10	1.27E-10	3.92E-10	7.63E-11	0.00E+00	1.06E-09	5.78E-10
Pore Water concentration (mg/L)	6.28E-14	5.03E-10	4.26E-11	7.08E-10	1.11E-09	1.08E-10	6.85E-11	0.00E+00	1.54E-13	6.89E-15
Sediment concentration (mg/kg)	2.89E-12	5.75E-08	1.80E-08	3.19E-07	9.60E-07	1.30E-06	1.50E-06	0.00E+00	1.42E-08	6.01E-09

Bioenergetic Inputs

	Species	Body Weight	Lipid	Moisture	Caloric Density	GE to ME	Met Energy	Caloric Density	Production	Respiration	Excretion	Caloric Density	Met Energy
		(kg)	(%-dw)	(%)	(kcal/g-dry weight)	Fraction	(kcal/kg-lipid)	(kcal/kg-lipid)	(% of total)	(% of total)	(% of total)	(kcal/g-wt weight)	(kcal/g-wt weight)
Pelagic Community													
Phytoplankton (TL-I)	Algae		10%	84%	2.36	0.6	13748	22913				0.3776	0.22656
Zooplankton (TL-II)	copepods	0.000005	22%	76%	3.6	0.65	10636	16364	18%	24%	58%	0.864	0.5616
Planktivore (TL-III)	herring	0.05	28%	75%	4.9	0.7	12206	17438	20%	60%	20%	1.225	0.8575
Piscivore (TL-IV)	jack	0.5	28%	75%	4.9	0.7	12206	17438	20%	60%	20%	1.225	0.8575
Reef / Vessel Community													
Attached Algae (TL-I)	Algae		10%	84%	2.36	0.6	13748	22913				0.3776	0.22656
Sessile filter feeder (TL-II)	bivalves (w/o shell)	0.05	5%	82%	4.6	0.65	59800	92000	28%	31%	41%	0.828	0.5382
Invertebrate Omnivore (TL-II)	urchin	0.05	29%	82%	4.6	0.65	10310	15862	7%	25%	68%	0.828	0.5382
Invertebrate Forager (TL-III)	crab	1	9%	74%	2.7	0.65	19118	29412	28%	59%	13%	0.702	0.4563
Vertebrate Forager (TL-III)	triggerfish	1	28%	75%	4.9	0.7	12206	17438	20%	60%	20%	1.225	0.8575
Predator (TL-IV)	grouper	1.5	28%	75%	4.9	0.7	12206	17438	20%	60%	20%	0.2	0.14
Benthic Community													
Infaunal invert. (TL-II)	polychaete	0.01	6%	84%	4.6	0.65	50000	76923	71%	26%	3%	0.736	0.4784
Epifaunal invert. (TL-II)	nematode	0.01	6%	82%	4.6	0.65	50000	76923	31%	19%	50%	0.828	0.5382
Forager (TL-III)	lobster	2	9%	74%	2.7	0.65	19118	29412	28%	59%	13%	0.702	0.4563
Predator (TL-IV)	flounder	3	22%	75%	4.9	0.7	15591	22273	20%	60%	20%	1.225	0.8575

Bioenergetic Inputs		Respiration Rate Allometric Regression Parameters			Resp. Rate	Resp. Rate	Consumption	Growth Rate	Consumption	Consumption	
		a	b1	b2	1 / day	gO2 / kg-lipid-day	kcal / kg-lipid-day	1 / day	g-wt weight / g-wt weight-d	kcal / wet weight-da	As a % of body weight
Pelagic Community											
Phytoplankton (TL1)	Algae										
Zooplankton (TL-II)	copepods	0.006375522	0	0.039935335	0.015425453	84.24400867	1286.168071	0.014147849	0.32636028	0.06790967	32.6%
Planktivore (TL-III)	herring	0.0033	-0.227	0.0548	0.004949927	21.1649	129.2512977	0.001482433	0.01616792	0.0090799	1.6%
Piscivore (TL-IV)	jack	0.001118602	-0.55	0.12	0.000630951	2.697821256	16.47524431	0.000188961	0.00139796	0.00115739	0.1%
Reef / Vessel Community											
Attached Algae	Algae										
Sessile filter feeder (TL-II)	bivalves (w/o shell)	0.012	0	0.036	0.024213411	581.8482643	6877.300342	0.020930914	0.24377539	0.0618957	24.4%
Invertebrate Omnivore (TL-II)	urchin	0.000675466	0	0.079181846	0.003163548	13.1069075	192.1012396	0.000847751	0.03471132	0.01002768	3.5%
Invertebrate Forager (TL-III)	crab	0.001158234	0	0.071193202	0.004642088	60.75673491	377.3221989	0.003592107	0.01678102	0.00900593	1.7%
Vertebrate Forager (TL-III)	triggerfish	0.015181024	-0.415	0.061	0.002837229	12.13142452	74.08503521	0.00084971	0.00907693	0.00520447	0.9%
Predator (TL-IV)	grouper	0.00279	-0.355	0.0811	0.001011362	4.324384181	26.40845301	0.000302889	0.00264734	0.00185519	0.3%
Benthic Community											
Infaunal invert. (TL-II)	polychaete	0.001682129	0	0.071034762	0.006721006	135.0382801	1903.064429	0.017565285	0.09800757	0.01820852	9.8%
Epifaunal invert. (TL-II)	nematode	0.001682129	0	0.071034762	0.006721006	135.0382801	2604.19343	0.0104949	0.09262416	0.02803154	9.3%
Forager (TL-III)	lobster	0.0035	-0.13	0.066	0.00471923	61.76639253	383.5925529	0.003651801	0.01899736	0.00915559	1.9%
Predator (TL-IV)	flounder	0.0046	-0.24	0.067	0.002486878	13.58174479	82.94195291	0.000744785	0.00974341	0.00456181	1.0%

Dietary Preferences	Suspended Solids (Epilimnion)	Suspended Solids (Hypolimnion)	Sediment	Phytoplankton	Zooplankton	Pelagic Plankitivore	Attached Algae	Reef Sessile Filter Feeder	Invertebrate Omnivore	Reef Invertebrate Forager	Reef Vertebrate Forager	Infaunal Benthos	Epifaunal Benthos	Benthic Forager
Pelagic Community														
Phytoplankton (TL1)														
Zooplankton (TL-II)	15%	15%		70%										
Planktivore (TL-III)					100%									
Piscivore (TL-IV)					10%	90%								
Reef / Vessel Community														
Attached Algae														
Sessile filter feeder (TL-II)		10%		80%	10%									
Invertebrate Omnivore (TL-II)							80%	20%						
Invertebrate Forager (TL-III)		5%			5%	5%		35%	50%					
Vertebrate Forager (TL-III)						19%		19%	15%	22%		12.5%	12.5%	
Predator (TL-IV)										15%	60%	8%	8%	8%
Benthic Community														
Infaunal invert. (TL-II)			50%	30%	20%									
Epifaunal invert. (TL-II)			25%	30%	20%							25%		
Forager (TL-III)			5%									50%	45%	
Predator (TL-IV)			2%									20%	20%	58%

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

Energy Estimates for Suspended Sediment and Bedded Sediment	GE	ME	ME	as kcal/g-ww
Sediment (kcal/kg-oc)	11456	6873.6	0.6	0.01099776
Suspended Sediment (kcal/kg-oc)	11456	6873.6	0.6	0.1649664

Respiratory Efficiencies	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Low body weight (<100g)	4.335E-01	8.000E-01	8.000E-01	8.000E-01	4.492E-01	2.582E-01	2.018E-01	1.127E-01	5.303E-02	1.255E-02
High body weight (>100g)	5.000E-01	5.000E-01	5.000E-01	5.000E-01	3.769E-01	2.857E-01	2.526E-01	1.888E-01	1.295E-01	6.299E-02
Dietary Assimilation Efficiencies	27%	46%	53%	62%	69%	69%	68%	59%	44%	16%

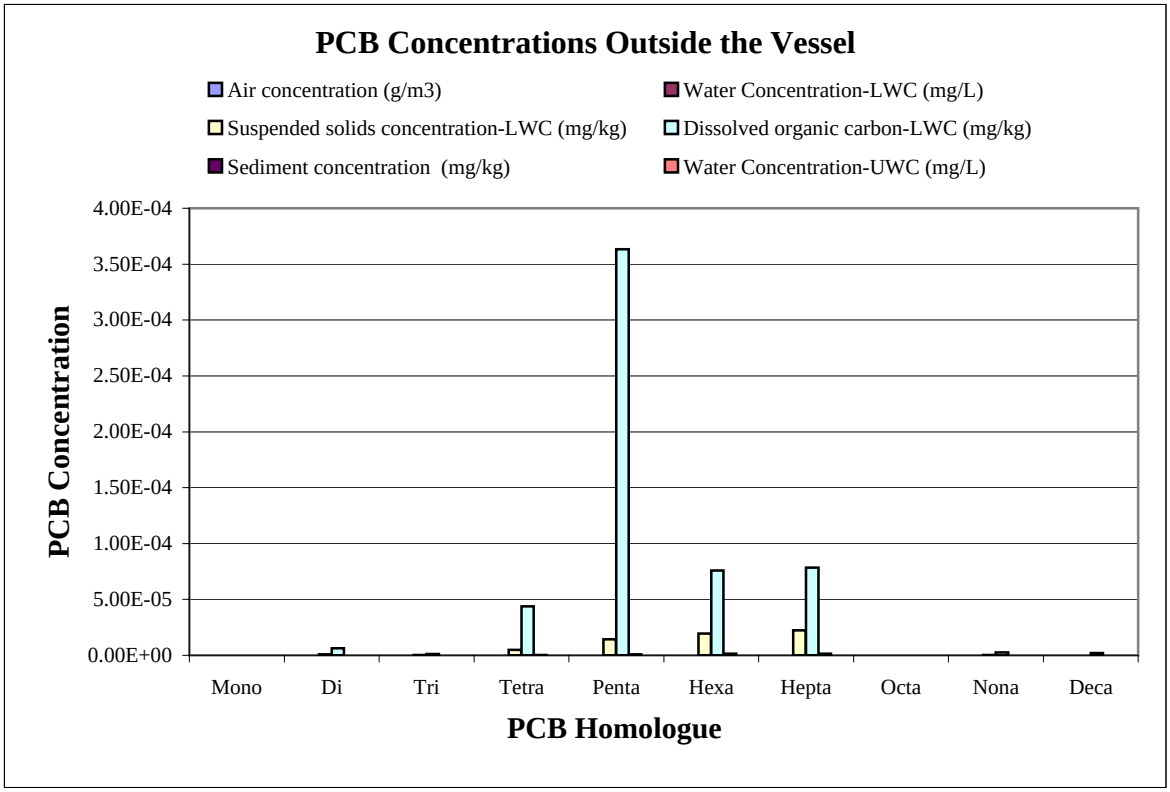
Tissue Conc. (mg/kg-lipid)	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Pelagic Community										
Phytoplankton (TL1)	8.387E-13	2.222E-08	1.787E-09	2.899E-08	3.807E-08	1.523E-09	6.239E-10	0.000E+00	2.811E-13	1.007E-15
Zooplankton (TL-II)	4.231E-09	1.571E-04	1.585E-05	2.991E-04	2.967E-04	4.244E-05	3.776E-05	0.000E+00	1.893E-07	2.799E-08
Planktivore (TL-III)	9.564E-10	1.331E-04	2.426E-05	8.873E-04	1.581E-03	2.488E-04	2.158E-04	0.000E+00	7.140E-07	3.758E-08
Piscivore (TL-IV)	2.501E-10	2.346E-05	6.441E-06	5.183E-04	2.772E-03	7.462E-04	7.296E-04	0.000E+00	2.131E-06	4.648E-08
Reef / Vessel Community										
Attached Algae	1.870E-09	5.035E-05	4.260E-06	7.080E-05	1.115E-04	1.084E-05	6.847E-06	0.000E+00	1.540E-08	6.887E-10
Sessile filter feeder (TL-II)	6.022E-08	2.031E-03	2.006E-04	3.773E-03	3.652E-03	3.235E-04	2.342E-04	0.000E+00	7.497E-07	8.135E-08
Invertebrate Omnivore (TL-II)	2.883E-07	2.235E-02	3.298E-03	1.060E-01	1.708E-01	1.202E-02	6.275E-03	0.000E+00	4.231E-06	5.249E-08
Invertebrate Forager (TL-III)	2.186E-06	8.904E-02	1.325E-02	4.464E-01	8.506E-01	6.702E-02	3.707E-02	0.000E+00	4.056E-05	2.689E-06
Vertebrate Forager (TL-III)	2.009E-07	1.406E-02	3.019E-03	1.767E-01	6.272E-01	6.326E-02	3.683E-02	0.000E+00	4.112E-05	1.369E-06
Predator (TL-IV)	1.112E-07	7.216E-03	1.703E-03	1.483E-01	1.143E+00	1.745E-01	1.116E-01	0.000E+00	1.199E-04	2.665E-06
Benthic Community										
Infaunal invert. (TL-II)	1.525E-08	5.992E-04	6.227E-05	1.232E-03	1.237E-03	1.132E-04	8.273E-05	0.000E+00	2.309E-07	1.645E-08
Epifaunal invert. (TL-II)	1.892E-08	1.114E-03	1.329E-04	3.008E-03	3.315E-03	3.177E-04	2.345E-04	0.000E+00	5.892E-07	3.231E-08
Forager (TL-III)	1.105E-08	6.101E-04	9.328E-05	2.819E-03	4.201E-03	3.928E-04	2.676E-04	0.000E+00	4.266E-07	9.788E-09
Predator (TL-IV)	9.779E-10	1.627E-04	4.287E-05	2.656E-03	8.002E-03	9.627E-04	6.798E-04	0.000E+00	8.739E-07	1.285E-08

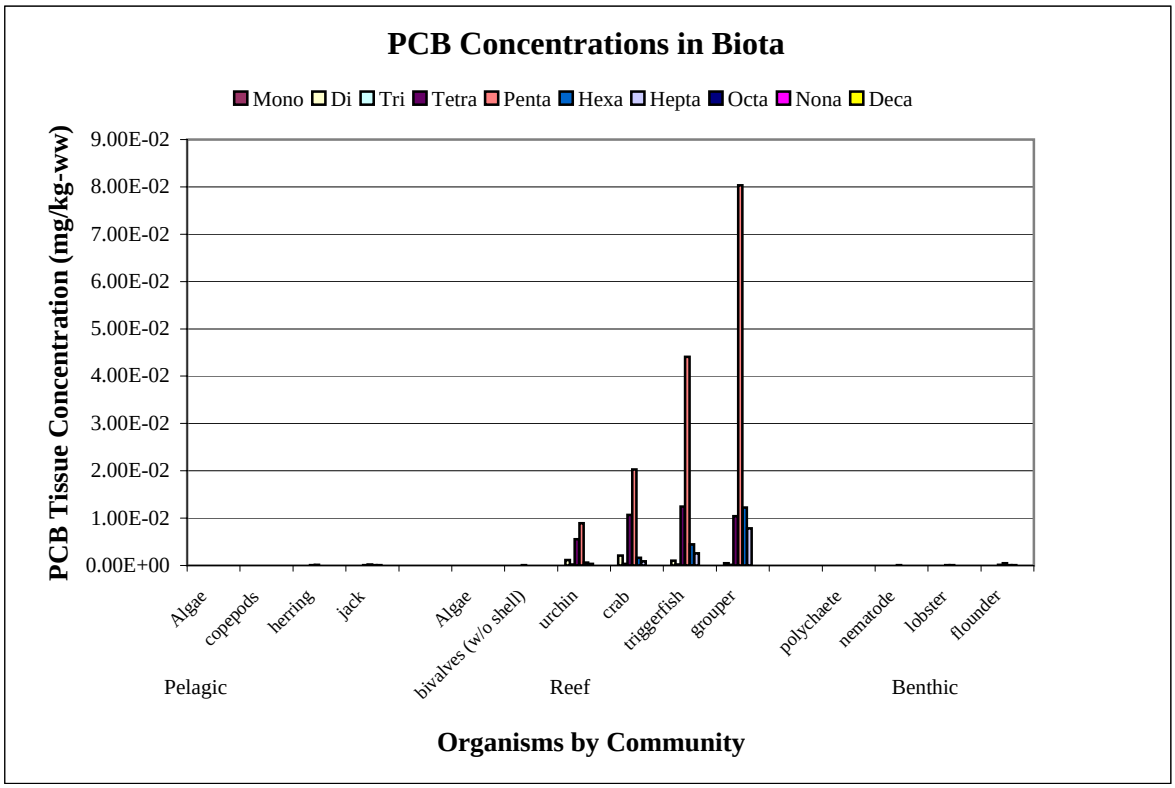
Tissue Conc. (mg/kg-WW)	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total PCB
Pelagic Community											
Phytoplankton (TL1)	1.382E-14	3.661E-10	2.946E-11	4.777E-10	6.275E-10	2.510E-11	1.028E-11	0.000E+00	4.633E-15	1.659E-17	1.536E-09
Zooplankton (TL-II)	2.234E-10	8.295E-06	8.368E-07	1.579E-05	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

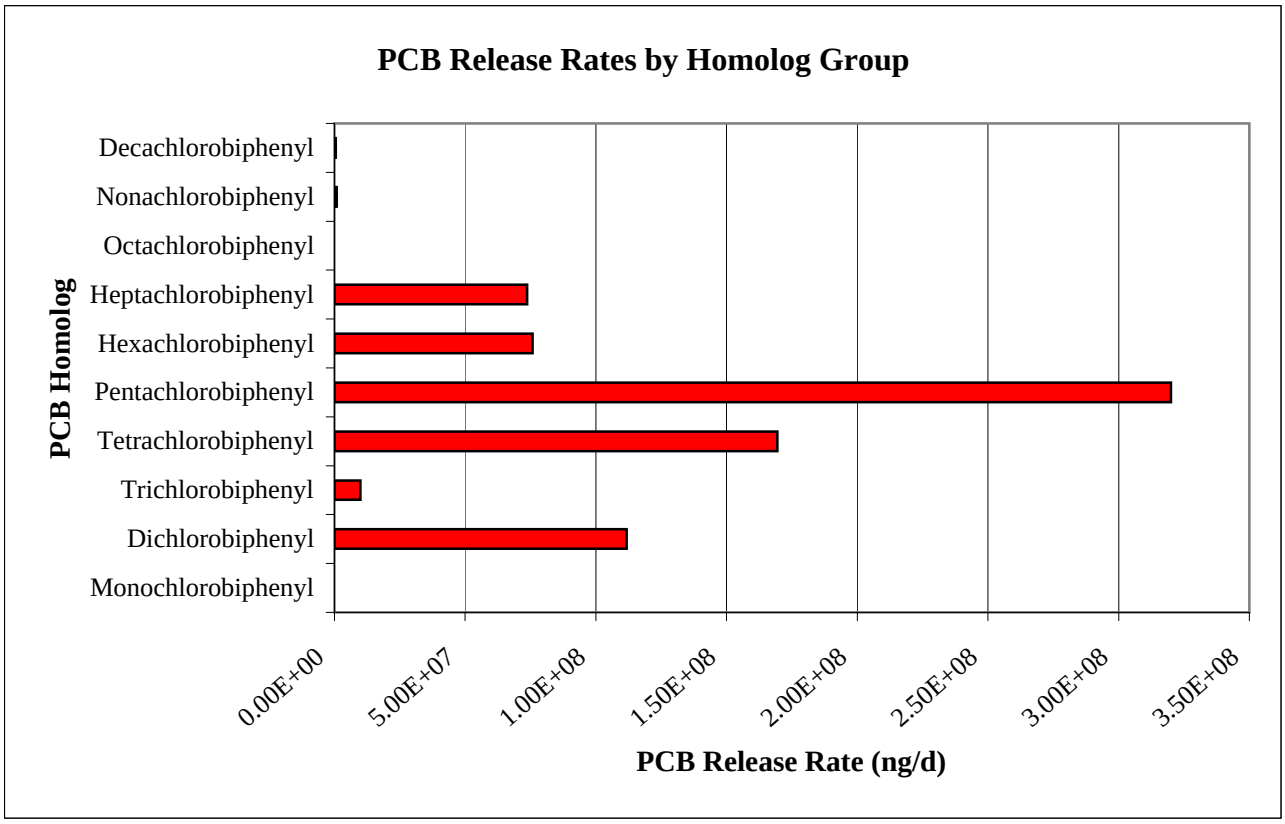
BAFs (L/kg-lipid)	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Pelagic Community										
Phytoplankton (TL1)	2.979E+04	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.000E+05	1.000E+05	0.000E+00	1.000E+05	1.000E+05
Zooplankton (TL-II)	1.347E+05	6.238E+05	7.437E+05	8.446E+05	5.321E+05	7.827E+05	1.103E+06	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

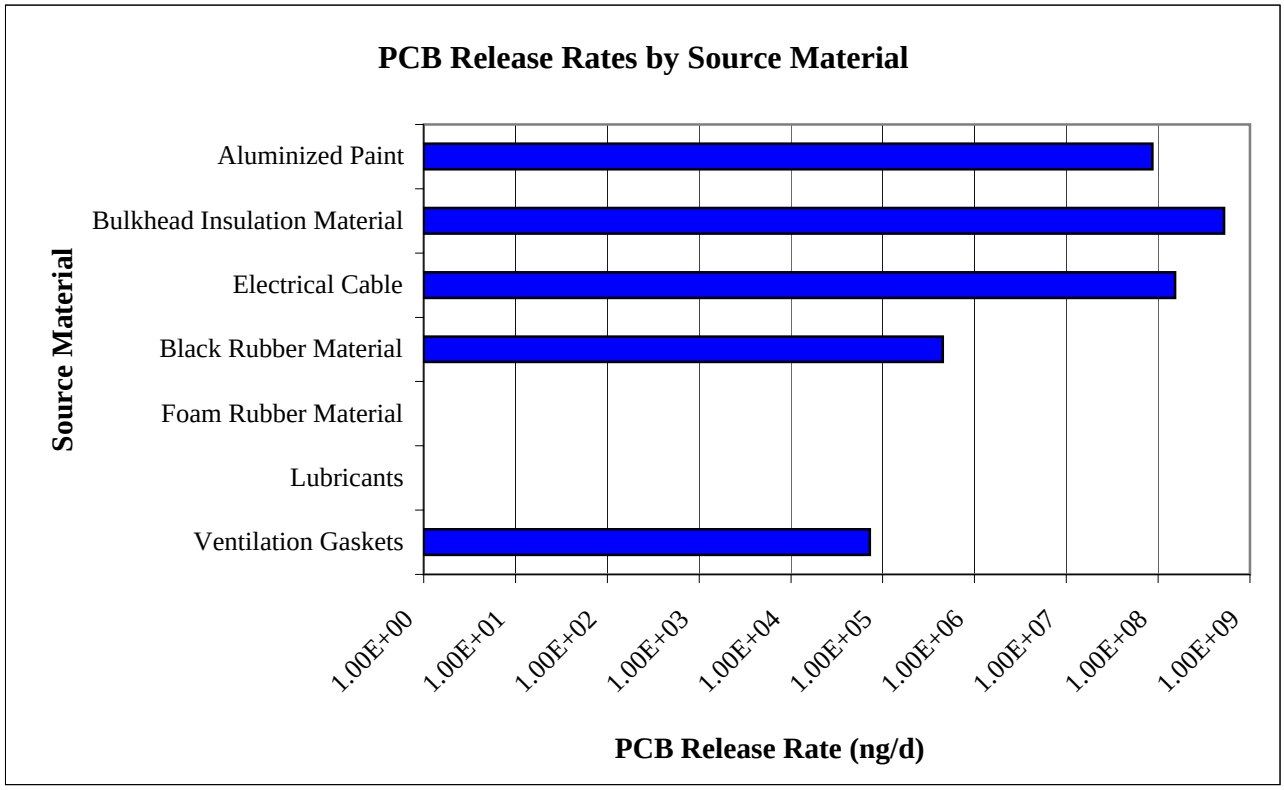
Notes:
Kow = octanol to water partitioning coefficient, Koc = organic carbon partitioning coefficient, Kdoc = dissolved organic carbon partitioning coefficient
TL = trophic level, ww = wet weight

APPENDIX H


PCB Concentrations Outside the Vessel
Air concentration (g/m3)
Water Concentration-LWC (mg/L)
Suspended solids concentration-LWC (mg/kg)
Dissolved organic carbon-LWC (mg/kg)
Sediment concentration (mg/kg)
Water Concentration-UWC (mg/L)
PCB Concentration
4.00E-04
3.50E-04
3.00E-04
2.50E-04
2.00E-04
1.50E-04
1.00E-04
5.00E-05
0.00E+00
Mono
Di
Tri
Tetra
Penta
Hexa
Hepta
Octa
Nona
Deca
PCB Homologue


PCB Concentrations in Biota
Mono
Di
Tri
Tetra
Penta
Hexa
Hepta
Octa
Nona
Deca
PCB Tissue Concentration (mg/kg-ww)
9.00E-02
8.00E-02
7.00E-02
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
Algae
copepods
herring
jack
Algae
bivalves (w/o shell)
urchin
crab
triggerfish
grouper
polychaete
nematode
lobster
flounder
Pelagic
Reef
Benthic
Organisms by Community

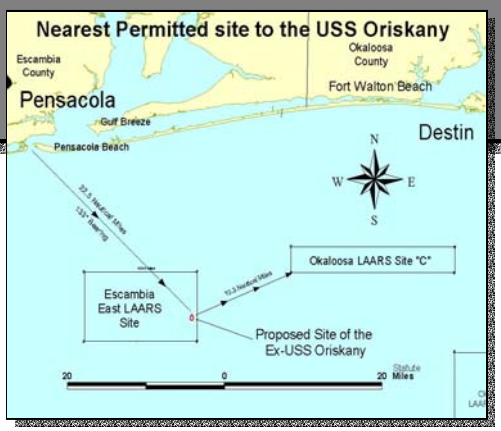

PCB Release Rates by Homolog Group
PCB Homolog
Decachlorobiphenyl
Nonachlorobiphenyl
Octachlorobiphenyl
Heptachlorobiphenyl
Hexachlorobiphenyl
Pentachlorobiphenyl
Tetrachlorobiphenyl
Trichlorobiphenyl
Dichlorobiphenyl
Monochlorobiphenyl
0.00E+00
5.00E+07
1.00E+08
1.50E+08
2.00E+08
2.50E+08
3.00E+08
3.50E+08
PCB Release Rate (ng/d)


PCB Release Rates by Source Material
Source Material
Aluminized Paint
Bulkhead Insulation Material
Electrical Cable
Black Rubber Material
Foam Rubber Material
Lubricants
Ventilation Gaskets
1.00E+00
1.00E+01
1.00E+02
1.00E+03
1.00E+04
1.00E+05
1.00E+06
1.00E+07
1.00E+08
1.00E+09
PCB Release Rate (ng/d)

Appendix I

Fact Sheet

ex-ORISKANY Artificial Reef Project



In June 2005 the Navy requested approval from the United States Environmental Protection Agency (USEPA) to sink the ex-ORISKANY approximately 26 land miles off the coast of Pensacola, Florida. The Navy has been working with USEPA, Florida's Fish and Wildlife Conservation Commission, and the Escambia County Marine Resources Division since 2003 to prepare the ship for use as an artificial reef in these waters. This fact sheet provides information about cleanup conducted on the ex-ORISKANY to prepare the vessel for sinking and studies that the Navy has conducted to ensure that people, plants, and animals can safely use the future ex-ORISKANY artificial reef.

NAVY SHIPS AS ARTIFICIAL REEFS

In recent years, several coastal states have expressed interest in using old U.S. Navy and Maritime Administration vessels to build artificial reefs. The ex-ORISKANY is the first decommissioned Navy vessel that will be sunk intentionally for this purpose. To ensure this is done safely, the USEPA developed Best Management Practice (BMP) guidance for preparing vessels to create artificial reefs.

The BMP guidance identifies materials of concern that may be found aboard vessels, likely areas where they may be found, and cleanup goals. The Navy conducted a comprehensive inventory of materials on board the ex-ORISKANY in accordance with the BMP.

Using the inventory, the Navy removed oil and fuel, asbestos, polychlorinated biphenyls (PCBs), certain paints, and loose debris as recommended by the BMP. Some PCB containing materials still remain onboard the ex-ORISKANY. These materials required additional study and review before the vessel can be sunk.

POLYCHLORINATED BIPHENYLS (PCBs)

PCBs are oil-like compounds that were once used world-wide in many products, especially in electrical equipment such as transformers and capacitors. Congress banned the manufacture of PCBs in the U.S. in 1979 because studies found they stay in the environment for a very long time, and, if ingested, they will build up in the fatty tissues of people and animals. Because of their past widespread use, PCBs are found onboard most Navy vessels built before 1979.

The Navy has removed all liquid PCB materials from the ex-ORISKANY as recommended by the BMP. There are also solid products on the ex-ORISKANY that contain PCBs. The amount of PCBs in these solid products can vary greatly. The BMP allows for solid materials containing small amounts of PCBs, less than 50 parts per million (ppm), to remain on board when the vessel is sunk. Materials containing 50 ppm or greater of PCBs must be removed unless special permission is granted by the USEPA.

There are several solid materials used on old ships that contain PCBs such as certain types of paint, insulation, felt gaskets and cabling. These products vary greatly in their ability to effect the environment because some of these products hold on tightly to the PCBs they contain while others allow the PCBs to easily move or "leach" out of the solid material into the surrounding water.

The Navy studied several types of solid PCB products to determine the amount of PCBs that would leach out of each type of material. The results showed bulkhead insulation has the highest leach rate. Based on these results the Navy has removed more than 70% of the bulkhead insulation and other solid materials on board the ex-ORISKANY to greatly reduce the risks to human health and the environment from the PCBs.

Approximately 700 pounds of PCBs remain throughout the ship in some of the solid materials. The Navy is proposing to leave these materials on board for two major reasons:

1. *Removing all of the electrical cabling and other solid PCB materials without totally dismantling the ex-ORISKANY is virtually impossible and would be extremely costly.*

2. Almost all of the remaining PCBs on the ex-ORISKANY are in electrical cabling (97%). The leach rate study found that the PCBs in the electrical cabling are very stable. Only very small amounts of PCBs moved out of the cabling and into the surrounding water over the 2 year study period.

USEPA APPROVAL

USEPA has the authority to grant a risk-based disposal approval to allow solid PCB containing materials to remain onboard ships scheduled for sinking as artificial reefs, provided the risks from the PCBs are acceptable. In order to receive the risk-based disposal approval for ex-ORISKANY, the Navy must demonstrate that the risks to people using the reef, and plants and animals living and feeding on the reef, will be safe. The Navy conducted studies known as "risk assessments" to estimate potential human health and environmental impacts for the future ex-ORISKANY artificial reef.

ARTIFICIAL REEF RISK ASSESSMENTS

Since the ex-ORISKANY reef is not yet established, sampling the water or fish at the proposed site will not tell us anything about the safety of the future artificial reef. Because of this, the Navy developed computer models to predict conditions on the ex-ORISKANY reef.

These models use information on the amount and types of PCB bulk products remaining on the ship, PCB leach rates observed by Navy scientists, and equations recommended by the USEPA to estimate:

- PCB concentrations in the water around the new reef,
- the amount of PCBs that will likely enter reef fish, and
- the amount of PCBs expected to accumulate in the bodies of reef fish.

The PCB concentrations predicted by the computer models were then used to complete a human health risk assessment and an ecological risk assessment.

Human Health Risk Assessment

Navy risk assessors reviewed the PCB concentrations predicted by the computer models, information on the chemistry of PCBs, and site specific information on whom in the area would likely visit/use the new artificial reef. They concluded that the groups of people that might have potential health risks from using the new reef are recreational scuba divers and people who catch and eat fish from the reef.

The risk assessors reviewed local seafood consumption surveys and other information about seafood eating habits in the area, and found that recreational angler fishermen and their families will likely eat the most fish from the new reef area.

A complete risk assessment was done for these two "highest risk groups" – scuba divers and angler fishermen and their families.

The results showed the water will be safe for scuba diving and both adults and children can safely eat fish caught at the new ex-ORISKANY artificial reef.

Ecological Risk Assessment

An ecological risk assessment was conducted to see if the PCBs left on-board the ex-ORISKANY will harm the environment at the new artificial reef site. The risk assessors used the PCB concentrations predicted by the computer models to assess the potential effects to survival, growth, and reproduction for various fish and other organisms that will live and feed on the new reef. They also assessed the potential for effects in other organisms higher up the food chain that will feed on the reef fish such as sea birds, sea turtles, dolphins, and sharks.

The results showed the new ex-ORISKANY artificial reef will be safe for the surrounding environment and the marine life that lives there.

NEXT STEPS…

The Navy submitted the risk assessments and other project studies and documents to USEPA and requested risk-based PCB disposal approval for ex-ORISKANY in June 2005. Since then, the documents have been through an intensive review process. They were examined by scientists from within the USEPA and outside experts participating in the USEPA's Science Advisory Board (SAB).

In December 2005 the USEPA announced their intent to issue Risk Based Disposal Approval for reefing the ex-ORISKANY. The USEPA is accepting public comments on this proposal until January 19, 2006. These comments will be reviewed before a final decision is made on the Navy's request for approval to sink the ex-ORISKANY.

The ex-ORISKANY is currently in temporary storage in Beaumont, Texas. If US EPA grants approval in early 2006, then the Navy will move the ex-ORISKANY to Pensacola and sink the ship in mid 2006. If approval is delayed, then the ex-ORISKANY will wait out the hurricane season in Texas.

FOR MORE INFORMATION

Copies of the study documents are available on-line for review on the US EPA Region 4 website at: **www.epa.gov/region4/air/lead/PCBWebPage.htm** and on the PCB home page maintained by EPA headquarters at **www.epa.gov/pcb/** .

Additional information on the ex-ORISKANY project is available on the Navy's website at **www.peoships.crane.navy.mil/reefing/oriskany.htm**

Appendix J

Response to USEPA Comments

Document 3 ORISKANY Human Health Risk Assessment (HHRA) Response to Comments (FINAL)

<table>
<tr><th></th><th>COMMENT</th><th>RESPONSE</th></tr>
<tr><td colspan="3">Major Comment</td></tr>
<tr><td>1</td><td>Section 2.2, page 2-2 stated that approximately 330 kg of PCBs are estimated to remain on-board after the ex-Oriskany is prepared for sinking. There are discrepancies in the estimated amount of PCBs left on-board as presented in Table 4-1 and Table 13 (Appendix D). Table 13 (Appendix D) estimated 330 kg PCB (=722.6 lb) left on-board, which agrees with the Section 2.2 statement. But, table 4-1 estimated about 56,420 kg, which is 170 times higher than the estimated value shown in table 13 (appendix D). EPA noticed that the current material mass (FWR Mass*A*B*C) was multiplied by the percentage of PCBs in the material instead of the fraction (%/100) leading to the incorrect PCB mass values as well as overestimating total mass of PCBs (56,442 kg). The revised calculations are below.

<table>
<tr><th></th><th colspan="2">Original Mass (1 kg= 2.2 lb)</th><th colspan="3">Adjustment Factors</th><th></th><th colspan="2">Current material mass (original mass*A*B*C)</th><th>PCB Fraction in material</th><th colspan="2">Current material mass * fraction PCB</th><th>Fraction of total PCB on board (%)</th></tr>
<tr><td></td><td>lbs</td><td>kg</td><td>CACI</td><td>30 yr growth</td><td>Mass remaining after preparation</td><td>Fraction Mass remaining</td><td>lbs</td><td>kg</td><td>%/100</td><td>lbs</td><td>kg</td><td>(Fraction PCB of material/total *100)</td></tr>
<tr><td>Vent Gaskets</td><td>2,680</td><td>1218.181818</td><td>1</td><td>1.2</td><td>100%</td><td>1</td><td>3216</td><td>1462</td><td>0.0000314</td><td>0.100982</td><td>0.0459</td><td>0.01</td></tr>
<tr><td>Lubricants</td><td>208,140</td><td>94609.09091</td><td>1</td><td>1</td><td>0%</td><td>0</td><td>0</td><td>0</td><td>0.0001</td><td>0</td><td>0</td><td>0.00</td></tr>
<tr><td>Foam Rubber material</td><td>0</td><td>0</td><td>na</td><td>na</td><td>na</td><td>na</td><td>0</td><td>0</td><td>0.0076</td><td>0</td><td>0</td><td>0.00</td></tr>
<tr><td>Rubber products</td><td>11,898</td><td>5408.181818</td><td>1</td><td>1</td><td>100%</td><td>1</td><td>11898</td><td>5408</td><td>0.000053</td><td>0.630594</td><td>0.28663</td><td>0.05</td></tr>
<tr><td>Cable insulation</td><td>403,600</td><td>183454.5455</td><td>1.384</td><td>1.3</td><td>90%</td><td>0.9</td><td>653541</td><td>297064</td><td>0.00185</td><td>1209.052</td><td>549.569</td><td>97.19</td></tr>
<tr><td>Bulkhead Insulation</td><td>115,695</td><td>52588.63636</td><td>1</td><td>1</td><td>27.40%</td><td>0.274</td><td>31700</td><td>14409</td><td>0.00054</td><td>17.11823</td><td>7.78101</td><td>1.38</td></tr>
<tr><td>Paints</td><td>298,999</td><td>135908.6364</td><td>1</td><td>3</td><td>95%</td><td>0.95</td><td>852147</td><td>387340</td><td>0.00002</td><td>17.04294</td><td>7.74679</td><td>1.37</td></tr>
<tr><td>Total</td><td>1,041,012</td><td>473,187</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1243.944</td><td>565.43</td><td></td></tr>
</table>

These calculations estimated 565 kg, not 330 kg, PCBs left on-board. Since 565 kg is a higher estimate, the human health risks might have been underestimated. Section 2.2 also states that electrical cables accounts for 95% of the total PCBs aboard the vessel, with BHI accounting for 3%. The revised calculations estimated 97% and 1% for electrical cables and BHI, respectively.

Section 4.3 indicated that "the mass of material estimated to remain onboard the ship, together with the normalized average leach rates developed from the Leachate Release study (George et al., 2005b) provide the source terms for the PRAM". Therefore, RAD recommends that the table data and PRAM inputs for PCB-containing materials are verified followed by a rerun of the PRAM model to make sure that the risk estimates are within EPA acceptable criteria.</td><td>The 330 kg and 565 kg estimates represent the arithmetic mean concentration and the 95% upper concentration limit (UCL), respectively, of PCBs in bulk materials remaining on the ex-ORISKANY. Table 4.1 will be modified to correct the PCB mass calculation error and to include 95 % UCLs.

PRAM calculations all used the 565 kg 95% UCL estimate as the source term for PCBs. Therefore, human health risks were appropriately calculated and PRAM does not need to be rerun. The revised HHRA will indicate that the 95% UCL estimate of PCB source mass remaining on the ex-ORISKANY was used to predict human health risks.</td></tr>
</table>

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	In addition, it would be informative if table 4-1 includes the 95% UCL (lbs, kg) as currently appearing in table 13 (appendix D).	
	General Comments	
1	**Calculation Error** - A significant discrepancy in the assessment was that our calculations showed that 565 kg, not 330 kg, of PCBs are estimated to be on board. Since the mass of material that remains on board as well as the average leach rates serve as source terms for the PRAM model, it is strongly recommended that the PRAM PCB input be verified and rerun to determine if any risk estimates are changed as a result of the higher PCB content on board the ship. See Major Comments, above.	See response to Major Comment 1.
2	**Pycnocline Issues** - Numerous questions regarding Sections 4.1 - 8.1 and Tables 4-3 and 4-5 are raised. These questions focus on issues such as leach rates and their influence on the risk assessment, how variations in the pycnocline might affect the risk estimates, and assumptions regarding the steady state being reached at day 730.	Responses to the topics identified in this comment are addressed within the specific comment section. Specifically, pycnocline questions are addressed in response to Specific Comment 6; leach rate questions are addressed in response to Specific Comments 2, 5, 7 and 27; and timing for reaching steady state conditions is addressed in response to Specific Comment 7. Please refer to these specific comments accordingly.
3	**Developmental Risks** - Risks to pregnant women were not addressed and should be considered/discussed since there are possible developmental and neurotoxic effects associated with PCBs.	The potential for risk from intrauterine exposures to PCBs was discussed briefly in Section 7.5.2 and Section 9.4.2 of the HHRA. A more extensive discussion of this topic will be provided in the revised HHRA. Recent toxicological studies of PCBs, including epidemiological studies suggesting adverse effects from *in utero* exposures, have not been incorporated into US EPA's RfDs for PCBs (USEPA, 2005). Therefore, risk from prenatal exposure is not quantitatively evaluated; instead prenatal risk will continue to be addressed qualitatively in the revised HHRA.
4	**General Document Considerations -** Some topics are well developed in the HHRA whereas others lack the necessary information to perform a sound review. Consequently, it was necessary to check other supporting documents and sometimes the discussions were too fragmented and multiple documents had to be referred to before understanding the issue. Assumptions should be transparent, well explained and justified by primary and supporting data. Assumptions should be transparent, well explained and justified by primary and supporting data. This should be improved throughout the document. An extensive QC process should be done to avoid such problems in the	We have undertaken an extensive internal technical review of consistency and clarity of presentation within and among the six technical documents for the ex-ORISKANY. The Navy will modify the HHRA based on this review and anticipates that the modifications will address the concerns raised in this comment. Given the volume of information that must be presented for this project, the HHRA will still need to reference other documents for more detailed discussion of selected topics. However, these references will be specific so that the reviewer does not waste time searching for the information. Also, a brief, general overview of the documents will be prepared to help the reviewer navigate through them.

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	final documents.	
	Specific Comments	
1	Executive summary, page ES-1 indicated that the ex-Oriskany reef should be on its way to maturity after 2 years without offering a citation. A discussion of the data supporting this position should be included.	The revised HHRA will include a brief discussion of the scientific literature relevant to the proposed ex-ORISKANY artificial reef to document expected reef progression over the initial two-year period. While there is no reef-associated community on the ship at the time of sinking, colonization by many reef organisms is likely to start almost immediately once the ship is sunk. Based on observations of other artificial reefs constructed from a variety of materials, colonization by organisms such as algae, barnacles, and fish occurs within a few weeks of immersion (Walker et al. 2002, Golani and Daimant 1999, Sherman *et al.* 1999, Clark and Edwards 1994). Bohnsack *et al.* (1994) noted that fish colonization of artificial reefs off southeastern Florida was very rapid, and within two years post-deployment, fish assemblages were abundant and diverse. That study was supported by a more recent evaluation of several types of artificial reefs off the coast of southeastern Florida, which documented increased fish abundance and richness, including higher trophic sport fish such as groupers and snappers, at two years post-deployment of the reefs (Walker et al.2002). Other studies in southeastern Florida have also found rapid colonization of artificial reefs by fish assemblages. Cummings (1994) found that species diversity within the fish community reached equilibrium within 2.5 months at a shallow artificial reef. Sherman *et al.* (1999) observed predatory fishes such as groupers, snappers, and jacks at their artificial reefs prior to two years post-deployment. Studies of artificial reefs in other marine waters have similarly found rapid fish recruitment. In the Mediterranean Sea, Coll *et al*. (1998) reported that after the first 17 months, deployment time did not affect fish species composition. Clark and Edwards (1994) also found rapid colonization of artificial reefs by fish, with increased richness observed at 12 months of deployment. Golani and Diamant (1999) found that the number of fish species at artificial reefs in the Red Sea increased during the first seven months after deployment, and then leveled off for the remainder of the 2-year study. Species from a variety of trophic guilds were observed to be residents of the artificial reef within two years post-deployment, including predatory fishes such as groupers (e.g., *Cephalopholis hemistiktos, Epinephelus fasciatus*). Based on these studies, a two-year time period is considered sufficient to account for uptake of PCBs through the food web to

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		higher trophic level fish that would be consumed by humans. The focus on reef development during the initial period after vessel sinking is necessary to evaluate the potential effects on reef organisms and uptake into fish from transient releases of PCBs from the bulk products. This issue was discussed in detail with members of the biology technical working group, including representatives from EPA and State of FL (Escambia County and Florida Fish and Wildlife Conservation Commission). This information and relevant citations will be provided in the revised HHRA.
2	Section 4.1, page 4-2 described the leach-rate study. The document acknowledged that the leach-rate study was conducted under abiotic conditions and that the influence of biological organism degradation on the leaching of PCBs is unknown. However, the document failed to justify why leach-rate data from abiotic conditions could be used as a good predictor of what it will happen in the marine environment. Such discussion should be included in the document.	We concur that it is possible for biological factors to influence the release of PCBs. However, the extent, mechanisms, and potential effects of biodegradation processes on matrices similar to shipboard solids are largely unknown. We will discuss this uncertainty in the revised HHRA. We also refer the reviewer to the response to SAB General Comment 1 on the Leach Rate Report.
3	Section 4.1.1, page 4-3 presented data from the final report entitled "Polychlorinated biphenyls (PCB) Source Term Estimates for ex-Oriskany (Appendix D)". The sampling protocol used for this analysis should be detailed. Also explain how the protocol ensured the collection of representative samples from materials containing high, medium and low concentrations of PCBs aboard the ex-Oriskany. Discussion of the sampling protocol should at least appear in the PCB Source Term Estimates final report.	The PCB sampling performed on the ex-ORISKANY was done in accordance with the NAVSEA PCB ADVISORY 95-1, dated 21 September 1995. NAVSEA also maintains a database on PCB sampling and, in addition to the sampling results specific to any vessel such as the ex-ORISKANY, NAVSEA can consult the database to confirm that the sampling results for a given ship are within the norms for all other ships that have been sampled. The sampling protocol that was followed for the ex-ORISKANY is based on the Navy's historic knowledge of the presence of PCBs in shipboard components. This user knowledge and the database were used to develop and implement what Navy believes to be an appropriate sampling protocol for the ex-ORISKANY because it is based on the best available knowledge from PCB sampling data that represents a large number of ships and their potentially PCB-containing components. The HHRA will be revised to include a brief description of the sampling protocol.
4	Section 4.1.2, page 4-3: The document should indicate background levels of PCBs (presumed to be 0) in artificial seawater before the conduct of the leach-rate experiments.	The leach rate studies were conducted using ASTM standard artificial seawater. The Navy sampled and analyzed (a) seawater blanks, which were clean seawater for each 20L batch (the "source" of clean leachate), and (b) procedural blanks, which were leaching vessels with clean seawater and cage/filter apparatus but no shipboard solid or Aroclor control. No PCBs were detected in these samples. The relevant data can be found in Appendix C of the Leach Rate Report (data for procedural blanks begin on p. 651, and data for

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		seawater blanks begin on p. 662). The revised HHRA will clarify this issue.
5a	Section 4.1.2, pages 4-4 and 4-5: The reference is missing for the statement "A regression analysis of detected PCB concentration data on a homolog basis showed that PCB releases decrease exponentially over time". If these data are from the leach-rate study, then the report should be cited.	Comment acknowledged. The revised HHRA will cite the Leach Rate Report.
5b	Section 4.1.2, pages 4-4 and 4-5: Explain why the analysis was conducted on the natural log transform.	The log transformation was used to simplify and perform a linear regression analysis of the decreasing portion of the leach rate curves, in a very general, but consistent manner. The decreasing leach rate behavior can generally be described by the power function $y = 10^A x^B$, where y is the average leach rate and x is time. The leach rate data were fit using the logarithmic form of this power function (in "y = mx + b" form), log[y] = B log[x] + A.
5c	Section 4.1.2, pages 4-4 and 4-5: A clarification statement should be added to this section regarding whether dioxin-like PCBs were included in the leach-rate analysis.	Yes, dioxin-like PCBs were included in the leach rate analysis. This will be clarified in the revised HHRA.
5d	Section 4.1.2, pages 4-4 and 4-5: On Table 4-3, electrical cable showed no detection levels for mono-, di-, octa-, nona- and deca-chlorobiphenyls, but the discussion claimed that mono- and octa-biphenyls were not detected. Please clarify.	Table 4-3 incorrectly lists the number of detections for di-, nona-, and deca-chlorobiphenyls as "0". The correct values for these congeners (see data summary in Appendix A of the PRAM documentation) are: di-chlorobiphenyl - 3 detections; nona-chlorobiphenyl - 1 detection; and deca-chlorobiphenyl - 1 detection. Table 4-3 will be corrected in the revised HHRA.
6a	Section 4.2.1, pages 4-6 and 4-7: The pycnocline was fixed at 15 m based on diver experience. Pycnoclines are variable within seasons and could be located >15 m or <15 m. The author should discuss how seasonal variability in the pycnocline depth can impact the PRAM-predicted human health risks. Also discuss whether this variability can be considered a source of uncertainty in the time dynamic model (TDM).	Data obtained from http://www.nodc.noaa.gov/OC5/indprod.html show that the pycnocline is relatively non-existent during the winter due to storm mixing and insufficient sunlight to stabilize the water column. The pycnocline gradually establishes throughout the spring, strengthens and deepens, and reaches a maximum of approximately 15 meters in October, according to Rob Turpin of Escambia County. As the weather cools, mixing (and PCBs) likely will extend from the top to near the bottom. Qualitatively, PCBs originating from the ex-ORISKANY will have access to surface waters in the winter and spring, and gradually will be limited to and concentrated in near-bottom water in the summer and fall. A pycnocline has the mathematical effect of "concentrating" PCBs in the lower water column. Thus, eliminating the pycnocline, which is likely the case during winter, has the effect of diluting PCB concentrations. PRAM, as a steady-state model, uses the average pycnocline depth. The steady-state

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		structure of PRAM is designed to simulate the long term impacts of sinking a ship. The variability in the pycnocline, even if explicitly modeled, is expected to lead to similar average predicted concentrations. It is possible to model this explicitly in the TDM, but we do not anticipate appreciably different predicted concentrations, particularly when averaged for input into the PRAM. Also refer to the response to EPA Specific Comment 5 on the TDM report.
6b	Section 4.2.1, pages 4-6 and 4-7: Define (with citation) what source supported the assumption that PCBs are released within the ship volume at one minute intervals and mix instantaneously into the interior wall.	To our knowledge, there are no published scientific studies which conclude that PCBs would likely be released within the ship volume at 1-minute intervals or that the PCBs so released would mix instantaneously in the interior vessel's bulk water. The assumption of 1-minute release intervals and instantaneous mixing facilitate modeling. In this case, the one minute time step in the TDM model allows for 15-meter resolution in PCB concentration predictions. In reality, PCBs are likely being released continuously, albeit at very slow rates from the bulk materials inside the vessel, and are mixing non-instantaneously with the media compartments in the vessel's interior water. The choice of a time step depends on the degree of resolution needed to appropriately model the release of PCBs from the ship into the marine environment and the concentrations that result in the various abiotic and biotic media. The initial TDM program calculated concentrations in 1-second release intervals. This approach yielded a data file so large that it could only be transmitted to reviewers by copying it to a computer hard drive and mailing the hard drive to the reviewers. Navy scientists, Dr. Craig Barber of EPA, and others agreed that 1-minute intervals were more than adequate to determine PCB concentrations in abiotic media, given that these concentrations would be used to calculate uptake of PCBs in fish and other biota.
6c	Section 4.2.1, pages 4-6 and 4-7: Assumptions should be supported by references or explaining the logical thinking behind them. Discuss the effects of a hurricane passing through the ex-Oriskany reef site and whether the assumptions would still be valid.	Extensive data on hurricane paths over the last thirty years are available from NOAA at: http://www.nhc.noaa.gov/verification/verify7.shtml. The passage of a hurricane could potentially damage the reef and impact the underlying modeling assumptions in several ways, including short-term increase in PCB releases 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 discussion of possible impacts with appropriate citations will be included in the revised HHRA.
7	Section 4.2.2, page 4-11 states "It is assumed that the community structure and PCB release rates will have both reached a steady-state condition at Day 730 (i.e., at the two-year mark)." Provide the basis of	The revised HHRA will provide more detail concerning this assumption. Please refer to response to Specific Comment 1.

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	this assumption. Explain the basis of the assumption in view of the primary and supporting data.	
8	Section 4.3: As stated in the PRAM document, PRAM has not undergone extensive testing and validation. It was mentioned in the Appendix K ("Response to EPA comments") that "…PRAM version 1.3 predicted PCB concentrations in trophic level 3 and trophic level 4 (Vermilion Snapper and Black Sea Bass) that are similar in comparison to the empirical data from the ex-VERMILLION reef for the Vermillion Snapper and Black Sea Bass." In addition, it was indicated that "the recently revised version of PRAM (version 1.4c) also predicts PCB concentrations in this range. This indicates that PRAM can predict a reasonable range of PCB concentrations that could be found in fish tissue associated with the ex-VERMILLION." Details of this validation exercise should be included in the report, including a comparison between the PRAM-predicted PCB values and the ex-Vermillion empirical data. Explain why background PCB levels in fish were not included into the PRAM algorithm.	PRAM cannot be validated against the results of the ex-VERMILLION because the PCB sources on that ship are not sufficiently understood. The discussion regarding the use of PRAM to predict fish tissue concentrations at the ex-VERMILLION site relates back to previous EPA questions (TWG meetings in August/September 2004) about whether PRAM was capable of predicting fish tissue concentrations comparable to those seen at the ex-VERMILLION site. We performed a quick analysis to demonstrate that, if one were to make a number of assumptions regarding the amount and distribution of PCBs that could have been on the ex-VERMILLION at the time of sinking, then PRAM (1.3 version) could predict fish tissue concentrations comparable to the levels found in fish collected at the ex-VERMILLION reef. This exercise primarily demonstrated the need to have accurate information on the amount (mass) of PCBs remaining on a sunken vessel as well as the distribution of those PCBs because the release rates of PCBs from bulk materials vary significantly, dependent on the type of PCB-containing bulk material. In addition, it is not appropriate to compare PRAM-predicted PCB values with the ex-VERMILLION empirical data because PRAM predicts only the incremental risks associated with releases of residual PCBs on the ship, whereas the fish collected from the ex-VERMILLION reef would have potentially accumulated PCBs from sources other than the ex-VERMILLION. The current version of PRAM (version 1.4) is a fugacity model that predicts PCB concentrations in abiotic media and the food web. While it has not undergone validation, the fugacity modeling and, specifically, the bioenergetic elements of the food web in PRAM are constructed similarly to a number of EPA models that provide a theoretically sound basis for predicting PCB concentrations at the reef. Also, the PRAM food web model predicts bioaccumulation factors similar to those predicted by BASS/FGETS, which was developed by EPA (See EPA General Comment 3 on PRAM, version 1.4c documentation, May 2005). Background levels of PCBs in fish tissue were not considered because PRAM is designed to model the incremental risks associated with exposures to PCBs originating in shipboard materials. Thus, the model does not estimate risks

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		from other sources. The uncertainty section will acknowledge this distinction.
9	Section 4.3.1, page 4-13: The 0.01 fraction of the prevailing water current that was used in modeling the interior flow rate should be defined relative to similar literature assumptions.	The Navy did not find relevant literature on flow rates within sunken vessels. The water current in the interior of the ship depends on the exterior water current as well as the number of openings and connections. The proposed sinking plan of the ex-ORISKANY indicates a minimal amount of openings into the ship's interior. We acknowledge the comment as an area of uncertainty and will discuss the potential impacts of varying this assumption in the revised HHRA. Also refer to the response to EPA Specific Comment 4 on the TDM report.
10	Section 4.3.2, page 4-33: Considering the consistent yearly hurricane incidences experienced by Florida, the author should consider catastrophic weather activities (perhaps in the uncertainty section) in the analysis.	Please see response to Specific Comment 6 (c). This issue will be addressed in the revised HHRA.
11	Section 6.2, page 6-3: Divers can be exposed to PCBs in the water column via a limited dermal pathway. The site conceptual exposure model depicted in Figure 6-1 does not illustrate this pathway.	The depiction of this pathway in Figure 6-1 will be clarified to better illustrate that it is a complete pathway for the diver.
12	Section 6.2.3, page 6-5 states "Because of the very low concentrations of PCBs that are expected in the water column at the ex-ORISKANY reef site, exposure to PCBs via this route is expected to pose a minor route of exposure." Sentence should indicate that Section 9.5 contains the dermal risk assessment supporting this claim. In addition, the water ingestion pathway is not mentioned in this section and should be added because it is a possible route of exposure. This section should also mention why the ingestion pathway was not evaluated further.	Incidental ingestion of seawater is unlikely to be a significant exposure pathway given the diving requirements at this depth. The text will be expanded to include a discussion on the oral route of exposure. In addition, Section 6.2.3 will be revised to reference Section 9.5 as containing the appropriate discussion on the dermal route of exposure.
13a	Section 6.2.4, page 6-6: Provide reference that supports the assumption that "fish caught by trolling have shorter residence times at the reef".	The reference will be provided.
13b	Section 6.2.4, page 6-6: Include children as potential human receptor population. This appears in the summary section (6.2.6) but was not mentioned in Section 6.2.4.	The text in Section 6.2.6 will be revised.
14	Section 6.2.6, page 6-7: The exposure scenario considered adult recreational fisherman and children as potential populations exposed via fish ingestion. Pregnant women and the fetus could be potentially exposed to PCB-contaminated fish originated from the ex-Oriskany reef site. A number of studies have reported possible developmental and neurotoxic effects in children from pre-natal or post-natal exposures to PCBs. The authors should include a section discussing such findings	The revised HHRA will contain a qualitative discussion of prenatal exposures and will quantify exposures to nursing infants via breast milk ingestion (also please see the response to General Comment 3 above).

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	and explain why potential adverse health effects from pre-natal and post-natal exposures were not considered in this HHRA.	
15	Section 6.2.7, page 6-9: The document indicates the use of ZOIs of 2 and 5. Because the ZOI is likely the most subjective parameter input entered into the PRAM, the reasoning behind its selection should be thoroughly explained in this section.	A detailed discussion of the choice of ZOI values is provided in Appendix L of the HHRA. The specific values were chosen based on the biology (foraging and behavior and habitat preferences) of representative reef fish species. Additional discussion will be added to Section 6.2.7 summarizing the rationale for the choice of ZOI values used in the HHRA, and the reader will again be referred to Appendix L for the detailed discussion.
16a	Section 6.3.1, pages 6-10 and 6-11: 1st paragraph, 2nd sentence has a typo ("rats" should be "rates").	Comment acknowledged. The sentence will be corrected.
16b	Section 6.3.1, pages 6-10 and 6-11: Last paragraph states "The IR term for total fish is applied to the consumption of each species of fish and shellfish in this HHRA. In other words, species-specific ingestion rates are not assumed, and the total fish ingestion rate is not adjusted to account for the consumption of different species from the site." Is this approach taken because there are no data for shellfish and therefore the fish ingestion rate for finfish is used for every kind of fish? Clarify this approach and include the justification in this section.	The assumption is made that the ingestion rate applies to each species, as opposed to evaluating the mix of species that anglers might consume. The risks calculated using this integrated approach encompass all possible risks one would calculate assuming different mixtures of species in an angler's diet. Also, as the reviewer suggests, insufficient data are available to quantify the fraction each fish species contributes to the diet of anglers consuming fish from the future reef. Divers are not likely to collect much shellfish given their brief time at a reef that will be approximately 200 feet below the water surface. Therefore, use of the ingestion rate for finfish likely overestimates exposure to shellfish. The revised HHRA will provide this more complete discussion of the fish consumption rates used to quantify exposure to PCBs in finfish and shellfish.
17	Section 6.3.2.2, page 6-12: It is atypical that the RME estimate be lower that the CTE. Perhaps the values should have comparable sources.	The site-specific data used in the risk assessment show that less frequent anglers tend to return to the same location, while more avid anglers tend to fish from multiple locations. The FI terms are derived from the angler surveys conducted by representatives from Escambia County and the State of Florida. The results of the survey indicate that individuals who reported fishing the most frequently (RME populations) also fished in more areas and consumed fish caught in all of those areas, thus reducing the FI for any one fishing location. Additional supporting text will be included in the revised HHRA.
18	Section 6.3.3, page 6-13: The ingestion rates used are daily rates averaged over 365 days per year. Clarify whether this implies consumption of fish 365 days per year.	The ingestion rate does not imply consumption of fish 365 days per year. The ingestion rate is an annual average daily ingestion rate. It is calculated by dividing the total amount of fish consumed in one year by 365 days. US EPA guidance typically reports fish ingestion rates in this manner, and these rates do not mean that the consumer is eating fish every day. The revised HHRA will clarify this issue.
19	Section 6.3.4 states that "during the first 90 days after vessel sinking,	While there are uncertainties regarding the predicted PCB concentrations in

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	the primary human PCB exposure will be for recreational divers through direct skin contact with water while diving. Water PCB concentrations are at their maximum in the first few weeks after vessel sinking". Due to high concentrations of PCBs during the first days after sinking, divers should be protected and therefore access to the ex-Oriskany reef site should be restricted until such high concentrations decrease.	water during the first 90 days post-sinking, it does not appear necessary to restrict diving during this period because (1) the predicted water concentrations are very low (4E-9 mg/L in the lower water column, 3E-14 mg/l in the upper water column), and (2) the amount of time a diver could spend near the ship is likely to be very short because of the proposed sinking depth of the vessel. Our discussion in the HHRA concerning the diver scenario concludes that there is a low degree of exposure because of the limited duration of submergence for typical recreational dives at the proposed depth. Thus, it is unlikely that a diver would be exposed to unacceptably high concentrations of PCBs while diving.
20	Section 6.3.6, page 6-14: The exposure duration used for the adult population was 30 yrs (default value), which is based upon the time spent at a single residence. The "Revised Human Health Risk Assessment, Hudson River PCBs Reassessment RI/FS" (November 2000; page 103) has a statement referring to this exposure: "While Superfund risk assessments typically use the length of time that an individual remains in a single residence as an estimate for exposure duration, such an estimate is not likely to be a good predictor of angling duration, because an individual may move into a nearby residence and continue to fish in the same location, or an individual may choose to stop angling irrespective of the location of their home". Using US Census data, the Hudson River HHRA estimated the range of residence durations within 6 counties surrounding the Mid-Hudson River as the basis to determine the exposure duration. The Hudson River HHRA reported a reasonable maximum exposure (RME) of 40 years based on the approach explained above. Because the default value has its limitations, is it possible to calculate a data-driven exposure duration value using the approach discussed in the Hudson River HHRA? Human health risks could change if such calculation yields a value greater than 30 yrs.	It is possible to attempt such a calculation; however, the calculation will be subject to uncertainty. For example, we cannot separate data for marine anglers, particularly those likely to fish the proposed reef, from other members of the population. We searched data from the National Oceanic and Atmospheric Administration's Marine Recreational Fisheries Statistical Survey and found no relevant data for recreational anglers in this region. However, uncertainty regarding the exposure duration assumption was addressed explicitly in the HHRA in Section 9.3.5, where risk estimates are presented assuming an exposure duration of 45 years.
21	Section 6.3.8, page 6-15 should include a reference.	The reference, *Risk Assessment Guidance for Superfund* (USEPA 1989), will be cited in the revised HHRA.
22	No comment provided.	
23	Section 7.2.3.1, page 7-3 should indicate whether averaging the RfDs for Aroclor 1254 and Aroclor 1016 in the CTE scenario is standard. Provide references.	Although averaging the RfDs is not "standard", it was done in this case due to uncertainty concerning the mixture of PCBs expected to occur in fish in the vicinity of the ex-ORISKANY. However, predicted congener patterns in species consumed by people resemble Aroclor 1254 more than Aroclor 1016;

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		therefore, the revised HHRA will use the RfD for Aroclor 1254 for both the CTE and RME scenarios.
24	Section 7.4.3, page 7-7: The Hudson River HHRA used a CSF = 1.5E+05 $(mg/kg\text{-}d)^{-1}$ to calculate the cancer risks associated with dioxin-like PCBs. The author should document (and apply) that approach in this document. But even if the CFS is used, concentrations of dioxin-like PCBs in fish are unknown and therefore the cancer risk analysis cannot be done. This section should mention this information so it is clear that the analysis cannot be performed even though a preliminary CSF is available.	The approach for quantifying risk from dioxin-like PCBs is provided in the HHRA (See section 7.4.3). As noted in Section 9.4.3, and noted by the reviewer, PRAM was not parameterized to quantify fish tissue concentrations; therefore, human health risk for fish consumers from dioxin-like PCB congeners was not quantified. Specifically, the bulk material estimates conducted for the ex-ORISKANY did not include quantification of dioxin-like PCB congeners and, although, these congeners were quantified in the leachate of the leach study, leach rates were not calculated. The dioxin-like PCB congener believed to be the most potent carcinogen among all PCB congeners, PCB #126, was not detected in leachate; therefore, it is not possible to quantify a leach rate for this congener. The discussion in Section 7.4.3 will be expanded to note that, although a preliminary slope factor is available for 2,3,7,8-TCDD and this value can be used to evaluate the potential carcinogenicity of dioxin-like PCBs, the analyses are not available to predict the concentrations of dioxin-like PCBs in fish and no risk evaluation will be performed for this class of PCBs for the ex-ORISKANY.
25	Section 8.1 indicates that background concentrations at the reef site were not considered in the risk estimates. This introduces uncertainty in the PRAM-derived risk estimates which should be acknowledged in the uncertainty analysis of the HHRA.	The HHRA was performed using a predictive model, PRAM, which estimates incremental risks associated with residual PCBs on the ship. The model does not estimate risks from other sources. This uncertainty will be discussed in the revised HHRA, and the Navy will consider modifying PRAM to incorporate background concentration data where such data are available under future reefing scenarios.
26	Table 4-2: The table's footer should include a description of the "Jackknife" and "Bootstrap" means meanings and/or mathematical formulas.	"Jackknife" and "Bootstrap" methods are used to calculate exposure point concentrations for datasets that are not fit either a normal or lognormal distribution. A footnote will be included to provide a brief description of these methods and to direct readers to one or more of the following references: Davidson, A.C., and D.V. Hinkley. 1997. *Bootstrap Methods and their Application.* Cambridge Series in Statistical and Probabilistic Mathematics. Cambridge University Press, Cambridge, UK. Efron, B. and G. Gong. 1983. A leisurely look at the bootstrap, the jackknife, and cross-validation. Am. Statistician. 37:36-48. EPA, 1997. *The Lognormal Distribution in Environmental Applications*.

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	COMMENT	RESPONSE
		Publication EPA/600/R-97/006, December.
27	Table 4-3: The r2 values are very variable. The leaching studies reported several homolog series with r2 < 0.30. The document should define how this impacts the validity of the PRAM.	For those regressions with low R^2, or where there were few detections, the maximum value was used. This approach is more likely to overestimate PCB uptake by biota and subsequent risks to anglers. A description of this approach, and its potential impacts on risk estimates, will be included in the revised HHRA.
28	Table 4-5: The web link to access the Dictionary of American Naval Fighting Ships does not work.	We apologize for the typographical error in the HHRA. The correct link is: http://www.hazegray.org/danfs/carriers/cv34.htm

Response to Appendix A of SAB Comments on Ex-Oriskany Artificial Reef Project: Human Health Risk Assessment (HHRA). June 2005 (Draft Final).

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1	It would help to see one more paragraph in the executive summary that identifies the most important factors in the overall assessments (based on both sensitivity and uncertainty) and why the reader should believe that the values used for these factors in the model are correct (or conservative). This information is provided in some detail in the various documents and appendixes but as part of the Executive Summary the authors should bring these findings forward. For example, I (Randy) would like to know up front that the bulkhead insulation and/or cable are most important source(s) of PCB and the grouper contributes most to human exposure because it is assumed to be exposed to 20% vessel interior water.	The revised HHRA will summarize the results of a detailed sensitivity and uncertainty analysis on PRAM, part of a larger QA/QC program, that is currently ongoing. The overall plan consists of several steps: • Verifying PRAM equations, calculations, and units • Making corrections to PRAM • Developing a sensitivity analysis matrix across all input parameters • Constructing and evaluating "uncertainty" scenarios based on the results of the sensitivity analysis The output of the sensitivity analysis is a matrix that ranks model inputs relative to output expressed on a fish concentration basis for each guild (predicted risks are linear with respect to fish concentration). The matrix will reflect the elasticity of each input parameter, and is constructed by varying each input parameter by a fixed percentage, and then dividing the percent change in the output to the percent change in the input. The target output will be the top level predator fish in each community (e.g., TLIV pelagic, TLIV benthic and TLIV reef). This is done because we assume that individual parameters will likely have a differential impact on each fish community depending on the specific equations used to predict uptake. The result is a relative ranking of parameters in matrix form. Finally, a second, smaller matrix reflects the elasticity of the human exposure parameters to predicted fish concentration. Since the equations in that model are all linear, it is done at the end after we know what parameters contribute most to predicted fish concentrations. We will do this analysis for the abiotic and biotic compartments, and we will systematically address every single input for the sake of completeness. Some input parameters, for example, Log K_{ow}, are strongly correlated if not completely linked to other parameters. Therefore, it is not appropriate to simply vary Log K_{ow} by 10% without simultaneously changing K_{oc} (and K_{doc}) as well, since changing K_{ow} without changing K_{oc} might lead to different predicted fish concentrations than varying one or the other alone. We know the partitioning parameters are correlated. Another example is growth rate and respiration. There may be others and these will be identified prior to the

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		analysis. Following the sensitivity analysis, we will use the matrix to develop scenarios that include uncertainty bounds for parameters that show high elasticity (e.g., small changes in the input lead to large changes in the output). Determining appropriate uncertainty ranges for input parameters will require some literature searching as well as Team discussions, for example, in terms of the leach rate and source term (e.g., how much of each material remains on-board). Although the original analysis used the 95% UCL of the regression (or indeed the maximum) for the leach rate, both the EPA comments as well as the SAB identified uncertainties that may not be quantified from the data itself but for which there may be a reasonable approach incorporating first principles and evidence from the literature. We will work with other Team members as appropriate to determine reasonable uncertainty bounds. The results of these analyses will be summarized in the executive summary, likely in table form, along with discussion of the key factors that influence the cancer risks and non-cancer hazard indices. Such factors include which materials are likely to release the most PCBs and which exposure assumptions have the most influence on PCB uptake by biota.
2	Comment requires no response.	
3	Comment requires no response.	
4	Breast-fed infant exposure pathways should be undertaken in the risk assessments.	We will revise the HHRA to include this exposure pathway.
5a	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • Release estimates	The revised report for the Leachate Study will include a table listing sources of uncertainty in the experiment itself and in extrapolating experimental results to field conditions. This table will discuss the quantitative effect and/or bias introduced by each source of uncertainty. To help the reviewer better understand the degree of confidence in leach rate estimates, the revised HHRA will include a summary of this table and associated discussion.
5b	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • Particle settling	Particle settling is not considered a major source of PCB input to the sediment near the ship because the particles are very small detritus/dead plankton. Given the relatively small size, low expected settling velocity, and relatively strong current in the area, limited settling would be expected in the vicinity of the ship. In a flow current, particles would enter the reef system from upstream of the ship while downstream particles would tend to be re-suspended and deposit away from the ship. With any reasonable settling time, PCB-contaminated particles would tend to erode away from the site, while clean

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		particles from some distance upstream would tend to deposit at the site. We will revise the HHRA text to discuss this source of uncertainty and to include any relevant data and information from the scientific literature.
5c	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • The time the fish spend inside the vessel and the interior concentrations. This is a source of uncertainty.	We agree that the time fish spend inside the vessel is a source of uncertainty, and an important one given that fish exposures to interior vessel water strongly influences the fish tissue concentrations and, consequently, the risk estimates. The Navy has not identified any published marine/reef studies in which this parameter was measured. Therefore, the Navy relied on the following anecdotal sources of information: 1) the personal observations of Florida marine biologists who dive to the reefs in Escambia County and who report that there appears to be an inverse relationship between biota prevalence and interior darkness/distance from the outside hull or wall; and 2) videographic evidence that fish swim in and out of reefs that contain exterior walls or hulls. Because the amount of time fish spend inside a vessel can vary, the uncertainty analysis will be expanded to include a discussion of how modifying this assumption would affect the results of the HHRA.
5d	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • Exploration of other sites which compare the Total PCBs and the congener assessment. Address interior and exterior waters (sampling and methods are problematic), looking at patterns and the fish populations will be informative in framing the bounds needed to address the more toxic PCBs.	A discussion will be included in the HHRA text regarding the uncertainty associated with calculating risks from exposure to total PCBs vs. calculating risks from exposure to dioxin-like PCB congeners, referring to relevant scientific literature and risk assessments as appropriate. For example, we are aware of several environmental studies/risk assessments that have calculated risks from both total PCBs and dioxin-like PCB congeners measured in fish, and any such results that are relevant to the ex-ORISKANY will be discussed in the revised HHRA.
6	The ZOI dimensions seem reasonable, and a 2 to 5 multiplier (of the ex-Oriskany's volume) is adequate. Factors of 2-2.5 for near-field foragers and 4-5 for less reef-related fish are reasonable. However, it is possible that a "near-field forager" may reside primarily on the down-current side of the vessel essentially residing in the "plume" while the ZOI approach distributes the foraging distance around the vessel. The ZOI also distributes the plume into a volume encircling the vessel. It is unclear whether this distribution based on range is appropriate.	Appendix L in the HHRA and Appendix F in the June 2005 PRAM document provides a detailed assessment of the ZOI. The current structure of both PRAM and TDM are such that there is no "down-current" side of the vessel. The assumption is that the current moves the PCBs throughout the "boxes" or "ellipses" and that there is fairly instantaneous and complete mixing. Actual foraging locations of the near-field foragers is an uncertainty, which will be addressed in the HHRA.
7	Comment requires no response.	

References

Bohnsack, J.A., D.E. Harper, D.B. McClellan, and M. Hulsbeck. 1994. Effects of reef size on colonization and assemblage structure of fishes at artificial reefs off southeastern Florida, U.S.A. *Bull. Mar. Sci.* 55:796-823.

Clark, S. and A.J. Edwards. 1994. Use of artificial reef structures to rehabilitate reef flats degraded by coral mining in the Maldives. *Bull. Mar. Sci.* 55:724-744.

Coll, J., J. Moranta, O. Renones, A. Garcia-Rubies, and I. Moreno. 1998. Influence of substrate and deployment time on fish assemblages on an artificial reef at Formentera Island (Balearic Islands, western Mediterranean). *Hydrobiologia* 385:139-152.

Cummings, S.L. 1994. Colonization of a nearshore artificial reef at Boca Raton (Palm Beach County), Florida. *Bull. Mar. Sci.* 55:1193-1215.

Golani, D. and A. Diamant. 1999. Fish colonization of an artificial reef in the Gulf of Elat, northern Red Sea. *Environ. Biol. Fishes* 54:275-282.

Sherman, R.L., D.S. Gilliam, and R.E. Spieler. 1999. A preliminary examination of depth associated spatial variation in fish assemblages on small artificial reefs. *J. Appl. Ichthyol.* 15:116-121.

USEPA. 1989. *Risk Assessment Guidance for Superfund (RAGS). Volume I: Human Health Evaluation Manual (Part A) (Interim Final).* EPA/540/1-89002. US Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

USEPA. 2000. *Phase 2 Report, Revised Human Health Risk Assessment, Hudson River PCBs Reassessment RI/FS.* U.S. Environmental Protection Agency, http://www.epa.gov/hudson/revisedhhra-text.pdf.

USEPA. 2005. Integrated Risk Information System Database. U.S. Environmental Protection Agency, http://www.epa.gov/iris.

Walker, B.K., B. Henderson, and R.E. Spieler. 2002. Fish assemblages associated with artificial reefs of concrete aggregates or quarry stone offshore Miami Beach, Florida, USA. *Aquat. Living Resour.* 15:95-105.

Document 3 - Response to EPA's December 2, 2005 Second Round of Comments on Ex-ORISKANY Artificial Reef Project: Human Health Risk Assessment (HHRA). June 2005 (Draft Final).

Comment	COMMENT	RESPONSE
1	Each artificial reef has its own characteristics and may undergo different development processes. Provide information such as reef size, reef depth, reef communities, and type of artificial reef, as part of the discussion of the scientific literature supporting the two-year maturity assumption. Make the case to answer how these studies are relevant to making inferences about the ex-ORISKANY reef site.	The discussion of the reef development to be expanded to include specific information from studies of artificial reefs on reef characteristics and the time of development of the biological components of the reef likely cannot be completed prior to issuance of final documents for the ex-ORISKANY. The Navy believes the best course of action is to defer this for inclusion within the National Permit Workgroup unless stated otherwise. The purpose of the expanded text would be to document the expected reef progression over the initial two-year period after vessel sinking. Although most of the published literature that describes reef development concerns small and very shallow near-shore reefs, the revised discussion would focus on reports or personal communications that describe larger and deeper artificial reefs that are located off the coast of southwest Florida, in Gulf waters, or in South Atlantic waters because these reefs more closely approximate conditions expected at the ex-ORISKANY reef. Some of the new information that may be added to the report will come from the following references that were mentioned in the initial response to comments from EPA on the Draft Final HHRA: Bohnsack, J.A., D.E. Harper, D.B. McClellan, and M. Hulsbeck. 1994. Effects of reef size on colonization and assemblage structure of fishes at artificial reefs off southeastern Florida, U.S.A. *Bull. Mar. Sci.* 55:796-823. Clark, S. and A.J. Edwards. 1994. Use of artificial reef structures to rehabilitate reef flats degraded by coral mining in the Maldives. *Bull. Mar. Sci.* 55:724-744. Coll, J., J. Moranta, O. Renones, A. Garcia-Rubies, and I. Moreno. 1998. Influence of substrate and deployment time on fish assemblages on an artificial reef at Formentera Island (Balearic Islands, western Mediterranean). *Hydrobiologia* 385:139-152. Cummings, S.L. 1994. Colonization of a nearshore artificial reef at Boca Raton (Palm Beach County), Florida. *Bull. Mar. Sci.* 55:1193-1215. Golani, D. and A. Diamant. 1999. Fish colonization of an artificial reef in the Gulf of Elat, northern Red Sea. *Environ. Biol. Fishes* 54:275-282. Sherman, R.L., D.S. Gilliam, and R.E. Spieler. 1999. A preliminary examination of depth associated spatial variation in fish assemblages on small artificial reefs. *J. Appl. Ichthyol.* 15:116-121.

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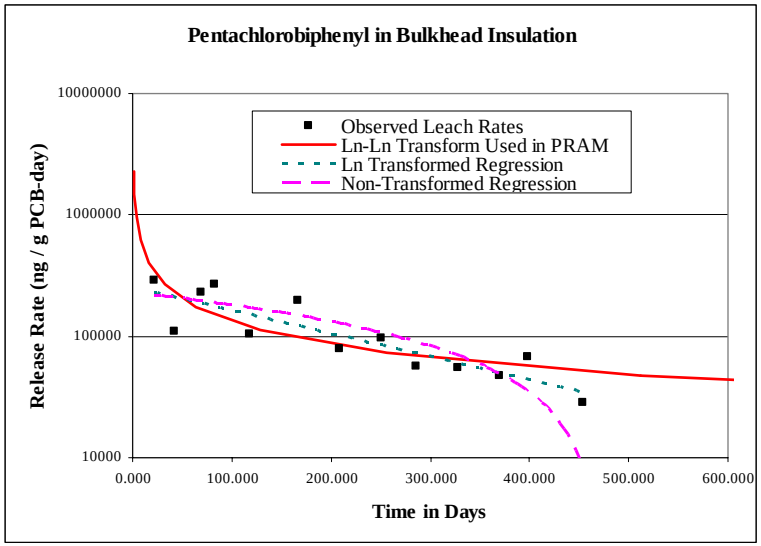
		Walker, B.K., B. Henderson, and R.E. Spieler. 2002. Fish assemblages associated with artificial reefs of concrete aggregates or quarry stone offshore Miami Beach, Florida, USA. *Aquat. Living Resour.* 15:95-105. The publications by Bohnsack et al. (1994) and Walker et al. (2002) describe the colonization and development of small structured reefs in shallow nearshore waters off the southeast coast of Florida. Although the sizes and depths of those reefs are not at the same scale as the planned ex-ORISKANY reef, the publications are the most applicable peer reviewed articles on artificial reefs in waters of the southeastern US. A preliminary summary of results and observations from the above cited reports was presented in our initial response to comments from EPA on the Draft Final HHRA. That summary pointed out that observations of artificial reefs constructed from a variety of materials have indicated rapid colonization by organisms such as algae, barnacles, and fish within a few weeks of immersion. For fish assemblages in particular, the review by Bohnsack *et al.* (1994) noted that fish colonization of artificial reefs off southeastern Florida was very rapid, and within two years post-deployment, fish assemblages were abundant and diverse. A very recent technical report, released from the University of West Florida within the past six weeks, (*Patterson, W.F. and M.A. Dance. 2005. The Refuge Effect of Unpublished Artificial Reefs Deployed on the Northwest Florida Shelf: Year 1 Final Report. Department of Biology, University of West Florida, Pensacola, Florida. October 31*) describes an ongoing study that focuses on artificial reefs in the East Escambia Large Area Artificial Reef Sites (LAARS), which is the location of the planned ex-ORISKANY artificial reef. Assembling information from these sources to demonstrate that the ex-ORISKANY reef will be sufficiently developed at two years such that the biological assemblage model, particularly for fishes, would be reasonable for use with steady-state modeling of PCB transfer through the food web, likely cannot be completed prior to issuance of final documents for the ex-ORISKANY. The Navy believes the best course of action is to defer this for inclusion within the National Permit Workgroup unless stated otherwise.
3	In addition to including a brief description of the sampling protocol, the document should also contain text language explaining how the protocol is designed to collect representative samples from PCB-containing materials aboard the ex-ORISKANY. Details of the sampling protocol should be in the PCB Source Term Estimates Document (Appendix D, HHRA document).	The PCB sampling performed on the ex-ORISKANY was done in accordance with the NAVSEA PCB ADVISORY 95-1 (Protocol) dated 21 September 1995. The Navy has provided the Protocol to EPA Region 4, and will include it as part of the Source Term Estimates document. Also see our response to General Comment 2 of the Source Term Estimates report.
5b	The Navy's response does not address the question. Although the response reveals how the calculation was performed, it does not reveal exactly <u>why</u> a natural log transformation approach was selected	A natural log (ln) transformation of the leach rate data was selected because it produced the best curve fit of the observed data and yielded the highest leach rate estimates among the regression models that we tested. The Navy will add this text to the HHRA narrative.

Comment	COMMENT	RESPONSE
	for the leach rate data. It would be prudent for the Navy to add further language to the HHRA document to inform readers of the rationale.	The leach rate study reported a time series of homolog release rates for each material tested. Regression analyses were then applied to release rate data of each PCB-containing material in order to derive a release rate during the steady-state period modeled by PRAM. The regression analyses used in PRAM were based on ln-ln transformed data sets of release rates. The data sets, regression analyses, and predicted steady-state release rates used in the PRAM are presented in Appendix A of the PRAM document. As an example of the regression analyses, the regressed leach data for pentachlorobiphenyl in bulkhead insulation are presented below:  In the above graph, the observed leach rates from the leach rate study are plotted as the black squares. Also presented are three regression analyses performed on the leach rate data: linear (non-transformed), semilog (ln transformed), and ln (ln-ln transformed). The non-transformed linear regression analysis predicts a release rate of zero by day 469 after sinking. The semilog (ln transformed) regression predicts a slower decline in release rate compared to the linear regression. The ln-ln transformed regression results in a higher release rate at day 365 than does the semilog (ln transformed) regression. Thus, the ln-ln transformed regression generally predicts a higher leach rate throughout the period modeled by PRAM (greater than 730 days after sinking) than the other regressions. Subsequently, the ln-ln transformed regression leach rate predicted at 730 days was used in the PRAM steady-state model. Further discussion of the application of the regression analysis release rates is presented in the PRAM document.
6a	Although the Navy included a good explanation about seasonal variability in the pycnocline depth and justified the selection of a pycnocline depth at	EPA's comment indicates that our explanation (provided in our response to EPA's November 2005 comments) regarding seasonal variability and its affect on the depth of the pycnocline is acceptable. We will include this discussion as part of the uncertainty assessment in the revised HHRA.

Comment	COMMENT	RESPONSE
	15 meters, it is unclear if this information will be incorporated in the HHRA document. This reviewer recommends adding the supporting information to the HHRA document.	
6b	This comment asked about information supporting the assumption that PCBs are released within the ship volume at one minute intervals and mix instantaneously into the interior wall. Although there are no publications supporting this assumption, the Navy's response to this question provided the reasoning behind why modelers chose to work with 1-min intervals over other options (e.g. 1-sec intervals). This reviewer recommends adding text to the TDM document to explain why modelers selected 1-min intervals for the TDM program.	We agree with EPA's comment and will add the rationale for the selection of 1-min intervals to the TDM report.
20	Navy's response is acknowledged and there is no need to calculate a data-driven exposure duration value.	Based on EPA's comment, the Navy will not conduct any calculations using other exposure durations. However, Section 9.3.5 of the June 2005 HHRA does address this issue as part of the uncertainty assessment where risk estimates are presented assuming an exposure duration of 45 years. This analysis will remain in the revised HHRA.
23	Make sure that the revised HHRA includes the justification for using Aroclor 1254's RfD instead of the average for both the CTE and RME scenarios.	We originally averaged the RfDs for Aroclor 1254 and Aroclor 1016 because of the uncertainty concerning the mixture of PCBs expected to occur in fish in the vicinity of the ex-ORISKANY. However, the predicted homolog patterns in species consumed by people more closely resemble Aroclor 1254 than Aroclor 1016 (See Figure 7-1 in the June 2005 Draft HHRA). Risks will not be recalculated using the RfD for Aroclor 1254 Comment will be deferred for inclusion within the National Permit Workgroup unless stated otherwise.
24 and SAB 5d	These comments reflect concerns regarding the need for a quantitative dioxin-like PCB assessment to be included in the HHRA. Overall, this PRAM-based Artificial Reefing approach should be thorough and include a dioxin-like PCB approach. Such would increase confidence in the protectiveness of final reefing decisions. The typical dual approach is suggested and is generally defined in the "Guidance for Assessing Human Health Risks from PCBs at Waste Sites" (63 FR 35383; June 29, 1998 Final Rule; 64 FR 69358 [June 24, 1999]). This added precaution is	The Navy did not quantify human health risk from dioxin-like PCB congeners because (1) the bulk material estimates conducted for the ex-ORISKANY did not include quantification of dioxin-like PCB congeners and therefore (2) PRAM was not parameterized to quantify fish tissue concentrations of the congeners. Congeners (with the exception of PCB-81) were quantified in the leachate of the leach study; however, as shown in the following table, two of the three dioxin-like PCB congeners that EPA refers to as being of primary interest (i.e. PCB-126 and PCB-169) were not detected in leachate from any of the PCB-containing materials. Therefore, no leach rates can be calculated for these congeners, which have the highest toxic equivalency factors.

<table>
<tr><th>Comment</th><th>COMMENT</th><th>RESPONSE</th></tr>
<tr><td></td><td>recommended because dioxin-like PCBs may be present and vary in concentration in materials from ship to ship. Dioxin-like PCBs may also result from weathering, degradation, transformation, and/or enhancement processes. Even if PCB concentrations are below a specified action level, dioxin-like congeners may still pose a risk. The primary PCB congeners of interest are PCB #'s 77, 126, and 169.</td><td>
<table>
<tr><th>Dioxin-like PCBs</th><th>TEF</th><th>Detected in Leach Rate Study?</th></tr>
<tr><td>PCB-77: 3,4,3’,4’-TeCB</td><td>0.0001</td><td>Yes</td></tr>
<tr><td>PCB-81: 3,4,4’5-TeCB</td><td>0.0001</td><td>Not included in LR study</td></tr>
<tr><td>PCB-126: 3,4,5,3’,4’-PeCB</td><td>0.1</td><td>No</td></tr>
<tr><td>PCB-169: 3,4,5,3’,4’,5’-HxCB</td><td>0.01</td><td>No</td></tr>
<tr><td>PCB-105: 2,3,4,3’,4’-PeCB</td><td>0.0001</td><td>Yes</td></tr>
<tr><td>PCB-114: 2,3,4,5,4’-PeCB</td><td>0.0005</td><td>Yes</td></tr>
<tr><td>PCB-118: 2,4,5,3’,4’-PeCB</td><td>0.0001</td><td>Yes</td></tr>
<tr><td>PCB-123: 3,4,5,2’,4’-PeCB</td><td>0.0001</td><td>Yes</td></tr>
<tr><td>PCB-156: 2,3,4,5,3’,4’-HxCB</td><td>0.0005</td><td>Yes</td></tr>
<tr><td>PCB-157: 2,3,4,3’,4’,5’-HxCB</td><td>0.0005</td><td>Yes</td></tr>
<tr><td>PCB-167: 2,4,5,3’,4’,5’-HxCB</td><td>0.00001</td><td>Yes</td></tr>
<tr><td>PCB-189: 2,3,4,5,3’,4’,5’-HpCB</td><td>0.0001</td><td>Yes</td></tr>
<tr><td colspan="3">Van den Berg et al. 1998. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs, for humans and wildlife. Environmental Health Perspectives 106(12):775-792.</td></tr>
</table>

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5c	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • The time the fish spend inside the vessel and the interior concentrations. This is a source of uncertainty.	We agree that the time fish spend inside the vessel is a source of uncertainty, and an important one given that fish exposures to interior vessel water strongly influences the fish tissue concentrations and, consequently, the risk estimates. The Navy has not identified any published marine/reef studies in which this parameter was measured. Therefore, the Navy relied on the following anecdotal sources of information: 1) the personal observations of Florida marine biologists who dive to the reefs in Escambia County and who report that there appears to be an inverse relationship between biota prevalence and interior darkness/distance from the outside hull or wall; and 2) videographic evidence that fish swim in and out of reefs that contain exterior walls or hulls. Because the amount of time fish spend inside a vessel can vary, the uncertainty analysis will be expanded to include a discussion of how modifying this assumption would affect the results of the HHRA.
5d	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • Exploration of other sites which compare the Total PCBs and the congener assessment. Address interior and exterior waters (sampling and methods are problematic), looking at patterns and the fish populations will be informative in framing the bounds needed to address the more toxic PCBs.	A discussion will be included in the HHRA text regarding the uncertainty associated with calculating risks from exposure to total PCBs vs. calculating risks from exposure to dioxin-like PCB congeners, referring to relevant scientific literature and risk assessments as appropriate. For example, we are aware of several environmental studies/risk assessments that have calculated risks from both total PCBs and dioxin-like PCB congeners measured in fish, and any such results that are relevant to the ex-ORISKANY will be discussed in the revised HHRA.
6	The ZOI dimensions seem reasonable, and a 2 to 5 multiplier (of the ex-Oriskany's volume) is adequate. Factors of 2-2.5 for near-field foragers and 4-5 for less reef-related fish are reasonable. However, it is possible that a "near-field forager" may reside primarily on the down-current side of the vessel essentially residing in the "plume" while the ZOI approach distributes the foraging distance around the vessel. The ZOI also distributes the plume into a volume encircling the vessel. It is unclear whether this distribution based on range is appropriate.	Appendix L in the HHRA and Appendix F in the June 2005 PRAM document provides a detailed assessment of the ZOI. The current structure of both PRAM and TDM are such that there is no "down-current" side of the vessel. The assumption is that the current moves the PCBs throughout the "boxes" or "ellipses" and that there is fairly instantaneous and complete mixing. Actual foraging locations of the near-field foragers is an uncertainty, which will be addressed in the HHRA.
7	Comment requires no response.	

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Response to USEPA Comments on:
"Oriskany – Key Outstanding Risk Assessment Issues"
From Ms. Beverly Banister, USEPA (6 August 2004)

	COMMENT	RESPONSE
	General Comments (Paraphrased) Included in Cover Letter to CAPT JM Jones	
1	USEPA requests copies of PRAM software and documentation.	Copies of the PRAM (Version 1.3) software were provided to EPA and the State of Florida, prior to the 12 August 2004 meeting in Atlanta. PRAM incorporates a number of equations, physical constants, and biological parameters, in order to model dispersion of PCBs into the environment, uptake and bioaccumulation by biota, and risk to human health from the ingestion of fish. The description of PRAM equations, input parameters, scientific literature sources for each of the specific equations, constants, and input parameters used were provided in Chapter 5 of the SHHRA. In addition, source documents cited in the PRAM write-up and relevant sections of texts were converted into electronic files (PDF files) and posted on the URS FTP website on 20 August 2004. Additional changes to the PRAM documentation were incorporated, as documented in our responses to the comments titled "Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels" (C. Barber, 15 September 2004) (Provided Separately). PRAM has recently been updated to version 1.4c to incorporate EPA comments, and has been fully documented in a separate document " Prospective Risk Assessment Model (PRAM) Version 1.4c Documentation" (NEHC/SSC-SD 2005). The software has been submitted to the agencies along with this documentation.
2	USEPA requests a copy of Resolve/ ESCO technical plan of 4 Nov 04 in order to evaluate the contractor's adherence to the BMP.	It should be noted that the technical plan is a process document, rather than a quantitative inventory of materials to be removed. As such, the Resolve/ESCO technical plan may not be very useful if the EPA's intent is to QA the BMP with respect to liquid and solid PCB-containing materials. Regarding potentially liquid PCB containing materials, removals were Quality Assured by NAVSEA contractor Tom Pape (CACI, Inc.) on 25-30 July 2004 while the ship was being prepared in Corpus Christi, TX. Craig Brown (EPA Region 4) also intends to shipcheck the ex-ORISKANY in the near future. The scope of Tom Pape's previous shipcheck as tasked by PMS 333 was:

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		1. Conduct a walkthrough of the vessel to ensure all probable liquid filled PCB items have been removed. 2. Review contractor's (Resolve Marine Group/ESCO Marine) waste manifests for disposal of PCB Bulk Product Waste and review categories of materials disposed of as PCB Bulk Product Waste. Verify quantities noted in progress reports. 3. Document the process contractor uses to identify and dispose of probable liquid-filled PCB Items. Document the quantity of material disposed of as liquid-filled PCB items and where they were disposed. 4. Investigate the "caulking" material found on the Flight Deck, estimate the quantity and physical characteristics of the material, and identify sample locations for a representative sampling of the material to determine if the material contains PCB's at regulated concentrations and if wooden deck components have been contaminated by contact with these materials. 5. Note the presence of cellulose/asbestos material in machinery spaces while conducting the PCB inspection of the vessel. Tom Pape's findings regarding liquid PCB materials were: The inspection revealed that all items identified in the NISMO Bremerton Inventory and labeled as PCB Items had been removed. However, a few additional items were not included in the inventory nor labeled by NISMO personnel; these items were located in the radar and communications equipment in the "island" of the vessel, in the CIC, and in the Radar Equipment Room (B-312-C). These items where physically marked with blue spray paint for easy identification and their location communicated to the contractor for removal and disposal. Regarding solid PCB-containing materials, this included removal of accessible fiberglass bulkhead insulation and electrical cabling from the interior of the island, removal of electrical cabling from the exterior of the island, and removal of exfoliating paint from throughout the ship. SUPSHIP was asked to provide photos of the completion of the Florida diver safety work, but they have not yet been provided. Craig Brown has indicated to the Navy that mitigation of the ex-ORISKANY is not an issue related to the SHHRA/risk-based disposal approval process. In 2004, based on findings of the leach rate study (SSC-SD, 2004) and PRAM 1.3 findings that the PCBs in bulkhead insulation (BHI) presents the greatest potential for environment release/ transport, and human health risks among all PCB-containing materials onboard of the ex-ORISKANY, the Navy conducted the removal of approximately 72.6% of the mass of BHI was removed (Pape, 2004) (CACI report).

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3	USEPA requests the results of the PCB sampling of the flight deck materials. EPA Region 4 expressed concerns that contamination may have resulted from PCB hydraulic fluids in the hydraulic catapults.	Copies of the sample results have been provided to EPA Region 4 and EPA OPPT. EPA has been advised that Navy is proceeding with the removal and disposal of this material IAW PCB Disposal Regulations. EPA has been advised that the axial flight deck was replaced with an angular flight deck in 1958, concurrently with the replacement of the hydraulic catapults with steam driven catapults, and also that the catapults are only located in the forward end of the flight deck.
Specific Comments		
1	**Model Uncertainties** - There are significant uncertainties associated with use of the Prospective Risk Assessment Model (PRAM) for making risk judgments about the ex-Oriskany. These uncertainties are evident because empirical data for the ex-Vermillion (which was estimated to have about one-third of the amount of PCBs on it than the ex-Oriskany) show that fish tissue concentrations for the White Grunt are higher than those estimated by the model. This discrepancy needs to be explained and accounted for to ensure that there is no unreasonable risk associated with the PCBs to be left on the ex-Oriskany. The model must be sufficiently conservative to ensure that risk management decisions are protective of populations ingesting Gulf of Mexico reef fish species representative of the White Grunt. (Note that EPA has requested copies of the PRAM along with its documentation/user manual.) In the absence of data that can be used to gain a better understanding of the uncertainties leading to the differences between model predictions and empirical data from the ex-Vermillion, it may be necessary to incorporate an uncertainty factor into the model that may be used to provide some assurance of its conservativeness.	It is noted that in the SHHRA for the ex-ORISKANY site, PRAM version 1.3 predicted PCB concentrations in trophic level 3 and trophic level 4 (Vermilion Snapper and Black Sea Bass) that are similar in comparison to the empirical data from the ex-VERMILLION reef for the Vermillion Snapper and Black Sea Bass. The recently revised version of PRAM (version 1.4c) also predicts PCB concentrations in this range. This indicates that PRAM can predict a reasonable range of PCB concentrations that could be found in fish tissue associated with the ex-VERMILLION. Observational studies conducted by Robert Turpin, Escambia County Marine Resources Division (ECMRD), have shown that White Grunt is not a likely catch at the ex-ORISKANY, although other species which are likely to be found at the ex-ORISKANY site, such as the Grey Triggerfish, could occupy a similar niche at the reef and exhibit similar feeding habits and trophic level. The Grey Triggerfish is a predominant species for the “White-Grunt like” trophic level in the North Gulf of Mexico and is also a targeted species of recreational fisherman. Detailed follow-up comments on the PRAM were received from USEPA (“Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels” (C. Barber, 15 September 2004)) that address in greater detail the uncertainties associated with the model. These issues were further discussed in the Technical Working Group (TWG) meeting that was held in Atlanta on 23-24 September 2004. Detailed responses to these concerns, including relevant information discussed at the TWG meeting, are presented in our responses to the comments titled “Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels” (C. Barber, 15 September 2004) (Provided Separately).
1a	Some of the potential sources of uncertainty in the PRAM include the following:	We acknowledge that there were statistical differences for fish tissue concentrations of PCBs between the target reef and the reference reef.

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	Background Sources - Based on the Navy's data, it does not appear that background PCBs account for the difference between fish concentrations predicted by the PRAM and those observed in White Grunt from the ex-Vermillion, as suggested by the Navy. The source of these differences needs further investigation.	Assuming that the White Grunt at the ex-VERMILLION site were subject to the same background exposure, as compared to the reference site, there may be other unknown source terms, fate and transport pathway(s), or exposure pathway(s) at the ex-VERMILLION specifically applicable to the White Grunt but not Black Sea Bass and the Vermilion Snapper. EPA has put a number of suggestions forward with regard to possible ways that the White Grunt tissue concentration issue can be investigated, especially as compared with the PRAM model results. For example, at the 12 August 2004 meeting, we discussed the possibility that the trophic level assigned to the White Grunt (in the PRAM model) may not be correct, and that it should be reviewed in the context of scrutinizing its food web. Another suggestion was that a monitoring program could be conducted, to determine Grey Triggerfish tissue concentrations over time. These issues were discussed in greater detail in the 23-24 September 2004 TWG meeting. The primary purpose of these suggestions is to find a way to corroborate the empirical White Grunt data from the ex-VERMILLION with PRAM predictions. As stated in the response to comment 1 above, PRAM version 1.4c predicts concentrations in trophic level III and IV reef fishes, including the Grey Trigger fish and grouper, respectively. Therefore, we believe that the White Grunt question can be explained based on the fate/transport and water-diet exposure pathways, although one would never be certain of the major contributing factors for the PCB levels in the White Grunt. For the ex-ORISKANY, we will continue to work with the EPA on addressing this very intriguing question.
1b	Some of the potential sources of uncertainty in the PRAM include the following: **Zone of Influence (ZOI)** - The PRAM was run utilizing ZOI values of 3, 5 and 10. The SHHRA indicated that the ZOI value is the most sensitive parameter in the PRAM. In order to adequately evaluate the uncertainty associated with the model, a wider range of ZOIs should be used (i.e., also running PRAM at ZOIs of 1 and 2). At what ZOI value does the model predict fish tissue concentrations that are consistent with the White Grunt data for the ex-Vermillion?	A number of issues related to ZOI were raised in USEPA's 15 September 2004 comment set on PRAM, and discussed in detail in the September 23-24, 2004 TWG meeting. Please see our responses to the comments titled "Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels" (C. Barber, 15 September 2004) (Provided Separately) for our responses to comments 2.1, 2.2, and 2.3 of the 15 September 2004 comments. Based on recommendations of the TWG, a review of the scientific literature was performed to identify ZOI ranges that could reasonably be expected to be representative of typical "reef fish" behavior. The recommendation, based on this review, was made to evaluate fish for ZOIs of 2 and 5, and accepted by the members of the TWG. The detailed review article has been included as Appendix F of the "Prospective Risk Assessment Model (PRAM) Version 1.4c Documentation

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		(NEHC/SSC-SD, 2005).
1c	Some of the potential sources of uncertainty in the PRAM include the following: **Biodegradation of PCB-containing Materials** - If the leach rates used in the PRAM are based on leaching studies using an abiotic system (i.e., accounting for factors such as temperature and pressure, but not factors that could enhance leaching such as biodegradation of the PCB-containing materials), it may be possible that leaching is underestimated in the model. Is it also possible that the food web of the White Grunt includes species involved in the biodegradation process, accounting for the higher PCB levels observed in the White Grunt?	This is an issue that has been discussed in a previous REEFEX TWG meeting. The decision was made at that time to limit the study to the more controllable abiotic leaching conditions (what we termed "baseline" leaching, or leaching based only on chemical properties of the system). In the leach rate study's initial experimental design phase that incorporated EPA-OPPTS input (Dr. John Smith), the possible biological impacts were considered. These impacts included both a possible increase in leach rate due to biodegradation of shipboard solid materials and a possible decrease in leach rates due to biological growth. Both of these processes would take a longer period of time to potentially impact leach rates and, as a result, the leach rate study did not incorporate either of these competing processes into the experimental approach (a short-term process). There is no empirical evidence available that the rate of PCB release will increase if shipboard solid materials biodegrade in the marine environment, nor is there any empirical evidence available that indicates leach rates are suppressed by biological fouling in marine environments. We can only hypothesize that both can occur and that the relative magnitudes of these competing effects likely cancel each other out. The leach rates used for PRAM very conservatively assume that leaching occurs at a constant rate over the long term, rather than at a decreasing rate dictated by the empirical data. It is plausible that the use of leach rates in such a conservative way will offset possible leach rate increases/decreases associated with biological activity. In order to release PCBs at a higher rate, it would require a catastrophic event to occur on a timescale shorter than the experimental timescale of the leach rate studies. Because biodegradation is not a catastrophic or fast event, requiring much longer timescales than can be tested in the laboratory, the magnitude of potential leach rate increases is expected to be very much below the leach rate values used in PRAM and is more likely to be decreased even further if leach rate suppression due to biological fouling is considered. This issue was discussed at the 23-24 September 2004 TWG meeting, as well as related issues, such as direct diffusion of PCBs into encrusting organisms. We believe that it is unnecessary to incorporate biodegradation of the source material into the already established leach rates for use in the PRAM model for the ex-ORISKANY SHHRA at this time. If the effects of biodegradation on leach rate need to be defined and incorporated into PRAM, the competing effects of biological fouling should also be defined and incorporated. The

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		magnitude of the leach rate enhancement due to biodegradation is very likely minimal compared to leach rate suppression due to bio-fouling and will not explain the White Grunt results. Even if some physico-chemical parameter such as leach rate or source loading term can be manipulated to account for much higher bioaccumulation (the White Grunt data), bioaccumulation in other species (the Vermilion Snapper and Black Sea Bass) would be over-predicted. Finally, this concern is somewhat addressed by these considerations:, (1) any such release will be quickly advected away from the exposure boundary, and (2) PRAM assumes steady-state and infinite source of PCBs, i.e., continuing release of PCBs, which is highly conservative. This issue is now recognized and discussed as an uncertainty factor in the PRAM documentation.
1d	Some of the potential sources of uncertainty in the PRAM include the following: **Reservoir PCBs** - Does PRAM account for cumulative exposure over time that results from not only the continuous leaching of PCBs from materials on the ship, but also the "buildup" of PCBs in sediments as the mass of PCBs is released over time? That is, since PCBs degrade so slowly, do reservoir sources develop in the sediment that increase exposure among certain fish species? Is it possible that higher concentrations in the White Grunt may be the result of a higher level of exposure to recycled PCBs (i.e., reservoir sources from earlier releases, possibly in the sediments; exposure to White Grunt may be higher because of their position in the food web) than other fish species, thus accounting for their higher fish tissue concentrations.	The issue of a possible significant impact from a detritus food web, which is currently not included in the PRAM food chain or the site conceptual model, was discussed at the 12 August 2004 TWG meeting. The Navy noted that a significant impact was not likely, for a variety of reasons. We noted that recycling of PCBs from dead animals to sediment is not likely to be a major PCB transport pathway. Carcasses are typically subject to scavenging and the bioaccumulation effect on the scavengers or detritivores feeding on this material. Living animals feeding on living or dead organisms are most likely the true reservoir for PCBs. Also, the PRAM does include a Total Organic Content (TOC) input parameter as part of the abiotic environment characterization. The TOC value is important to the dispersion model, because the TOC content of sediment determines the degree to which PCBs adsorb to the sediment. In sandy ocean bottoms, the TOC is low. The default TOC value used in PRAM is higher than would be expected in a sand-only bottom (thus we believe a conservative estimate of TOC content was used for the ex-ORISKANY). If it is hypothesized that a significant amount of detritus could accumulate around a sunken ship, then it must be recognized that there would be a concomitant increase in the TOC in the sediments around the ship. Sediment sampling at the ex-VERMILLION was not conducted; however, the SCDNR evaluation of the area surrounding the ex-VERMILLION reef indicated that the bottom was sandy, probably with low TOC content. As discussed at the 23-24 September 2004 TWG meeting, a future improvement of PRAM may include the addition of a detrital/scavenger component to the food web evaluation in PRAM to simulate high organic carbon/PCB rich pools (sediment and biota), if it is determined to be necessary. In the interim, we would conduct additional evaluation of this potential effect (sediment build-up

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		and eventual uptake by biota via the food web) by the current PRAM model by running the model with increasing concentrations of PCBs in the sediment (increasing TOC values) and present the findings in the uncertainty section of the revised SHHRA (now titled the ex-ORISKANY HHRA). In addition, prior to the 23-24 September 2004 meeting, we conducted an emission rate study that indicated that if various PCB material loadings on the ex-VERMILLLION were assumed, then PRAM predicts fish tissue concentrations equivalent to the White Grunt levels seen at the ex-VERMILLION.
1e	Some of the potential sources of uncertainty in the PRAM include the following: **Bioaccumulation** - The PRAM may not adequately account for bioaccumulation for the various types (e.g., trophic levels) of reef fish. A determination needs to be made as to whether it is the factors that affect bioaccumulation or the leach rates that account for the differences in fish tissue concentrations from the ex-Vermillion and those estimated by PRAM. In addition, the PRAM appears to estimate a single fish tissue concentration for "reef fish" that does not account for variability among species.	A number of issues related to bioaccumulation were raised in USEPA's 15 September 2004 comment set on PRAM, and discussed in detail in the 23-24 September 2004 TWG meeting. Please see our responses to the comments titled "Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels" (C. Barber, 15 September 2004) (Provided Separately) for our responses to comments 1.1 through 1.4 of the 15 September 2004 comments.
1f	Some of the potential sources of uncertainty in the PRAM include the following: **Model Validation** - PRAM should be tested with the range of mass loading estimates provided for the ex-Vermillion. Such an effort would be helpful in assessing uncertainty. Once sinking of the ex-Oriskany occurs and enough data are collected for the ex-Oriskany, PRAM should be further validated and calibrated to ensure that it accurately predicts fish tissue concentrations and risks.	The issue of model testing/validation/verification/corroboration was raised in USEPA's 15 September 2004 comment set on PRAM, and discussed in detail in the 23-24 September 2004 TWG meeting. Please see our responses to the comments titled "Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels" (C. Barber, 15 September 2004) (Provided Separately) for responses to comment 3.5 and conclusion comment 4 of the 15 September 2004 comments.
2	**Risk Characterization Based on Comparison to ex-Vermillion Risks** - Risks for the ex-Vermillion and ex-Oriskany are not compared in the SHHRA. It is important to be able to evaluate not only the differences between individual parameters, but also the multiplicative effects of these differences on the risks for the ex-Oriskany site (i.e., using data from the SHHRA for the (1) mass loading of PCBs, (2) fish ingestion rate, and (3) fraction ingested term for the ex-Oriskany site, as compared to the ex-Vermillion site).	On 18 May 2004, EPA Region 4 and EPA OPPT representatives concurred with the approach of two independent lines of evidence for the ex-ORISKANY effort, (a) a qualitative/semi-quantitative evaluation of the comparability of potential exposures and level of mitigation between the two ships via the SHHRA, and (b), a semi-quantitative evaluation of the potential risks on ex-ORISKANY using the PRAM model. In previous ex-ORISKANY TWG conference calls on the same issue, we maintained that a quantitative risk comparison could not be made since there is no hard data on the specific PCB

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		loading on the ex-VERMILLION but rather a range of possible values. On further consideration and to be responsive, we agreed in the 12 August 2004 meeting that we will make a quantitative comparison for all three fish species (White Grunt, Black Sea Bass, and Vermilion Snapper), and present the evaluation findings with a discussion of uncertainty using the ratioing approach. However, it should be noted that the EPA ratioing approach assumes linearity or proportionality between the two ship reefs. It is a highly simplified and non-site-specific approach for evaluating risks. PRAM predicts PCB concentrations in the environment and in fish based on the leach-rate of PCBs from various PCB-containing materials and their respective loading. The ratioing approach assumes that the mass or mass/volume ratio for the ex-VERMILLION can be used to extrapolate, by the principle of proportionality, PCB concentrations in fish at the ex-ORISKANY. This is a gross assumption; it does not depend on the specific quantity or leach rates of individual types of materials, e.g., BHI is more leachable than electrical cable, and is expected to contribute more to total PCB release despite its much lower quantity than the cable onboard of the ex-ORISKANY. Also, it is noted that the evaluation is non-site-specific. Thus, we feel that the rationing methodology is fatally flawed due to our inability to ascertain the amount of PCB-containing material and their distributions onboard the ex-VERMILLION within reasonable limits of uncertainty. Note also that previously submitted responses to these and related comments relate back to results predicted by the previous version 1.3 of PRAM. However, PRAM 1.4c has been developed in collaboration with the USEPA via the TWG to address concerns regarding the predictive ability of the model. PRAM v. 1.4c as used in the revised HHRA for the ex-ORISKANY is now a fugacity level III model, with other component revisions such as incorporation of a pycnocline, that is designed to address concerns about predicting PCB concentrations in water and fish tissue. Thus, we cannot justify continued comparisons of the two vessels via the ratioing method in light of the use of a substantially revised model (PRAM, version 1.4c) for the ex-ORISKANY HHRA. .In addition, we agreed that we should include the fish ingestion risks for a child receptor into PRAM. The outputs of PRAM that include the child receptor risks, in additional to adult risks, are reported in the ex-ORISKANY HHRA (revised SHHRA)
2a	**Mass Loading -** Note that although PCBs that will leach from the ex-	We agree that the ex-ORISKANY will contain more PCBs than is thought to

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	Oriskany will be diluted in a bigger volume of water, based on the Navy's estimates, the PCB mass per unit volume (lbs/ft^3) is expected to be about 2 times higher for the ex-Oriskany than for the ex-Vermillion.	have been on board the ex-VERMILLION when it was sunk, however, mass and volume alone are not the only contributing factors to PCB release rates. The leach rates of the various PCB-containing materials are equally as important. For example, although the greatest mass of PCBs on board the ex-ORISKANY is present in electrical cabling, because this material releases PCBs very slowly (relative to materials such as bulkhead insulation), PCBs in cable are not a primary source of PCB release to the environment. In addition to the uncertainties associated with the mass of PCBs present on the ex-VERMILLION at the time of sinking, and the distribution of these PCBs in various shipboard materials, a further reason that a ratioing evaluation will not be conducted is because of the use of the new version of the model (PRAM, version 1.4c) in this HHRA. Response to Comment 2 also discusses this issue.
2b	**Fish Ingestion Rate -** As indicated by the Navy, the fish ingestion rate is higher for the ex-Oriskany site than for the ex-Vermillion site.	We acknowledge that the fish ingestion rate for the ex-ORISKANY site is likely to be higher than for the ex-VERMILLION site, based on information supplied in the Exposure Factors Handbook (USEPA, 1997),. However, as discussed in response to Comment 2, we do not feel it is appropriate to compare the ex-VERMILLION and ex-ORISKANY exposure scenarios. PRAM version 1.4c has been developed in collaboration with the USEPA via the TWG, and applies site-specific exposure information for the fish ingestion exposure scenario, which was obtained from surveys of anglers that fish at artificial reefs located near the proposed ex-ORISKANY reef site. Also see response to comment 2.
2c	**Fraction Ingested (FI Term) -** As indicated by the Navy, the FI term is higher for the ex-Oriskany site than for the ex-Vermillion site. Relying on empirical White Grunt data from the ex-Vermillion and then scaling it up to what might be expected for the ex-Oriskany based on the amount of PCBs remaining on the ships at sinking and the relative size of the ships, EPA predicted the risk values provided in Table 1 (for the ex-Oriskany, this would correspond to risk from consuming White Grunt or similar species such as Grey Triggerfish). **[*The example Table provided by USEPA in the original comment letter is attached to the end of this comment/response document*]** As you can see from this table, the estimated cancer risk posed by dioxin-like PCB congeners alone is *greater than* the upper-bound of the	We acknowledge that the FI term for the ex-ORISKANY site is likely to be higher than for the ex-VERMILLION site, based on information gathered from angler surveys, and documented in the SHHRA in an appendix to the revised HHRA. As discussed above, we believe that the ratioing approach is flawed due to our inability to ascertain the amount of PCB-containing material, their distributions onboard the ex-VERMILLION, and their leach rates within reasonable limits of uncertainty, and that the revised PRAM v. 1.4c addresses many of the modeling uncertainties of the previous version (see response to comment 2). Regarding risks associated with dioxin-like PCB congeners, the only value shown to be greater than the upper-bound range of 1E-06 to 1E-04 was associated with a direct mass-to-mass comparison between the two ships. The difference in volume, and its impact on PCB dispersion to the surrounding reef environment was not considered. In our 12 August 2004 meeting with

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	risk range of 1E-06 to 1E-04. Since dioxin-like congeners may not account for all of the PCB cancer risk posed by mixtures of PCB congeners, the predicted cancer risk is probably higher (i.e., one could reasonably add the dioxin-like PCB congener and PCB cancer risks together, with the understanding that there may be some double counting of risk).	USEPA, USEPA agreed that a comparison based strictly on total PCB mass was not appropriate, and that the ratioing evaluation should be based on a comparison of mass as a function of volume (as labeled "PCB Mass (lbs/ft^3)" in the example table provided by USEPA). Also regarding dioxin-like PCBs, it should be noted that EPA's Risk Assessment Guidance for PCBs recommends that dioxin-like PCB congeners be assessed only as another line of evidence in the uncertainty section of the risk assessment. The ex-ORISKANY HHRA (revised SHHRA) discusses the uncertainty associated with evaluating total PCB concentrations rather than risks from various dioxin-like PCBs.
3	**Fish Species Assumptions** - In EPA's June 25, 2004, comments, it was noted that empirical data for White Grunt at the ex-Vermillion were higher than the modeled fish tissue concentrations. The Navy noted in their response to EPA that "...measured concentrations for species preferred by anglers (Black Sea Bass and Vermilion Snapper) from the ex-Vermillion site are similar to those in reef fish predicted for the ex-Oriskany site by the PRAM." While it is true that PRAM appears to do a better job predicting fish tissue concentrations for the other two species tested at the ex-Vermillion, it was our understanding that White Grunt was also selected at the ex-Vermillion site because it too was a species preferred (i.e., caught and eaten) by anglers. Also, the White Grunt is intended to be representative of other species that may accumulate PCBs in a similar manner that might be consumed by anglers. Thus, consideration of the White Grunt data is essential.	Both the Navy and EPA are concerned about any impact that PCB bulk products may have on fish at an artificial reef. While the White Grunt is not expected to be a predominant species at the ex-ORISKANY site, as mentioned previously, the Grey Triggerfish is considered a logical species to fill the same ecological niche as the White Grunt. Since the Grey Triggerfish may be considered comparable to the White Grunt, with respect to the trophic level and dietary preferences, its is agreed that it is appropriate to be concerned about the likely PCB concentrations that could occur in the Grey Triggerfish. Further, we recognize that it is an important issue that should be properly addressed. Given that White Grunt caught at the ex-VERMILLION reef had higher PCB levels (by approximately an order of magnitude) than the Black Sea Bass and the Vermilion Snapper, and that this increase is unexplained, a post-sinking monitoring program for this fish (or a comparable species, such as the Grey Triggerfish) may be appropriate. This issue was discussed in detail in the 23-24 September 2004 TWG meeting, including this as a primary reason for refining PRAM (e.g., fugacity level III, division of the water column into two regions, water-diet matrix, and re-examining the ZOI that must be modeled). A method of evaluating PRAM results with respect to the White Grunt levels found at the ex-VERMILLION was suggested by EPA (see Barber comments on PRAM, i.e., to run a sensitivity analysis to see if PRAM, using assumed sources loading parameters for the ex-VERMILLION, could predict fish tissue levels equivalent to those found in the White grunt). The Navy conducted this analysis (an emission study), presented the results in the November TWG meeting, and found that if various PCB loadings on the ex-VERMILLION were assumed, then PRAM can predict fish tissue concentrations equivalent to the White Grunt found at the ex-VERMILLION. Also please note that the

	COMMENT	RESPONSE
		previous modeling results were based on the earlier version of PRAM, which has been substantially revised in version 1.4c to address concerns about the accuracy of predicted PCB concentrations in fish tissue.
4	**Dioxin-like PCBs** - The SSHRA does not address the dioxin-like PCBs using PRAM. Dioxin-like PCBs were the risk drivers for the ex-Vermillion but were not evaluated by the PRAM for the ex-Oriskany (only "PCBs" in a more general sense were evaluated). Thus, it is very likely that the PRAM-based risks for the ex-ORISKANY are underestimates. This should be addressed in the SHHRA, at a minimum, using the comparative approach discussed in Issue Number 2 above.	Conversion factors can be developed using the ex-VERMILLION reef data to convert total PCB levels in fish to dioxin-like exposure levels, albeit with some uncertainty. In the 12 August 2004 meeting with EPA, we agreed that we would conduct such an evaluation in the SHHRA, However, given our inability to ascertain the amount of PCB-containing material and their distributions onboard the ex-VERMILLION, and the fact that the PRAM version 1.4c is now a fugacity level III model, as discussed in response to comment 2, we no longer believe that a comparative approach is appropriate.
5	**Fish Advisory Guidance** - As indicated in comment 1 above, the Prospective Risk Assessment Model (PRAM) used to evaluate the impacts of sinking the ex-Oriskany found that human health cancer risks and non-cancer hazards were acceptably low for all "reef fish." However, empirical data for a similar artificial reef (the ex-Vermillion) are in direct conflict with this result. Specifically, the PRAM was used to estimate the uptake of PCBs by "reef fish" and subsequent consumption by recreational fishermen. The PRAM's predicted cancer risk from "reef fish" was 1E-06 (under reasonable maximum exposure or RME conditions). However, when this result is compared to the three species of reef fish sampled at the ex-Vermillion, it is clear that not all reef fish are equal with respect to their tendency to bioaccumulate PCBs and that the PRAM may not be adequately accounting for this fact. Of those three species sampled at the ex-Vermillion, two showed risk results that were comparable or lower than the PRAM's result for reef fish (1E-06 for Black Sea Bass and 5E-07 for Vermillion Snapper). However, PCB concentrations in White Grunt were *substantially higher* than these two other reef species (e.g., 0.3 ppm average total PCBs in White Grunt versus 0.014 ppm average total PCBs in Vermillion Snapper and 0.04 ppm in Black Sea Bass). This is strong evidence that the PRAM may not adequately predict the potential	The EPA Fish Advisory Guidance document recommends using a similar risk paradigm as was used in the ex-VERMILLION HHRA; however, it contains more conservative assumptions when compared to the EPA's Risk Assessment Guidance (RAGS), including: (1) exposure over 70 years vice 30 years and (2) 100% of the fish ingested is assumed to come from the reef (i.e., there is no site-specific Fraction Ingested term). The ex-ORISKANY HHRA follows the methodology recommended by the EPA's Risk Assessment Forum; i.e., a site-specific risk assessment. In this context, the risk equations in the ex-ORISKANY HHRA incorporate a Fraction Ingested (FI) term, based on site-specific information about marine anglers' consumption patterns, and exposure is assumed to occur over 30 years. The regulatory agencies responsible for issuing fish advisories are the State, or the Food and Drug Administration (FDA), specifically for fish that is sold across state lines. The decision as to whether or not a regulatory agency would issue a fish advisory is a risk management decision that takes into factors like scientific judgment, social, economic, and political factors. The ex-VERMILLION HHRA is a site-specific risk assessment based on the EPA's Risk Assessment Guidance (RAGS) and concludes no unacceptable human health risks. The thresholds referenced for a fish advisory by EPA Region 4 are generic and non-site specific values (0.019 ppm [wet weight] or 0.166 ppm

[1]EPA's National Guidance for Assessing Chemical Contaminant Data for Use In Fish Advisories (see http://www.epa.gov/ost/fishadvice/volume2/v2ch4.pdf).

	COMMENT	RESPONSE
	impact of a PCB-laden ship carcass on sportfish tissue concentrations. Indeed, the SHHRA acknowledges this fact, noting (page 5-13) that: ...it is observed in actual sampling of fish tissues from the ex-Vermillion that the PCB levels found in the While Grunt are higher than in other reef fishes, i.e., Black Sea Bass and Vermillion Snapper. It is believed that, among other reasons (e.g., background contribution), the higher White Grunt PCB tissue concentration found near the ex-Vermillion may be due to an alternate dietary composition than what is presently within the PRAM. According to ECMRD, White Grunt is not prevalent at the East Escambia County LAARS; however, the Gray Trigger Fish, that could occur at the ex-Oriskany reef, may have similar tendency to accumulate PCBs as the White Grunt due to its dietary preferences (ingestion of encrusting benthic macroinvertebrates.) Based solely on the total PCB levels in White Grunt at the ex-Vermillion, a "DO NOT EAT" fish advisory for this species is expected based on EPA fish advisory methodologies.[1] Based on the risk estimates in Table 1, one would also expect the ultimate establishment of a DO NOT EAT fish advisory for the species corresponding to White Grunt at the ex-Oriskany site (Grey Triggerfish or similar species). In summation, available information indicates that the PRAM may be inadequate regarding its ability to adequately characterize PCB uptake in fish across species of interest.	[dry weight]). As discussed in the 12 August 2004 meeting, we expressed that it would be appropriate for the Navy, in the ex-ORISKANY HHRA, to address the potential State of Florida regulatory and risk management options, including issuance of a fish advisory. Our understanding is that the State is the cognizant party to determine whether a fish advisory is necessary, and that the state will evaluate all factors, including the risk assessment findings and fish consumption patterns of the receptors of concern.
6	**Child Receptor Not Analyzed** - There does not appear to be an evaluation of the child receptor in the ex-Oriskany risk assessment. Since sport fishermen commonly feed their families with their catch, the child receptor scenario should be considered.	The lack of a child receptor in the SHHRA was an inadvertent omission. A child receptor was previously evaluated as part of the ex-VERMILLION HHRA. The ex-ORISKANY HHRA (revised SHHRA) incorporates the same child scenario used for the ex-VERMILLION, using site-specific information (fish ingestion rates, fraction ingested, etc.) where appropriate.

	COMMENT	RESPONSE
7	**Ecological Risk** - There is no ecological risk analysis for the ex-Oriskany, and EPA is concerned that the conclusion of the existing eco risk analysis for the ex-Vermillion (i.e., acceptably low risk) is incorrect. For example, the average PCB concentration of total PCBs in White Grunt is 0.3 ppm. However, EPA has developed wildlife protection values for fish tissue concentrations protective of wildlife that rely on fish for most of their diet. The wildlife protection value for PCBs is 0.16 ppm.[2]	Although it appeared that USEPA accepted the use of the ex-VERMILLION SERA for evaluation of the ex-ORISKANY during the 18 May 2004 ex-ORISKANY, it is acknowledged that there are now reservations in making this broad extrapolation. Pursuant to discussion held in the 23-24 September 2004 meeting with USEPA in Atlanta, another Screening Ecological Risk Assessment (SERA) has been performed for the ex-ORISKANY. This supplemental ERA compares benchmark values, developed as part of the SERA for the ex-VERMILLION, to tissue concentrations at the ex-ORISKANY site, as predicted by PRAM. The Wildlife Protective Value (WPV) is essentially equivalent to the benchmarks used in the SERA for protection of dolphins, ospreys, and diving ducks. The benchmarks used in the SERA are slightly different than the WPV because the benchmarks for dolphins, ospreys, and diving ducks are scaled to the body weights and dietary requirements of organisms that would actually feed and forage on the reef. The WPV is a generic benchmark based on the most sensitive wildlife species among birds (Kingfisher, Herring Gull, and Eagle) and mammals (Otter and Mink) and is not scaled to account for organisms found on the reef. It is noted that when the WPV benchmark is placed within the SERA report benchmarks, it falls under the threshold screening value (TSV) and above the Dolphin value, therefore approximating the most conservative benchmark but actually slightly above it.

[2]USEPA. 1997. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: National Sediment Quality Survey. EPA 823-R-97-006. U.S. EPA. Washington D.C. pp. B14-B15.

Response to USEPA Region 4 Comments on "PRAM Issues"
(Source: Ms. Beverly Banister, USEPA Region 4, 17 September 2004)

Table 1. Comparative Risks*

	Ratio of ex-ORISKANY to ex-Vermillion[b]	HHRA ex-Vermillion PCB Risk[d]	Estimated ex-ORISKANY PCB Risk[e]	HHRA ex-Vermillion Dioxin Risk[d]	Estimated ex-ORISKANY Dioxin Risk[e]
Reasonable Maximum Exposure (RME) Exposure Conditions					
PCB Mass (tons)[a] IR (g/day) FI (unitless) TOTAL[c]	3.14 1.64 1.70 8.76	1.10E-5	9.63E-5	2.34E-5	2.05E-4
PCB Mass (lbs/ft^3)[a] IR (g/day) FI (unitless) TOTAL[c]	1.95 1.64 1.70 5.44	1.10E-5	5.98E-5	2.34E-5	1.30E-4
Central Tendency (CT) Exposure Estimate					
PCB Mass (tons)[a] IR (g/day) FI (unitless) TOTAL[c]	3.14 1.53 1.79 8.59	1.05E-6	9.01E-6	2.75E-6	2.36E-5
PCB Mass (lbs/ft^3)[a] IR (g/day) FI (unitless) TOTAL[c]	1.38 1.53 1.79 3.79	1.05E-6	3.98E-6	2.75E-6	1.04E-5

[a] Taken from the footnote on page 3-4 of the SHHRA.
[b] Calculated by dividing the value from the ex-ORISKANY by the corresponding value for the ex-VERMILLION.
[c] Total ratio was calculated by multiplying the ratios for each of the three factors (i.e., PCB Mass ratio * IR ratio * FI ratio).
[d] Risk from ingestion of White Grunt from the HHRA for the ex-Vermillion; slope factor of 2 $(mg/kg/day)^{-1}$ used.
[e] Calculated by multiplying the risk from the HHRA times the total ratio; slope factor of 2 $(mg/kg/day)^{-1}$ used.

* This rationing methodology is fatally flawed due to our inability to ascertain the amount of PCB-containing material and their distributions onboard the ex-VERMILLION within reasonable limits of uncertainty. As described in Section 6 of the ex-ORISKANY HHRA, each material has different leach rates with patterns of homologs releases specific to their rates. The PCB mass for the ex-VERMILLION was an extrapolation of an extrapolation. Previously submitted responses to these and related comments relate back to results predicted by the previous version 1.3 of PRAM. A new version PRAM version 1.4c has been developed in collaboration with the USEPA via the TWG (see response to comment 2). Thus, we cannot justify continued comparisons via the rationing method in light of the development of a new version of the model (PRAM, version 1.4c)

Response to USEPA Region 4 Comments on "PRAM Issues"
(Source: Ms. Beverly Banister, USEPA Region 4, 17 September 2004)

COMMENT	RESPONSE
PRAM Issues (paraphrased)	**General Response: To address the comments raised by ORD and Region 4 regarding the model, the Navy has completed a revision of PRAM, completed testing and QA/QC check, and provided documentation of the model. The Navy has also revised and reissued the July 04 SHHRA document, which is now called the HHRA for the ex-ORISKANY.**
The fish bioenergetic algorithms are probably overly simplistic. These algorithms are not consistent with formulations found in commonly used bioenergetic models such as the Wisconsin Bioenergetics Model.	PRAM was designed to be simple, using commonly applied methods, and is considered to be robust. Respiration algorithms were taken directly from the Wisconsin Bioenergetics Model. The growth model used in PRAM, derived from a balanced energy equation, is comparable, if not identical, to the simple linear growth equation used in the Wisconsin Fish Bioenergetics Model (Hewitt and Johnson 1992) for freshwater fish. Linear growth equations are commonly used. In a recent review paper (Barber, 2003) it was noted that, growth rates reported by the studies analyzed in the paper were *always* described using a linear growth model (pg. 1985). While this review paper provided a rationale for recommending that bioconcentration models use a more complex fish growth rate algorithm, we are not sure how significant a parameter this may be to PRAM predictions. The PRAM models fish growth in a generic, or average, way, in order to predict fish bioconcentration at a trophic level, rather than for individual fish species. Additionally, the PRAM models bioaccumulation and bioconcentration based on both water exposure and dietary uptake. To the extent that dietary uptake is considered the more significant source of PCBs for fish living at a reef for their entire lifespan, the importance of using a more complex growth algorithm in PRAM (which may more closely approximate growth rates in individual species) is uncertain. We satisfactorily discussed and explained our basis and rationale for use of the growth rate algorithm in our model. This issue has been resolved with no changes on the existing growth model necessary.
Bioaccumulation algorithms should be re-evaluated in light of recent	Biouptake and subsequent bioaccumulation of PCBs can occur via food intake

COMMENT	RESPONSE
review papers. For example, the algorithms used by PRAM for modeling the elimination/excretion of PCBs by fish have been shown to be poor predictors of this important bioaccumulation process when used as is without model calibration.	(ingestion) or direct dermal contact, or across respiratory exchange membranes (i.e., the gills). The primary uptake route for fish is through the food chain (ingestion). Direct dermal contact and uptake across the gill are relatively minor pathways. A review of the detailed comments provided by Dr Craig Barber in his 15 September 2004 comments indicates that the primary algorithm of concern was related to gill exchange. The gill exchange algorithm used in PRAM differs from the "best fit" model, per the Barber (2003) study, by only 6%. The relative difference in predictability for all of the gill exchange models evaluated is from 4 to 16% (for uptake and elimination, respectively). In our opinion, such findings may not provide sufficient reason to invalidate the use of the algorithm used within the PRAM. It should be noted that, while the gill exchange algorithm remains unchanged, PRAM version 1.4c incorporates new gill exchange rates, based on marine species instead of fresh species, and the gill rates have been corrected for PCBs per comments from Dr Barber (see response to comment 1.1 from USEPA 15 Sept 2004 comments), with minor revisions to his recommended algorithms to reflect proper unit conversions (Section 2.7.2.4, PRAM Documentation, NEHC/SSC-SD, 2005). The issues of gill exchange, direct dermal contact (specifically related to encrusting organisms), and food chain were discussed in the 23-24 September 2004 TWG meeting. We intend to work closely with EPA to ensure that the revised PRAM adequately addresses these issues. Note that the last comment/response in this attachment addresses the issue of model calibration/corroboration/testing.
The theoretical foundations and conceptual model for the PRAM fate and transport models must be fully documented and defended. PRAM's current equations appear to be inconsistent with mass balanced, fugacity-based models that can be objectively reviewed and defended.	It was not our intent to be parsimonious or presumptive, in the description of PRAM (i.e., for not providing an in-depth defense of the fugacity model in the SHHRA document). Rather, from the continued stages of PRAM development we purposively sought a "pre-defended" model, one that we believed had already received EPA endorsement (in that it was applied in the Great Lakes Water Quality Initiative [USEPA 1995]). As such, we believed the fugacity model developed by Mackay was widely known, and widely accepted as an adequate model, for modeling PCB fate and transport at the resolution needed for the PRAM human health risk assessment predictions. Version 1.3 of PRAM is a fugacity based, Level II, equilibrium model. Based

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	on further discussions with Dr. Craig Barber (USEPA) and Dr. Keith Little (RTI), it was concluded that a fugacity based, Level III, equilibrium model would provide a more robust evaluation. As such, PRAM 1.4c has been revised as a Level III model. Documentation for PRAM version 1.4c has been prepared (NEHC/SSC-SD, 2005) as a separate document from the human health risk assessment to provide a detailed, defensible discussion of the abiotic fate-transport modeling approach (fugacity equations) and other components used in the model.
The implicit conceptual model used by PRAM is overly simplistic. In particular, it only considers advective transport of PCBs within the zone of influence (ZOI); no diffusive transport is considered.	PRAM was designed to be simple. Diffusion out of the PCB-containing materials is the driving force for PCB release. However, diffusion between the media "boxes" within the PRAM was considered to be a minor transport vector, as advection is several orders of magnitude greater. Nevertheless, based on discussions with the EPA and others, it is recognized that the level II fugacity equations used in PRAM version 1.3 may not address the impedances associated with diffusion between the model compartments. As discussed in the previous response (above), PRAM version 1.4c has been modified as a Level III equilibrium model. Diffusive transport is now addressed directly as a separate transport mechanism in the revised PRAM model.
Encrusting biota that will bioaccumulate leaching PCBs should be added to the PRAM fate and transport module.	Encrusting biota are included within the PRAM but their exposure is limited to water exposure and not "direct-contact," with passive diffusion into their tissues. As discussed in the November TWG meeting in Atlanta, direct absorption of PCBs into encrusting organisms from the outer surface of the ship is considered a minor exposure route at most. The exterior of the ship, where most of the encrusting organisms are likely to attach, is not believed to contain PCBs. Interior compartments, while containing potentially significant levels of PCBs in some materials, do not provide prime habitat for encrusting organisms. As such, encrusting organisms on the ship's interior are likely to provide only a small fraction of the overall diet of predatory fish that could be consumed by humans, and would be expected to contribute little to the overall PCB loading in the fish. A discussion of this pathway has been included in the uncertainty section of the ex-ORISKANY HHRA.
An objective and defensible method for designating the ZOI of a reefed vessel must be developed.	We agree that the ZOI needs to be objectively defined relative to the physical constraints of the vessel and surrounding environment, as well as the biological community being modeled. The Navy, working closely with modelers and biologists in the Technical Working Groups (TWGs), has defined two ZOIs for use in the ex-ORISKANY HHRA that are thought to best represent uptake of PCBs released from the reef into the biological community. A ZOI of 2

COMMENT	RESPONSE
	(equivalent to 15 meters) is used to model uptake into reef-associated organisms, while a ZOI of 5 (approximately 50 meters) is used to evaluate less-reef-associated species. The basis and rationale for developing the ZOI approach has been documented, based on a review of literature and biological habitat considerations, in a paper by Dr. John Conner (NEHC, 2005). This paper has been attached as Appendix F of the "Prospective Risk Assessment Model (PRAM) version 1.4c Documentation, May 2005, Draft Final".
The PRAM parameterization for fishes is very subjective and insufficiently researched. For example, pelagic predators are parameterized by data for lake whitefish (coregonids) which are freshwater planktivores. Similarly, reef predators are parameterized as largemouth bass.	The fish and invertebrate parameterization within the PRAM was based on our research of studies that provided a full data set that included energy budgets and temperature-dependent respiration rates. As pointed out by Connolly (1990), the exact species may not be overly important when the species selected is representative of the organisms within the trophic level, and results using alternate species will therefore not be significantly different. We recognize that the use of parameterization values based on freshwater species added a level of uncertainty to PRAM version 1.3. Parameterization values used in PRAM version 1.4c have been revised, and are now based on marine species.
There is a major quality assurance issue with the total PCB water concentrations reported on the PRAM *Estimate* output worksheets and their associated *Supplemental Info* output worksheets. In particular, concentrations of individual PCB homologs appear to exceed total PCB concentrations by three orders of magnitude between the two sheets.	Comment acknowledged. We most sincerely regret our oversight in forwarding PRAM (Version 1.3) to EPA as an in-progress review product. The disparities EPA observed, between the PCB concentrations reported in the *Estimate* output worksheet and the *Supplemental Info* output worksheet, resulted because two of the "scenario analysis" modules in PRAM had not been revised to reflect the specific dimensions, PCB source terms, etc. for the ex-ORISKANY. Therefore, results associated with the updated *Risk Calculation* module in PRAM ver. 1.3 were not consistent with the results associated with the non-updated *Calculate Amount of Material* module. This problem has been resolved, as PRAM ver. 1.3 has been updated and revised to become PRAM ver. 1.4c.
There are numerous inconsistencies between units specified for equations in the SHHRA dated June 18, 2004, and the PRAM model itself. There is a real concern that such errors and inconsistencies in the PRAM's written description are real or potential indicators that similar errors and inconsistencies may have been propagated to the model's mathematical code.	Comment acknowledged. We agree that this is a valid concern on EPA's part. For PRAM 1.4c, we have conducted testing and QC checks, including mass balance algorithms. Regardless, we strive to reach the goal of perfection, and continue to look forward to any comments EPA may have on the model. Documentation of the testing /QC is presented in PRAM Documentation (NEHC/SSC-SD, 2005). We also maintained a log on revisions made to the draft before it is finalized for this submission to the EPA.
PRAM predictions must be tested or corroborated. More specifically, a validation study should be performed to see if PRAM could predict the white grunt data for the ex-Vermillion.	Through the TWG, the Navy collaborated with the agencies to satisfactorily resolve issues or concerns expressed by the EPA and State of Florida. These issues included:

COMMENT	RESPONSE
	- Determining the feasibility of defining the ZOI in terms of home ranges and/or dietary preferences or habitation preferences of fish species - Comparing the BAFs calculated by PRAM to BAFs cited in the literature - Applicability or relationship of PCB fish concentrations predicted by PRAM and fish sampling results from the ex-VERMILLION reef - Evaluating the potential impacts of PCB pulses that may occur in or around the sunken vessel prior to the system reaching steady-state/equilibrium conditions - Evaluating pulse PCB loading of sediment/biota during early stages of reef history - Evaluating the potential for higher PCB loading in encrusting organisms and potential diffusion into tissue from direct contact with ship materials - Conducting additional literature research to identify and evaluate studies of marine fish species that can be used to parameterize PRAM (for predator and reef fish) - Updating PRAM to include a child-receptor scenario in the risk assessment - Updating PRAM to allow output of additional parameters such as assimilation efficiencies, BAFs, and BCFs. With regard to corroborating PRAM ver. 1.4c, we will look forward to working with the agencies, especially the State of Florida who has a robust reef monitoring program in place for its artificial reefs. The Navy evaluated PRAM in terms of its ability to predict specific data set from the ex-VERMILLION reefin an "Emission Rate" studyto see if PRAM could predict the white grunt data for the ex-VERMILLION. A brief description of this effort was provided at the 23-24 September meeting. This study demonstrated that white grunt-like fish tissue loadings could be predicted by PRAM, based on a variety of assumed PCB loadings within the ex-VERMILLION. PRAM version 1.4c outputs for the ex-ORISKANY site also predict fish tissue concentrations for trophic level III (triggerfish) and IV (grouper) reef fish similar to those seen in White Grunt from the ex-VERMILLION.
SERA Issues (Paraphrased)	**Note: The Navy has revised the ex-VERMILLION SERA to address the comments and suggestions provided by ORD and Region IV and have reissued the document (The Ecological Risk of Using Former Navy Vessels to Construct Artificial Reefs: An Initial and Advanced Screening Level Ecorisk Assessment. Final Report May 22, 2005, Space and Naval Warfare**

COMMENT	RESPONSE
	Systems Center, San Diego, CA, 597pp.) The Navy has also prepared a separate document to address the ecological risks from sinking ex-ORISKANY (An evaluation of ecological risks associated with sinking the ex-ORISKANY to create an artificial reef within the Escambia East Large Area Artificial Reef Site, Florida. Draft Report, June 2005, Space and Naval Warfare Systems Center, San Diego, CA).
Use of residue data derived solely from analysis of fillets from the supplemental fish sampling potentially underestimates ecological risk and is not sufficiently conservative. Whole body burdens should have been used in screening calculations. In the absence of those data, the risk assessment may require development of statistical relationships between fillet and whole body concentrations to support conservative analyses.	A procedure to estimate whole body PCB residues was developed and a spreadsheet with the assumptions, equations, and calculations for the supplemental fish data was reviewed as satisfactory by ORD. The calculations for whole body tissue residues were higher than the estimates derived solely from analysis of fillets and these data have been incorporated into the revised report. Because the fillets were analyzed with “skin on” the increases were not drastic. The calculations for whole body tissue residues, the bounds associated with those estimates, and uncertainty in the estimates have also been included in the revised report.
The discussion of screening methods, possible interpretations, and assessment uncertainties in the SERA is unclear and incomplete, resulting in and inadequate understanding of the ecological risks. A more neutral and transparent description of methods and results, and of the strengths and limitations of what was done, is required to support the assessment conclusions.	The SERA report was revised to more clearly communicate the strengths and limitations of the assessment. Specific comments provided by ORD were also addressed in the revised document. Furthermore, recommendations and suggestions for improvements on the SERA received from ORD were also incorporated into the ecorisk assessment prepared for the ex-ORISKANY.
The summary conclusions offered in the document are not supported by the results of the assessment. Certain findings suggest the need to conduct more refined assessments of risks posed by PCBs and other chemicals to the reef community.	The SERA report has been revised and improved to address specific comments and suggestions received from ORD and Region IV. In addition, an advanced screening for potential effects from PCBs was also conducted. The advanced screening was warranted because some PCB concentrations exceeded the initial screening levels and because of the importance of evaluating potential toxicological effects from PCBs to support the risk management process.

Response to USEPA Comments on:
"Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels"
By Dr. M. Craig Barber, USEPA/ORD/NERL/ERD (15 September 2004)

	COMMENT	RESPONSE
1. Review of PRAM Bioaccumulation and Bioenergetic Algorithms		
1.1	The algorithms used for gill uptake and excretion (i.e., Equations 28 and 45) should be either calibrated or replaced. In a recent review of the performance of 10 of the most widely used/cited gill exchange models (Barber [2003]) demonstrated that the formulations used by PRAM to describe these processes were the least accurate, uncalibrated algorithms reviewed. That is, these algorithms exhibited the largest deviations from the ideal model fit of observed equals predicted (see results for Model 8 in Tables 13 and 14 in Barber 2003).	Regarding Equation 28 (for gill uptake [Ku_i]): This equation, from Connolly (1991) was evaluated as one of the ten-gill exchange models evaluated by Barber (2003). For the ten models evaluated, the range in performance, as represented by the r^2 (pg. 1978) is from 0.655 to 0.694, for routine respiration, with 1 equal to a perfect correlation between predicted and observed results. For standard respiration, the range in performance, as represented by r^2, was between 0.671 and 0.720. Stated another way, the relative difference in predictability for all models evaluated is from 4 to 16%. In our opinion, we believe that the findings do not provide sufficient reasons to invalidate the use of the algorithm used within the PRAM. Moreover, we note that Barber (2003) states that "With such small differences between r^2s, there seems to be very little difference between any of the models analyzed, with respect to their predictive abilities." The author also states, "what is equally important is that none of the models examined could be identified as the most inaccurate or worst model for all analyses considered." We do recognize and appreciate the sophisticated analyses conducted by Barber (2003) in systematically comparing the structure and quantitative behavior of ten of the most widely cited fish bioconcentration models. And we agree that the uptake rate equation (Equation 28) used in PRAM is from Connolly (1995), which Barber describes as essentially "isomorphic to the model proposed by Norstrom et al. and Neely," in that Connolly assumed that the permeability ratio could be estimated by the ratio of uptake assimilation efficiencies. Regarding the EPA recommendation that this gill uptake equation should be "calibrated," several changes have been made to PRAM. Respiration efficiency values used in the previous version of PRAM, based on freshwater fish, have been replaced with values for marine species, and the uptake rates have been corrected for PCBs per the recommendations in Barber (2003).

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		With respect to the elimination rate (Ke), Equation 45 was not used in the PRAM, but rather presented in the text of the SHHRA as an equation reviewed and rejected for use in the PRAM. The elimination rate constant used in the PRAM is calculated using equation 47 (used by Thomann (1989), Fisk et al. (1998) and Woodburn et al. (2003)). We regret the confusion and have revised the PRAM documentation.
1.2 (a)	The claim that PRAM is a "most" conservative formation because chemical assimilation efficiencies used by the model are upper bounds of the results of Gobas et al. (1988), Thomann (1989), and Fisk et al. (1998) is not well founded. See text following Equation (44) on page 5-12 and Figure 5-4. Assimilation efficiencies cited and used by PRAM are <u>not</u> fundamental uptake parameters but rather are net exchange parameters whose values depend on exposure conditions and on the growth, feeding, and gill exchange capacities of the fishes of interest. See, for example, Barber (1991, 2001, 2003, 2004, Barber in preparation). "Constant" assimilation efficiencies, for example, can be shown to decrease as a function of exposure duration.	We were unable to find the citation noted by the reviewer (i.e., that PRAM is a "most" conservative model). In the text following Equation 44 (page 5-12), we state that, "the curve fit in Figure 5-4 appears to be adequate and conservative, since virtually all of the empirical data fall below the prediction line." We were simply stating that the PRAM model uses conservative assumptions. We were unable to find any specific description or definition within the PRAM or its documentation to the effect that assimilation efficiencies are "uptake parameters"; the Navy agrees that these are not uptake parameters. The "constant" assimilation efficiencies used in PRAM do not decrease over time as a function of exposure duration. We welcome specific recommendations and collaboration with EPA to improve PRAM where changes will increase confidence in the predictions.
1.2 (b)	Additionally, the assimilation efficiencies presented in Figure 5-4 are calculated using very different methods. Fisk et al. (1998), for example, calculated assimilation efficiencies by fitting the dietary uptake model of Bruggeman et al. (1981) to growth-corrected whole-body concentrations. One can easily verify that such assimilation efficiencies, for all other conditions are equal, are always less than assimilation efficiencies estimated from <u>unadjusted</u> whole-body concentrations, i.e., data analyzed by Gobas et al. (1988) and Thomann (1989).	The assimilation efficiencies presented in (plotted on) Figure 5-4 are from a variety of sources, based on a review of the raw values as reported in the literature, and we recognize that the various assimilation efficiency values were calculated, by the various researchers, using very different methods. We compiled and evaluated these values in the context of the descriptive algebraic functions as they relate to chemical K_{ow}. The functional relationship between K_{ow} and assimilation were evaluated in that context. Our purpose was to derive a functional algorithm that would ensure that PRAM was conservatively estimating the assimilation of PCBs in fish. While it may be true that the Fisk et al. (1998) values are less than those reported by Gobas et al. (1988), Thomann (1989), and Woodburn et al. (2002), the final regression we conducted shows *all* of the observed values

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		(whole-body and growth-normalized) fall below the prediction line. This was the acceptance criterion, where the goal was to assure that assimilation was not underestimated. To reiterate, we do not claim that PRAM is the "most conservative" assimilation model, only that it uses conservative algorithms. We welcome specific recommendations and collaboration with EPA to improve PRAM where changes will increase confidence in the predictions.
1.3	The growth model used by PRAM has been seldom used in the literature. Moreover, the mathematical ramifications of this model are not demonstrated by statistical analyses of fish growth data. PRAM assumes that growth/production, feeding, respiration, and excretion are simple linear fractions of the fish's total energy budget that is estimated directly from the fish's oxygen consumption. Thus, this formulation predicts that allometric exponents for a fish's specific rate of oxygen consumption and growth should be approximately equal. This prediction, however, is seldom observed. The mean exponent for weight-specific growth rates summarized in Table 1 for common reef-associated fishes in the southeastern US and Gulf of Mexico is -0.858. The mean allometric exponent for weight-specific growth rates calculated by Barber (2003) for 68 species of freshwater fish was -0.675. Both of these exponents are significantly different from the exponents typically reported for the weight-specific rates of oxygen consumption by fish that are typically on the order of -0.2.	The growth model used in PRAM, derived from a balanced energy equation, is derived from the simple linear growth equation used in the Wisconsin Fish Bioenergetics Fish Model (Hewitt and Johnson 1992) for freshwater fish where growth is calculated with the following equation: Growth rate = C – (R + S) – (F + U) Where: C = metabolic energy consumption (feeding rate), R = respiration, S = specific dynamic action, F = fecal excretion, and U = urinary excretion The Wisconsin Fish Bioenergetics Fish Model is an often-cited reference for modeling bioenergetics such that it was considered useful in the construct in the PRAM. We understand the EPA's position, presented in the section of Barber (2003) entitled "Improving Bioconcentration Models", that one area of improvement for current and future bioconcentration models is a more accurate prediction of fish growth and biotransformation. As noted in the equation: $BCF = k_1/(k_1/W + \gamma + k_m)$ where γ and k_m denote the fish's specific growth rate and chemical's biotransformation rate, respectively, if a fish's growth dominates the denominator, then the fish's BCF may appear to be independent of any physical property.. However, it is also noted in Barber (2003) that, "when growth rates were reported by the studies analyzed growth was *always described* using the simple linear growth model." While we agree that this may be an area of improvement for future

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		bioconcentration models, we note that PRAM is constructed to predict fish concentrations (and subsequently human health risks) for various trophic levels of fish, as opposed to modeling at a species-specific level. PRAM was developed for use as a predictive risk assessment tool, using accepted equations that have been elsewhere applied, as opposed to being developed as a refinement to existing models. If EPA believes that a more sophisticated model for growth is needed in PRAM, in particular for application of PRAM at a National approval level, we would welcome specific recommendations and would like to work collaboratively with EPA to determine the most appropriate growth rate model for PRAM.
1.4a	To evaluate how PRAM bioaccumulation predictions might differ from the predictions of a more process-based bioaccumulation model, BAFs (Bioaccumulation Factors) predicted by PRAM were compared to the range of BAFs predicted by the BASS bioaccumulation and fish community model. See Barber (1996, 1998, 2001, 2004). ….. For example, the $\log_{10}$ BAF for total PCBs in white grunt was estimated to range from 5.89 to 6.45. Table 5 summarizes BAFs for total PCBs predicted by PRAM for the ex-ORISKANY using the model's default parameterization. …… The mean $\log_{10}$ BAF for reef foragers and predators calculated from these PRAM predictions is 5.89. Although this value agrees well with the lower bound of the preceding BASS prediction for white grunt, this agreement may be coincidental since these BASS and PRAM predictions use different K_{ow}s and physiological and ecological fish data.	Although we understand that agreement in BAFs, between those predicted in PRAM and the reviewer's own model "may be coincidental", we find this corroboration encouraging. Moreover, we greatly appreciate that the reviewer conducted this in-depth comparative analysis. Per discussions with EPA at the recent meeting in Atlanta, EPA also suggested that we may improve PRAM by building in more "output" parameters, including the bioaccumulation factors calculated by PRAM (such that future reviewers will have these values readily available for comparison). Navy has agreed to improve PRAM in this manner prior to resubmitting the revised model for further EPA evaluation/review.
1.4b	More important, there is an undetermined QA issue with the BAFs calculated using the water and fish concentrations summarized in Table 5. In particular, these concentrations are summary values reported for total PCBs on the PRAM *Estimate* output worksheet. Inner vessel water concentrations reported for the individual PCB homologs on the *Supplemental Info* output worksheet, however, can exceed their corresponding total concentrations on the *Estimate* output worksheet by three orders of magnitude.	Comment acknowledged. We most sincerely regret our oversight in forwarding PRAM (Version 1.3) to EPA without better explanations for the users. The disparities EPA observed, i.e., between the PCB concentrations reported in the *Estimate* output worksheet and the *Supplemental Info* output worksheet, were because two of the "scenario analysis" modules in PRAM had not been revised to reflect the specific dimensions, PCB source terms, etc., for the ex-ORISKANY. Three "analysis" options/modules are included within the PRAM: the first is

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		the risk / hazard module, which calculates risk and hazard given an input of the loads of PCB-containing material onboard; the second (the module used by the reviewer) is intended to solve for an allowable mass of a specific PCB-containing material, given a set risk level; and the third is used to estimate risk / hazard given a range of PCB containing material onboard. Only the first module was modified from Version 1.2 of the PRAM for use in the SSHRA for the ex-ORISKANY and the apparent transcription error was a direct result of the modification. We recognize the "transcription error" raised a QA concern for PRAM. We fully intend to update the latter two modules and will conduct a thorough mathematical review and tests to ensure that no similar issues exist within PRAM prior to submitting the revised product to EPA for further evaluation/review.
1.5 Editorial Remarks regarding PRAM Biological Model Algorithms		
1.5.1	Equation 35 is incorrect as written. In particular, the term (1 - *%moisture*) must be replaced with (1 – *fraction* $_{moisture}$) or (1 – *proportion* $_{moisture}$).	The formulas in the text have been revised.
1.5.2	Equation 38 is dimensionally wrong as written. The units of I must be changed to [$kg_{lp} \bullet kg_{lp}^{-1} \bullet d\text{-}^{1}$].	The dimensions on the ingestion equation have been revised.
1.5.3	The sentence preceding and describing Equation 39 must be modified to define *fdiet* as a fraction or proportion; *fdiet* cannot be a percentage in Equation 39.	The sentence was modified to reflect a fraction and not a percentage.
1.5.4	In Equation 39 the upper indices to the summations should be *n* not *j*.	The summation term has been revised corrected.
1.5.5	In Equations 38, 39, and 40 the caloric content of prey items is defined with units [kcal/kg_{lp}]. However, when changing this parameter in PRAM the units are listed as [kcal/g-dry body wt]. Is this a unit inconsistency or a typographical error?	The caloric density reported in the USEPA Exposure Factors Handbook is in dry-weight and was converted to kcal per kilogram lipid within the PRAM. The intent of presenting the data this way was to make it easier to find the values within the source document. This has been made clearer in the revised PRAM documentation.
1.5.6	There are many units inconsistencies between the equations in the SHHRA and their description with the PRAM *Review Governing Equations for the Model*. Some equations, as noted in comment 1.5.4, have incorrect upper summation indices while the counterparts of other (e.g., Equation 38) have been incorrectly rewritten.	Comment acknowledged. The PRAM help files had not been updated from Version 1.2 to reflect the changes made for Version 1.3. The screens containing the governing equations within the PRAM have been revised. See our response to comment 1.5.2.

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2. Review of PRAM Fate and Transport		
Preface (Abbreviated form Comments provided)	There are at least two fundamentally different ways to formulate a fugacity-based model for the fate and transport of PCBs within the ZOI of a reefed vessel. The first of these is formulating PCB fate and transport as a homogeneous, first-order, linear differential equation in which the PCB source material is a static variable or compartment of the system of interest. The second formulation is a nonhomogeneous, first-order, linear differential equation in which the PCB source material is treated as an external forcing function of the system of interest. Importantly, the form and nature of the solutions of these two system models are fundamentally different.	Version 1.3 of PRAM is a fugacity based, Level II, equilibrium model. Based on further discussions with Dr. Craig Barber (USEPA) and Dr. Keith Little (RTI), it was concluded that a fugacity based, Level III, equilibrium model would provide a more robust evaluation. As such, PRAM 1.4 has been revised as a Level III model. .
2.1	Although the PRAM Equation 19 is dimensionally correct, its applicability to modeling PCBs in the reefed vessel ZOI must be explained and defended. Likewise, Equations 20-24 must be explained from a process-based perspective. This reviewer cannot understand how thay are applicable to the analysis at hand. PRAM is basically using the nonhomogeneous system model represented in Equations (10) and (11) with all diffusive transport coefficient D_i set to zero. That is, only advective processes drive the compartmental loading/burdens of the ZOI. In this case, the steady-state fugacity of the water is simply (15). Not only does this solution disagree with PRAM Equations 19 and 21, but it also predicts, all other things being equal, a much higher steady-state water fugacity. PRAM's formulation of Equations 19 through 24 must be explained and defended if its predictions are to be believed.	In view of the detailed descriptions provided in Barber (2003), of the structures and quantitative behaviors of various bioconcentration models, PRAM Equation 19, presented in the SHHRA, does indeed appear unexplained/undefended. Moreover, in the section preceding Equation 19, the "D values" used in the fugacity model, that were constructed/defined by Mackay et al., are simply introduced by definition; i.e., "Media-specific D-values incorporate transport and transformation processes with the fugacity capacities of the media or phase (e.g., Mackay et al., 1995)". Further explanation, such as was provided in Barber (2003) (pgs. 1969-1970) is not presented, nor was there any attempt made to compare the strengths/limitations of this model with other bioconcentration models. Similarly, between Equation (19), which defines Fugacity (F) in terms of its relationship to the D values (as well as PCB mass [emission rates]), we "transition", rather abruptly, (i.e. without further discussion) to the equations that show how PCB concentrations for the various media compartments are calculated, based on the fugacity capacity of that compartment. Prior to presenting any of these equations, i.e. on page 5-3, following Equation (7), we provided the following statement "see also Mackay et al., 1995 for a general review of the methodology." We acknowledge that there may be some impedances associated with this approach, and would be interested in pursuing this further with EPA It was not our intent to be parsimonious or presumptive, in the description of PRAM (i.e., for not providing an in-depth defense of the fugacity model) in

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		the SHHRA. Rather, from the continued stages of PRAM development we purposively sought a "pre-defended" model, one that we believed had already received EPA endorsement [in that it was applied in the Great Lakes Water Quality Initiative (USEPA 1995)]. As such, we believed the fugacity model developed by Gobas and Mackay was widely known, and widely accepted as an adequate model for modeling PCB fate and transport at the resolution needed for the PRAM human health risk assessment predictions. As noted previously, PRAM version 1.4 has been revised as a fugacity based Level III equilibrium model, compared to PRAM version 1.3, which was a Level II fugacity based model. Equations presented in the PRAM documentation have been updated to be consistent with the Level III approach. The term D used in PRAM version 1.3 was a transfer parameter that included both diffusive and advective transport. PRAM version 1.4 now incorporates separate diffusion coefficients and advective transport values.
2.2	Regardless of whether the source of PCBs from the reefed ship is an internal static variable or an external forcing function, it is absolutely critical to objectively define and defend the dimensions of the ZOI. The ZOI dimensions must be defined objectively by considering both the physical boundary layers around the reefed ship based on hydrodynamic and diffusion kinetics, and the biological dimensions of the home ranges of the reef-associated fishes that will bioaccumulate PCBs from the near vessel water and from contaminated vessel-encrusting biota.	We agree that the ZOI needs to be objectively defined relative to the physical constraints of the vessel and surrounding environment, as well as the biological community being modeled. The Navy, working closely with modelers and biologists in the Technical Working Groups (TWGs), has defined two ZOIs for use in the ex-ORISKANY SHHRA that are thought to best represent uptake of PCBs released from the reef into the biological community. A ZOI of 2 (equivalent to approximately 15 meters) will be used to model uptake into reef-associated organisms, while a ZOI of 5 (approximately 50 meters) will be used to evaluate less-reef-associated organisms.
2.3	PRAM only models PCB fate and transport between water, total suspended solids (TSS), dissolved organic carbon (DOC), sediment, and air. Biota that will encrust the reefed vessel should or must be added to the model. Encrusting biota must be added for two important reasons. First, encrusting biota would be expected to have tremendously large diffusive transport coefficients (see Equation (5)). As such, encrusting biota would be expected to accumulate significant fractions [of] the leaching PCBs before they can be	The PRAM not only models PCB fate and transport between water, total suspended solids (as organic carbon), dissolved organic carbon (DOC), sediment, and air, but also between these media and in-faunal sediment-associated macroinvertebrates, epi-faunal sediment-associated macroinvertebrates, benthic foraging first-order carnivores, benthic second-order predators, pelagic phytoplankton, zooplankton, pelagic forage fish, pelagic predators, reef-associated foraging invertebrates, reef-associated 1st – order carnivorous fish, reef-associated 2nd – order carnivorous fish, and sessile (encrusted) filter-feeders.

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	transported out of the ZOI by advection. In essence, encrusting biota could act like a capillary retention column for PCBs leaching from the reefed vessel. Secondary, these encrusting biota will obviously serve as the basis of the reef food web. Their contribution by leaching PCBs could dramatically offset projected PCB accumulations in higher reef-associated organisms.	As discussed in the November TWG meeting in Atlanta, direct absorption of PCBs into encrusting organisms from the outer surface of the ship is considered a minor exposure route at most. The exterior of the ship, where most of the encrusting organisms are likely to attach, is not believed to contain PCBs. Interior compartments, while containing potentially significant levels of PCBs in some materials, do not provide prime habitat for encrusting organisms. As such, encrusting organisms on the ship's interior are likely to provide only a small fraction of the overall diet of predatory fish that could be consumed by humans, and would be expected to contribute little to the overall PCB loading in the fish. A discussion of this pathway has been included in the uncertainty section of the SHHRA.
2.4 Editorial Remarks regarding PRAM Non-Biological Model Algorithms		
2.4.1	The units of fugacity capacity are incorrectly cited as $mol \cdot m^{3}$ / Pa. The correct units are $mol \cdot m^{-3} \cdot Pa^{-1}$.	The fugacity capacity units have been revised.
2.4.2	Units of the left-hand side of Equation 20 do not match the units of the right-hand side of the equation, i.e.,….	The Equation has been changed to reflect the correct molecular weight conversion (presently stated as mol / g, this will be changed to g / mol, which will correct the unit error).
2.4.3	Same units issue for Equation 21	See response to 2.4.2
2.4.4	Same units issue for Equation 22	See response to 2.4.2
2.4.5	Same units issue for Equation 23	See response to 2.4.2
2.4.6	Same units issue for Equation 24	See response to 2.4.2
3. PRAM Quality Assurance (QA) and Parameterization Issues		
3.1	The PRAM parameterization for fishes is very subjective and insufficiently researched. For example, pelagic predators are parameterized by data for lake whitefish (coregonids) which are freshwater planktivores. Similarly, reef predators are parameterized as largemouth bass, and benthic predators, that include active species such as groupers (Figure 5-6) are parameterized as flounders that are sedentary.	The fish and invertebrate parameterization within the PRAM was based on our research for a full data set that included energy budgets and temperature-dependent respiration rates. As pointed out by Connolly (1990), the exact species may not be overly importantif the species selected is representative of the organisms within the trophic level, results using alternate species will not be significantly different. We recognize that the use of parameterization values based on freshwater species added a level of uncertainty to PRAM version 1.3. Parameterization values used in PRAM version 1.4 have been revised, and are now based on marine species.
3.2	Lipid fractions described in the SHRRA are not consistent with the 3% default values shown in the PRAM model for all biota.	The "default values" for lipid fraction that are currently displayed within the PRAM (i.e., in the "Default Values" column) are specific to the earlier, Version 1.2, of the PRAM; in this column, the constant 3% value for lipid fraction is shown. In the adjacent, "In Use" column, the specific lipid

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		fractions that were used in the ex-ORISKANY assessment are displayed. As the reviewer has noted, the lipid fractions described in the SHRRA are not consistent with the default values displayed in PRAM. This inconsistency will be rectified before the next submittal.
3.3	Relationships between PRAM default PCB values for K_{ow} and K_{oc} are not consistent with published QSAR relationships. In particular, it is generally assumed that K_{oc} .. = 0.4 K_{gas} (See Karlckhoff (1981) and Seth et al. (1999).) The proportional constant for PRAM default values vary from 0.00966 to 0.141 for tetra-, penta-, hexa-, and hepta-PCBs.	USEPA guidance (1995) was consulted in the development of the PRAM. This guidance recommended the use of empirical K_{ow} and K_{oc} values over estimated values. Thus we searched for measured values in the scientific literature. The K_{ow} and K_{oc} values used in PRAM for the various PCB homolog groups were derived from empirical values for specific PCB congeners. Statistical analyses were conducted to derive proportional constants for the various PCB homolog groups. Documentation of this process was not provided in the SHHRA, but is provided as attachment 1. Attachment 1 compares the K_{ow} and K_{oc} values used in PRAM with the published QSAR values.
3.4	There is a major QA issue with the total PCB water concentrations reported on the *Estimate* output worksheet and the individual PCB water concentrations reported on the *Supplemental Info* output worksheet. In particular, concentrations of individual PCB homologs may exceed total concentrations by three orders of magnitude.	Comment acknowledged. We most sincerely regret our oversight in forwarding PRAM (Version 1.3) to EPA as an unfinished product. As explained above (comment 1.4b), the disparities EPA observed, between the PCB concentrations reported in the *Estimate* output worksheet and the *Supplemental Info* output worksheet, resulted because two of the "scenario analysis" modules in PRAM had not been revised to reflect the specific dimensions, PCB source terms, etc. for the ex-ORISKANY. The Navy acknowledges that the PRAM, once fully updated and revised, consistent with agreed upon improvements, will need a QA/QC review. QA/QC review is being performed prior to re-submittal of the PRAM.
3.5	PRAM must be tested/validated/verified/ corroborated. More specifically, a validation study should be performed to see if PRAM can predict the white grunt data for the ex-VERMILLION. This could be done as a sensitivity analysis, since exact estimates of PCBs on the ex-VERMILLION are unavailable.	To respond to this EPA recommendation, which was verbally relayed in telephone conferences prior to the receipt of written comments, such a sensitivity analysis has been conducted, and has been documented and submitted to the EPA. Specifically, we used a backward calculation to determine what PCB emission rate would have been required at the ex-VERMILLION reef to produce the fish tissue concentrations that were found in the White Grunt samples collected at the ex-VERMILLION reef. As the overall PCB emission rate at a ship-artificial reef is a function of the amount of PCB-containing materials remaining on the vessel, the proportional distribution of those materials, the concentrations of PCBs in each type of material, and the

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		material-specific leach rates, we then disaggregated the emission rate by varying the proportionate amounts of each PCB-containing material assumed to have been onboard the ex-VERMILLION. Initial results, using PRAM in this application, show that the white grunt data can be predicted based on a variety of assumed PCB loadings within the ex-VERMILLION. This sensitivity analysis demonstrated that PCB loading in fish, as a result of assumed leaching from solid PCB-containing materials onboard the vessel, is highly dependent on the amount of those materials that have relatively high leach-rates, and not very dependent on the amount of those materials that have relatively low leach rates.
Conclusions		
1	This reviewer believes that the PRAM risk assessment model should not be accepted in its present form as part of any weight-of-evidence evaluation for the permitting of the reefing of decommissioned US Navy vessels that contain PCB source materials.	The Navy believes that the PRAM represents a viable and important tool in developing a weight-of-evidence for the decision-making process regarding the sinking of the ex-ORISKANY and other decommissioned vessels. The algorithms in PRAM Version 1.4 have been revised to address technical concerns identified by the TWG. The documentation for PRAM Version 1.4 describes these algorithms in detail.
2	Theoretical modeling philosophies aside, this reviewer is extremely concerned with the discrepancies and errors in the model's documentation.	The PRAM documentation has been expanded and revised to address EPA's concerns.
3	Although it may seem like an unfair conclusion, this reviewer believes that errors and inconsistencies in the written descriptions of a model are real or potential indicators that similar errors and inconsistencies may have been propagated in the model's mathematical code. The problems noted in comments 1.4 and 3.4 justify this concern.	Comment acknowledged. The Navy and it's contractors have assembled a technical team to review the PRAM Version 1.4 documentation and coded algorithms to address this concern.
4	PRAM must be validated or corroborated in some fashion before it is accepted as an adequate model for the fate, transport, and bioaccumulation of PCBs from reefed vessels. Presently, no should [such] testing has been documented.	The Navy is evaluating a variety of means of satisfying this issue of corroborating / testing of the PRAM simulations with reported results in the scientific literature. The Navy is looking forward to working with the EPA in defining what acceptance criteria are appropriate and functional for such corroboration and/or testing.

Attachment 1 - "Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels" By Dr. M. Craig Barber USEPA/ORD/NERL/ERD (15 September 2004)

Comment 3.3.
Relationships between PRAM default PCB values for Kow and Koc are not consistent with published QSAR relationships. In particular, it is generally assumed that

$$K_{oc} = \approx 0.4\ K_{ow} \qquad (21)$$

See Karickhoff (1981) and Seth et al. (1999). The proportional constant for PRAM default values vary from 0.00966 to 0.141 for tetra-, penta-, hexa-, and hepta-PCBs.

Response:

The following table presents the log10K_{ow} and log10K_{oc} default values in the PRAM. As the commentor indicates, there is a significant range of values for the K_{oc} : K_{ow} proportionality constant, ranging from 0.028 to 0.141 for the tetra-chlorobiphenyls (Tetra-CBs) through hepta-CBs and are generally smaller than the proportionality value of 0.411 provided by Karickhoff (1981) and referenced in the comment.

Parameter	Mon-CB	Di-CB	Tri-CB	Tetra-CB	Penta-CB	Hexa-CB	Hepta-CB	Octa-CB	Nona-CB	Deca-CB
log10Kow =	4.474	5.236	5.521	5.922	6.495	6.976	7.190	7.696	8.351	9.603
log10Koc =	3.663	4.058	4.625	4.654	4.935	6.080	6.340	6.455	6.965	7.941
Koc/Kow	0.155	0.066	0.127	0.054	0.028	0.127	0.141	0.057	0.041	0.022

We were not able to reproduce the ratio of 0.00966 from the comment, but do not believe that this will materially affect the discussion or response.

Karickhoff also provided an equation based on a linear regression of Log K_{ow} against Log Koc.

$$\text{Log } K_{oc} = 0.989 \log K_{ow} - 0.346$$

The comment also references Seth et al (1999) as a source of a quantitative structure-activity relationship (QSAR) equation. They provided the following equation:

$$\text{Log } K_{oc} = 0.81 \log K_{ow} + 0.09$$

Values for Log Koc and for K_{oc}/Kow derived from these equations from Karickhoff and Seth are compared to those used in the PRAM in the following Tables.

Log Koc	Mon-CB	Di-CB	Tri-CB	Tetra-CB	Penta-CB	Hexa-CB	Hepta-CB	Octa-CB	Nona-CB	Deca-CB
Pram	3.663	4.058	4.625	4.654	4.935	6.080	6.340	6.455	6.965	7.941
Karickhoff	4.079	4.832	5.114	5.511	6.078	6.553	6.765	7.265	7.913	9.151
Seth	3.714	4.331	4.562	4.887	5.351	5.741	5.914	6.324	6.854	7.868

Koc/Kow	Mon-CB	Di-CB	Tri-CB	Tetra-CB	Penta-CB	Hexa-CB	Hepta-CB	Octa-CB	Nona-CB	Deca-CB
Pram	0.155	0.066	0.127	0.054	0.028	0.127	0.141	0.057	0.041	0.022
Karickhoff	0.403	0.395	0.392	0.388	0.382	0.378	0.376	0.371	0.365	0.353
Seth	0.174	0.124	0.110	0.092	0.072	0.058	0.053	0.042	0.032	0.018

The log K_{oc} values selected for use in the PRAM are generally lower than those derived from equations from either Karickhoff or Seth. The equations from Karickhoff and Seth both were derived from a variety of hydrophobic organics. Several other papers (Di Toro (1985), Endicott et al (1990), Kenaga and Goring (1980) and Lyman (1990) have presented similar QSAR equations. These equations area presented below.

$$\log K_{oc} = 0.983 \log Kow + 0.00028 \qquad \text{Di Toro (1985)}$$

$$\log K_{oc} = 0.442 \log Kow + 3.54 \qquad \text{Endicott et. Al (1990)}$$

$$\log K_{oc} = 0.544 \log Kow + 1.377 \qquad \text{Kenaga and Goring (1980)}$$

$$\log K_{oc} = 0.442 \log Kow + 3.54 \qquad \text{Lyman et al (1990)}$$

These equations have commonly been used for estimating K_{oc}s for PCBs. For example, EPA (2000) has used the Endicott equation to study the effect of partitioning of PCBs among different phases in evaluating the effect of zebra mussels on bioavailability of PCBs. The Lyman equation is used in the Risk-Integrated Software for clean-ups (RISC) described below for estimating K_{oc} values for PCBs for which experimentally determined K_{oc}s are not available. Zeng et al (1997) have used the Kenaga and Goring relationship in studying PCB congener bioaccumulation patterns in Sea Urchins (*Lytechinus pictus)* with equilibrium partitioning predictions and empirical relationships obtained for other marine species. The Di Toro equation has been used by US EPA for estimating K_{oc} values that were used in calculating sediment quality criteria (for non-ionic organic contaminants (EPA 1993).

When these equations are applied to the Kow values used in the PRAM, a set of representative calculated Log K_{oc} values is obtained. Figure 1 presents a comparison of these calculated values for Log K_{oc}. Also plotted in this figure are the Log K_{oc} values used in the PRAM. As can be seen in Figure 1, the values used in the PRAM generally fall about in the middle of the range of values calculated from these published QSAR equations. Thus, the default values used in the PRAM are considered to be consistent with published QSAR equations for PCBs.

The K_{oc} values used in the PRAM were derived in two ways. For the mono-CB through hexa-CB homologous series, there existed K_{oc} measurements in the literature for congeners in these homologous series from which to calculate a K_{oc} value to use in the PRAM. For the PRAM, the K_{oc} values from Chou and Griffin (1986) were used to calculate Koc values for each of these homolog groups. The K_{oc} values used for these homolog groups correspond to the geometric mean of the K_{oc} values measured for the individual congeners within an homologous series. Insufficient measurements of K_{oc} were found in the literature to allow determination of representative values for K_{oc} for the hepta- octa-CB, nona-CB and deca-CB homologous series. Therefore, a QSAR approach was taken to estimating these values. The equation used was one developed by Lyman (1990).

$$\textbf{Log } K_{oc} = 0.779 \log K_{ow} + 0.46$$

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

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

Thus, EPA selected measured K_{oc} values for use in the reassessment when they were available and used the values derived by QSAR methods in those cases in which measured data were not available. This is identical to the approach adopted in selecting the default parameters in the PRAM.

The approach used in the PRAM is also consistent with that used in Risk-Integrated Software for clean-ups (RISC). RISC is software developed by Lynn Spence and BP Oil, Ltd for performing human health risk assessments for contaminated sites. Fate and transport models are available to estimate receptor point concentrations in groundwater and other media. Experimentally measured K_{oc} values were used for many chemicals in the database. The following references were used as a source of K_{oc} values (by order of preference):

1. EPA's Soil Screening Guidance: Technical Background Document (EPA 1996b).
2. EPA: Basics of Pump and Treat Groundwater Remediation Technology (EPA 1990)

Consistent with the approach in the PRAM, the RISC model uses the equation listed above from Lyman (1990) for estimating K_{oc} for some compounds for which a measured K_{oc} is not available.

Thus, we believe that the K_{oc} values used in the PRAM are adequately representative of the PCB partitioning. As described in the dioxin reassessment report (EPA 2003), experimentally determined K_{oc} values were used when available and the use of QSAR relations was restricted to those situations for which there were insufficient empirical K_{oc} data available. We believe that these values should be used in the PRAM, but recognizing that other partitioning models might be preferred by the end-user, we have programmed in the ability to easily substitute other K_{oc} values or K_{oc}/Kow QSAR equations.

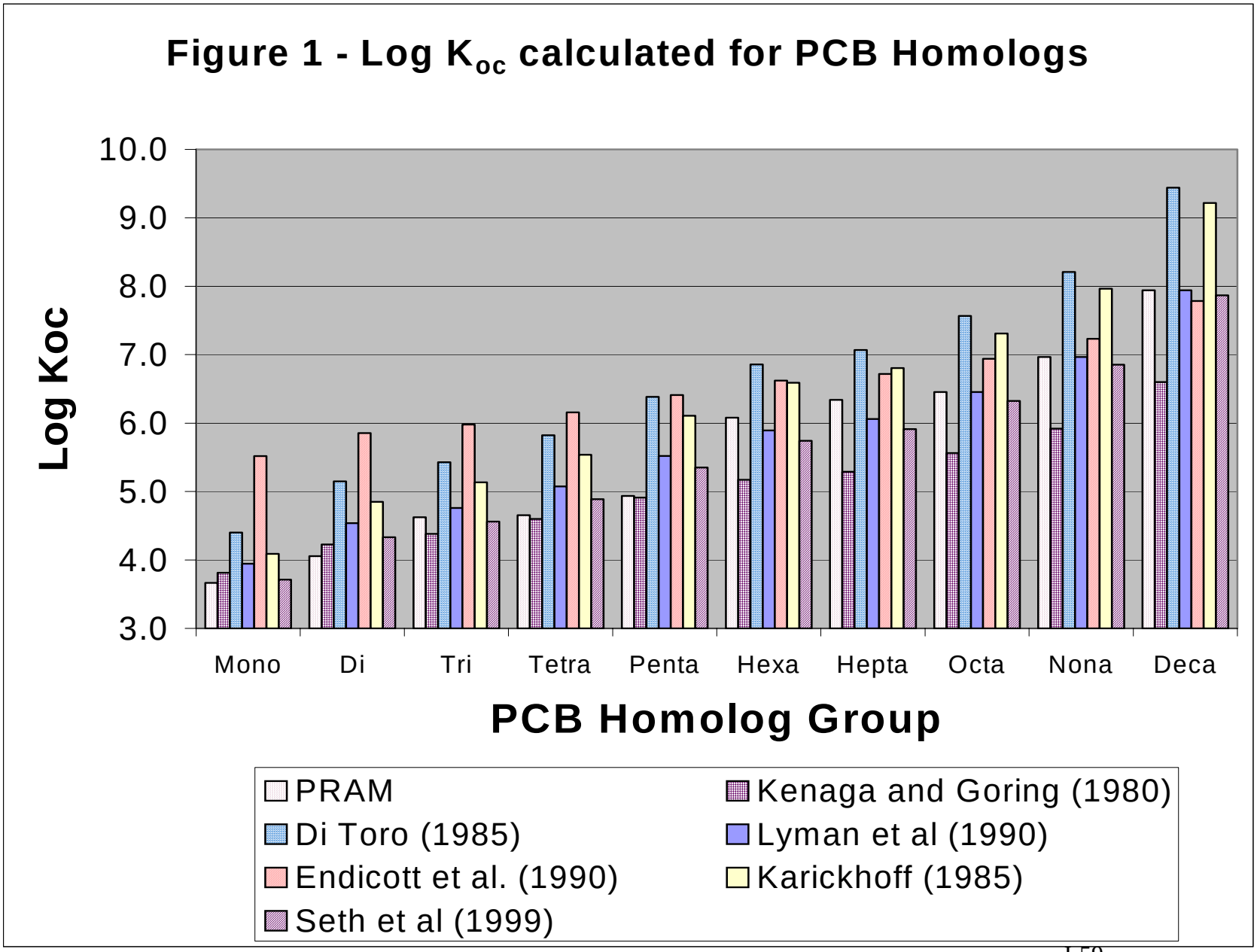
Figure 1 - Log K_{oc} calculated for PCB Homologs
Log Koc
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
Mono
Di
Tri
Tetra
Penta
Hexa
Hepta
Octa
Nona
Deca
PCB Homolog Group
PRAM
Kenaga and Goring (1980)
Di Toro (1985)
Lyman et al (1990)
Endicott et al. (1990)
Karickhoff (1985)
Seth et al (1999)

References:

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Karickhoff, S.W., 1981: Semi-Empirical Estimation of sorptiono of Hydrophobic Pollutants on Natural Sediments and Soils, Chemospher, Vol 10, No. 8, PP 833-846,

Kenaga, E.E. and C.A. Goring. 1980: Relationship between water solubility, soil sorption, octanol-water partitioning, and concentration of chemicals in biota. pp. 78-115 in: J.G. Eaton, P.R. Parrish and A.C. Hendricks (eds.), Aquatic Toxicology. American Society for Testing and Materials, Special Technical Publication 707. New Orleans, LA.

Lyman, W.J., W.F. Reehl and D.H. Rosenblatt. 1990: Handbook of Chemical Property Estimation Methods. American Chemical Society, Washington, DC. Cited in HSDB, 1990.

Seth, R. Mackay, D. and Muncke, J. 1999: Estimating the Organic Carbon Partition Coefficient and Its Variability for Hydrophobic Compounds.

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USEPA, 1996b: Soil Screening Guidance: Technical Background Document, OSWER, EPA/540/R-95/128.

USEPA, 2000: The Effect of Zebra Mussels on Cycling and Potential Bioavailability of PCBs: Case Study of Saginaw Bay FINAL COPY, Prepared by Joseph V. DePinto, Jagjit Kaur, Victor J. Bierman, Jr., and Timothy J. Feist for the U.S. EPA Great Lakes National Program Office http://www.epa.gov/glnpo/invasive/zmussels/.

USEPA, 2003: Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p - Dioxin (TCDD) and Related Compounds, ORD, EPA/600/P-00/001Cb, NAS Review Draft

Zeng, E. Bay, S. Vista, C. Yu, C. and Greenstein, D. 1997: Bioaccumulation and Toxicity of Polychlorinated Biphenyls in Sea Urchins Exposed to Contaminated Sediments pp. 79-89 *i*n: S.B. Weisberg, C. Francisco and D. Hallock (eds.), Southern California Coastal Water Research Project. Westminster, CA http://www.sccwrp.org/pubs/annrpt/96/ar-08.htm

Appendix J

Response to EPA Comments

Document 3 ORISKANY Human Health Risk Assessment (HHRA) Response to Comments (FINAL)

<table>
<tr><th></th><th>COMMENT</th><th>RESPONSE</th></tr>
<tr><td colspan="3">Major Comment</td></tr>
<tr><td>1</td><td>Section 2.2, page 2-2 stated that approximately 330 kg of PCBs are estimated to remain on-board after the ex-Oriskany is prepared for sinking. There are discrepancies in the estimated amount of PCBs left on-board as presented in Table 4-1 and Table 13 (Appendix D). Table 13 (Appendix D) estimated 330 kg PCB (=722.6 lb) left on-board, which agrees with the Section 2.2 statement. But, table 4-1 estimated about 56,420 kg, which is 170 times higher than the estimated value shown in table 13 (appendix D). EPA noticed that the current material mass (FWR Mass*A*B*C) was multiplied by the percentage of PCBs in the material instead of the fraction (%/100) leading to the incorrect PCB mass values as well as overestimating total mass of PCBs (56,442 kg). The revised calculations are below.

<table>
<tr><th></th><th colspan="2">Original Mass (1 kg= 2.2 lb)</th><th colspan="3">Adjustment Factors</th><th></th><th colspan="2">Current material mass (original mass*A*B*C)</th><th>PCB Fraction in material</th><th colspan="2">Current material mass * fraction PCB</th><th>Fraction of total PCB on board (%)</th></tr>
<tr><td></td><td>lbs</td><td>kg</td><td>CACI</td><td>30 yr growth</td><td>Mass remaining after preparation</td><td>Fraction Mass remaining</td><td>lbs</td><td>kg</td><td>%/100</td><td>lbs</td><td>kg</td><td>(Fraction PCB of material/total *100)</td></tr>
<tr><td>Vent Gaskets</td><td>2,680</td><td>1218.181818</td><td>1</td><td>1.2</td><td>100%</td><td>1</td><td>3216</td><td>1462</td><td>0.0000314</td><td>0.100982</td><td>0.0459</td><td>0.01</td></tr>
<tr><td>Lubricants</td><td>208,140</td><td>94609.09091</td><td>1</td><td>1</td><td>0%</td><td>0</td><td>0</td><td>0</td><td>0.0001</td><td>0</td><td>0</td><td>0.00</td></tr>
<tr><td>Foam Rubber material</td><td>0</td><td>0</td><td>na</td><td>na</td><td>na</td><td>na</td><td>0</td><td>0</td><td>0.0076</td><td>0</td><td>0</td><td>0.00</td></tr>
<tr><td>Rubber products</td><td>11,898</td><td>5408.181818</td><td>1</td><td>1</td><td>100%</td><td>1</td><td>11898</td><td>5408</td><td>0.000053</td><td>0.630594</td><td>0.28663</td><td>0.05</td></tr>
<tr><td>Cable insulation</td><td>403,600</td><td>183454.5455</td><td>1.384</td><td>1.3</td><td>90%</td><td>0.9</td><td>653541</td><td>297064</td><td>0.00185</td><td>1209.052</td><td>549.569</td><td>97.19</td></tr>
<tr><td>Bulkhead Insulation</td><td>115,695</td><td>52588.63636</td><td>1</td><td>1</td><td>27.40%</td><td>0.274</td><td>31700</td><td>14409</td><td>0.00054</td><td>17.11823</td><td>7.78101</td><td>1.38</td></tr>
<tr><td>Paints</td><td>298,999</td><td>135908.6364</td><td>1</td><td>3</td><td>95%</td><td>0.95</td><td>852147</td><td>387340</td><td>0.00002</td><td>17.04294</td><td>7.74679</td><td>1.37</td></tr>
<tr><td>Total</td><td>1,041,012</td><td>473,187</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1243.944</td><td>565.43</td><td></td></tr>
</table>

These calculations estimated 565 kg, not 330 kg, PCBs left on-board. Since 565 kg is a higher estimate, the human health risks might have been underestimated. Section 2.2 also states that electrical cables accounts for 95% of the total PCBs aboard the vessel, with BHI accounting for 3%. The revised calculations estimated 97% and 1% for electrical cables and BHI, respectively.

Section 4.3 indicated that "the mass of material estimated to remain onboard the ship, together with the normalized average leach rates developed from the Leachate Release study (George et al., 2005b) provide the source terms for the PRAM". Therefore, RAD recommends that the table data and PRAM inputs for PCB-containing materials are verified followed by a rerun of the PRAM model to make sure that the risk estimates are within EPA acceptable criteria.</td><td>The 330 kg and 565 kg estimates represent the arithmetic mean concentration and the 95% upper concentration limit (UCL), respectively, of PCBs in bulk materials remaining on the ex-ORISKANY. Table 4.1 will be modified to correct the PCB mass calculation error and to include 95 % UCLs.

PRAM calculations all used the 565 kg 95% UCL estimate as the source term for PCBs. Therefore, human health risks were appropriately calculated and PRAM does not need to be rerun. The revised HHRA will indicate that the 95% UCL estimate of PCB source mass remaining on the ex-ORISKANY was used to predict human health risks.</td></tr>
</table>

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	COMMENT	RESPONSE
	In addition, it would be informative if table 4-1 includes the 95% UCL (lbs, kg) as currently appearing in table 13 (appendix D).	
	General Comments	
1	**Calculation Error** - A significant discrepancy in the assessment was that our calculations showed that 565 kg, not 330 kg, of PCBs are estimated to be on board. Since the mass of material that remains on board as well as the average leach rates serve as source terms for the PRAM model, it is strongly recommended that the PRAM PCB input be verified and rerun to determine if any risk estimates are changed as a result of the higher PCB content on board the ship. See Major Comments, above.	See response to Major Comment 1.
2	**Pycnocline Issues** - Numerous questions regarding Sections 4.1 - 8.1 and Tables 4-3 and 4-5 are raised. These questions focus on issues such as leach rates and their influence on the risk assessment, how variations in the pycnocline might affect the risk estimates, and assumptions regarding the steady state being reached at day 730.	Responses to the topics identified in this comment are addressed within the specific comment section. Specifically, pycnocline questions are addressed in response to Specific Comment 6; leach rate questions are addressed in response to Specific Comments 2, 5, 7 and 27; and timing for reaching steady state conditions is addressed in response to Specific Comment 7. Please refer to these specific comments accordingly.
3	**Developmental Risks** - Risks to pregnant women were not addressed and should be considered/discussed since there are possible developmental and neurotoxic effects associated with PCBs.	The potential for risk from intrauterine exposures to PCBs was discussed briefly in Section 7.5.2 and Section 9.4.2 of the HHRA. A more extensive discussion of this topic will be provided in the revised HHRA. Recent toxicological studies of PCBs, including epidemiological studies suggesting adverse effects from *in utero* exposures, have not been incorporated into US EPA's RfDs for PCBs (USEPA, 2005). Therefore, risk from prenatal exposure is not quantitatively evaluated; instead prenatal risk will continue to be addressed qualitatively in the revised HHRA.
4	**General Document Considerations -** Some topics are well developed in the HHRA whereas others lack the necessary information to perform a sound review. Consequently, it was necessary to check other supporting documents and sometimes the discussions were too fragmented and multiple documents had to be referred to before understanding the issue. Assumptions should be transparent, well explained and justified by primary and supporting data. Assumptions should be transparent, well explained and justified by primary and supporting data. This should be improved throughout the document. An extensive QC process should be done to avoid such problems in the	We have undertaken an extensive internal technical review of consistency and clarity of presentation within and among the six technical documents for the ex-ORISKANY. The Navy will modify the HHRA based on this review and anticipates that the modifications will address the concerns raised in this comment. Given the volume of information that must be presented for this project, the HHRA will still need to reference other documents for more detailed discussion of selected topics. However, these references will be specific so that the reviewer does not waste time searching for the information. Also, a brief, general overview of the documents will be prepared to help the reviewer navigate through them.

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	COMMENT	RESPONSE
	final documents.	
	Specific Comments	
1	Executive summary, page ES-1 indicated that the ex-Oriskany reef should be on its way to maturity after 2 years without offering a citation. A discussion of the data supporting this position should be included.	The revised HHRA will include a brief discussion of the scientific literature relevant to the proposed ex-ORISKANY artificial reef to document expected reef progression over the initial two-year period. While there is no reef-associated community on the ship at the time of sinking, colonization by many reef organisms is likely to start almost immediately once the ship is sunk. Based on observations of other artificial reefs constructed from a variety of materials, colonization by organisms such as algae, barnacles, and fish occurs within a few weeks of immersion (Walker et al. 2002, Golani and Daimant 1999, Sherman *et al.* 1999, Clark and Edwards 1994). Bohnsack *et al.* (1994) noted that fish colonization of artificial reefs off southeastern Florida was very rapid, and within two years post-deployment, fish assemblages were abundant and diverse. That study was supported by a more recent evaluation of several types of artificial reefs off the coast of southeastern Florida, which documented increased fish abundance and richness, including higher trophic sport fish such as groupers and snappers, at two years post-deployment of the reefs (Walker et al.2002). Other studies in southeastern Florida have also found rapid colonization of artificial reefs by fish assemblages. Cummings (1994) found that species diversity within the fish community reached equilibrium within 2.5 months at a shallow artificial reef. Sherman *et al.* (1999) observed predatory fishes such as groupers, snappers, and jacks at their artificial reefs prior to two years post-deployment. Studies of artificial reefs in other marine waters have similarly found rapid fish recruitment. In the Mediterranean Sea, Coll *et al*. (1998) reported that after the first 17 months, deployment time did not affect fish species composition. Clark and Edwards (1994) also found rapid colonization of artificial reefs by fish, with increased richness observed at 12 months of deployment. Golani and Diamant (1999) found that the number of fish species at artificial reefs in the Red Sea increased during the first seven months after deployment, and then leveled off for the remainder of the 2-year study. Species from a variety of trophic guilds were observed to be residents of the artificial reef within two years post-deployment, including predatory fishes such as groupers (e.g., *Cephalopholis hemistiktos, Epinephelus fasciatus*). Based on these studies, a two-year time period is considered sufficient to account for uptake of PCBs through the food web to

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	COMMENT	RESPONSE
		higher trophic level fish that would be consumed by humans. The focus on reef development during the initial period after vessel sinking is necessary to evaluate the potential effects on reef organisms and uptake into fish from transient releases of PCBs from the bulk products. This issue was discussed in detail with members of the biology technical working group, including representatives from EPA and State of FL (Escambia County and Florida Fish and Wildlife Conservation Commission). This information and relevant citations will be provided in the revised HHRA.
2	Section 4.1, page 4-2 described the leach-rate study. The document acknowledged that the leach-rate study was conducted under abiotic conditions and that the influence of biological organism degradation on the leaching of PCBs is unknown. However, the document failed to justify why leach-rate data from abiotic conditions could be used as a good predictor of what it will happen in the marine environment. Such discussion should be included in the document.	We concur that it is possible for biological factors to influence the release of PCBs. However, the extent, mechanisms, and potential effects of biodegradation processes on matrices similar to shipboard solids are largely unknown. We will discuss this uncertainty in the revised HHRA. We also refer the reviewer to the response to SAB General Comment 1 on the Leach Rate Report.
3	Section 4.1.1, page 4-3 presented data from the final report entitled "Polychlorinated biphenyls (PCB) Source Term Estimates for ex-Oriskany (Appendix D)". The sampling protocol used for this analysis should be detailed. Also explain how the protocol ensured the collection of representative samples from materials containing high, medium and low concentrations of PCBs aboard the ex-Oriskany. Discussion of the sampling protocol should at least appear in the PCB Source Term Estimates final report.	The PCB sampling performed on the ex-ORISKANY was done in accordance with the NAVSEA PCB ADVISORY 95-1, dated 21 September 1995. NAVSEA also maintains a database on PCB sampling and, in addition to the sampling results specific to any vessel such as the ex-ORISKANY, NAVSEA can consult the database to confirm that the sampling results for a given ship are within the norms for all other ships that have been sampled. The sampling protocol that was followed for the ex-ORISKANY is based on the Navy's historic knowledge of the presence of PCBs in shipboard components. This user knowledge and the database were used to develop and implement what Navy believes to be an appropriate sampling protocol for the ex-ORISKANY because it is based on the best available knowledge from PCB sampling data that represents a large number of ships and their potentially PCB-containing components. The HHRA will be revised to include a brief description of the sampling protocol.
4	Section 4.1.2, page 4-3: The document should indicate background levels of PCBs (presumed to be 0) in artificial seawater before the conduct of the leach-rate experiments.	The leach rate studies were conducted using ASTM standard artificial seawater. The Navy sampled and analyzed (a) seawater blanks, which were clean seawater for each 20L batch (the "source" of clean leachate), and (b) procedural blanks, which were leaching vessels with clean seawater and cage/filter apparatus but no shipboard solid or Aroclor control. No PCBs were detected in these samples. The relevant data can be found in Appendix C of the Leach Rate Report (data for procedural blanks begin on p. 651, and data for

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	COMMENT	RESPONSE
		seawater blanks begin on p. 662). The revised HHRA will clarify this issue.
5a	Section 4.1.2, pages 4-4 and 4-5: The reference is missing for the statement "A regression analysis of detected PCB concentration data on a homolog basis showed that PCB releases decrease exponentially over time". If these data are from the leach-rate study, then the report should be cited.	Comment acknowledged. The revised HHRA will cite the Leach Rate Report.
5b	Section 4.1.2, pages 4-4 and 4-5: Explain why the analysis was conducted on the natural log transform.	The log transformation was used to simplify and perform a linear regression analysis of the decreasing portion of the leach rate curves, in a very general, but consistent manner. The decreasing leach rate behavior can generally be described by the power function $y = 10^A x^B$, where y is the average leach rate and x is time. The leach rate data were fit using the logarithmic form of this power function (in "y = mx + b" form), log[y] = B log[x] + A.
5c	Section 4.1.2, pages 4-4 and 4-5: A clarification statement should be added to this section regarding whether dioxin-like PCBs were included in the leach-rate analysis.	Yes, dioxin-like PCBs were included in the leach rate analysis. This will be clarified in the revised HHRA.
5d	Section 4.1.2, pages 4-4 and 4-5: On Table 4-3, electrical cable showed no detection levels for mono-, di-, octa-, nona- and deca-chlorobiphenyls, but the discussion claimed that mono- and octa-biphenyls were not detected. Please clarify.	Table 4-3 incorrectly lists the number of detections for di-, nona-, and deca-chlorobiphenyls as "0". The correct values for these congeners (see data summary in Appendix A of the PRAM documentation) are: di-chlorobiphenyl - 3 detections; nona-chlorobiphenyl - 1 detection; and deca-chlorobiphenyl - 1 detection. Table 4-3 will be corrected in the revised HHRA.
6a	Section 4.2.1, pages 4-6 and 4-7: The pycnocline was fixed at 15 m based on diver experience. Pycnoclines are variable within seasons and could be located >15 m or <15 m. The author should discuss how seasonal variability in the pycnocline depth can impact the PRAM-predicted human health risks. Also discuss whether this variability can be considered a source of uncertainty in the time dynamic model (TDM).	Data obtained from http://www.nodc.noaa.gov/OC5/indprod.html show that the pycnocline is relatively non-existent during the winter due to storm mixing and insufficient sunlight to stabilize the water column. The pycnocline gradually establishes throughout the spring, strengthens and deepens, and reaches a maximum of approximately 15 meters in October, according to Rob Turpin of Escambia County. As the weather cools, mixing (and PCBs) likely will extend from the top to near the bottom. Qualitatively, PCBs originating from the ex-ORISKANY will have access to surface waters in the winter and spring, and gradually will be limited to and concentrated in near-bottom water in the summer and fall. A pycnocline has the mathematical effect of "concentrating" PCBs in the lower water column. Thus, eliminating the pycnocline, which is likely the case during winter, has the effect of diluting PCB concentrations. PRAM, as a steady-state model, uses the average pycnocline depth. The steady-state

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		structure of PRAM is designed to simulate the long term impacts of sinking a ship. The variability in the pycnocline, even if explicitly modeled, is expected to lead to similar average predicted concentrations. It is possible to model this explicitly in the TDM, but we do not anticipate appreciably different predicted concentrations, particularly when averaged for input into the PRAM. Also refer to the response to EPA Specific Comment 5 on the TDM report.
6b	Section 4.2.1, pages 4-6 and 4-7: Define (with citation) what source supported the assumption that PCBs are released within the ship volume at one minute intervals and mix instantaneously into the interior wall.	To our knowledge, there are no published scientific studies which conclude that PCBs would likely be released within the ship volume at 1-minute intervals or that the PCBs so released would mix instantaneously in the interior vessel's bulk water. The assumption of 1-minute release intervals and instantaneous mixing facilitate modeling. In this case, the one minute time step in the TDM model allows for 15-meter resolution in PCB concentration predictions. In reality, PCBs are likely being released continuously, albeit at very slow rates from the bulk materials inside the vessel, and are mixing non-instantaneously with the media compartments in the vessel's interior water. The choice of a time step depends on the degree of resolution needed to appropriately model the release of PCBs from the ship into the marine environment and the concentrations that result in the various abiotic and biotic media. The initial TDM program calculated concentrations in 1-second release intervals. This approach yielded a data file so large that it could only be transmitted to reviewers by copying it to a computer hard drive and mailing the hard drive to the reviewers. Navy scientists, Dr. Craig Barber of EPA, and others agreed that 1-minute intervals were more than adequate to determine PCB concentrations in abiotic media, given that these concentrations would be used to calculate uptake of PCBs in fish and other biota.
6c	Section 4.2.1, pages 4-6 and 4-7: Assumptions should be supported by references or explaining the logical thinking behind them. Discuss the effects of a hurricane passing through the ex-Oriskany reef site and whether the assumptions would still be valid.	Extensive data on hurricane paths over the last thirty years are available from NOAA at: http://www.nhc.noaa.gov/verification/verify7.shtml. The passage of a hurricane could potentially damage the reef and impact the underlying modeling assumptions in several ways, including short-term increase in PCB releases 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 discussion of possible impacts with appropriate citations will be included in the revised HHRA.
7	Section 4.2.2, page 4-11 states "It is assumed that the community structure and PCB release rates will have both reached a steady-state condition at Day 730 (i.e., at the two-year mark)." Provide the basis of	The revised HHRA will provide more detail concerning this assumption. Please refer to response to Specific Comment 1.

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	COMMENT	RESPONSE
	this assumption. Explain the basis of the assumption in view of the primary and supporting data.	
8	Section 4.3: As stated in the PRAM document, PRAM has not undergone extensive testing and validation. It was mentioned in the Appendix K ("Response to EPA comments") that "…PRAM version 1.3 predicted PCB concentrations in trophic level 3 and trophic level 4 (Vermilion Snapper and Black Sea Bass) that are similar in comparison to the empirical data from the ex-VERMILLION reef for the Vermillion Snapper and Black Sea Bass." In addition, it was indicated that "the recently revised version of PRAM (version 1.4c) also predicts PCB concentrations in this range. This indicates that PRAM can predict a reasonable range of PCB concentrations that could be found in fish tissue associated with the ex-VERMILLION." Details of this validation exercise should be included in the report, including a comparison between the PRAM-predicted PCB values and the ex-Vermillion empirical data. Explain why background PCB levels in fish were not included into the PRAM algorithm.	PRAM cannot be validated against the results of the ex-VERMILLION because the PCB sources on that ship are not sufficiently understood. The discussion regarding the use of PRAM to predict fish tissue concentrations at the ex-VERMILLION site relates back to previous EPA questions (TWG meetings in August/September 2004) about whether PRAM was capable of predicting fish tissue concentrations comparable to those seen at the ex-VERMILLION site. We performed a quick analysis to demonstrate that, if one were to make a number of assumptions regarding the amount and distribution of PCBs that could have been on the ex-VERMILLION at the time of sinking, then PRAM (1.3 version) could predict fish tissue concentrations comparable to the levels found in fish collected at the ex-VERMILLION reef. This exercise primarily demonstrated the need to have accurate information on the amount (mass) of PCBs remaining on a sunken vessel as well as the distribution of those PCBs because the release rates of PCBs from bulk materials vary significantly, dependent on the type of PCB-containing bulk material. In addition, it is not appropriate to compare PRAM-predicted PCB values with the ex-VERMILLION empirical data because PRAM predicts only the incremental risks associated with releases of residual PCBs on the ship, whereas the fish collected from the ex-VERMILLION reef would have potentially accumulated PCBs from sources other than the ex-VERMILLION. The current version of PRAM (version 1.4) is a fugacity model that predicts PCB concentrations in abiotic media and the food web. While it has not undergone validation, the fugacity modeling and, specifically, the bioenergetic elements of the food web in PRAM are constructed similarly to a number of EPA models that provide a theoretically sound basis for predicting PCB concentrations at the reef. Also, the PRAM food web model predicts bioaccumulation factors similar to those predicted by BASS/FGETS, which was developed by EPA (See EPA General Comment 3 on PRAM, version 1.4c documentation, May 2005). Background levels of PCBs in fish tissue were not considered because PRAM is designed to model the incremental risks associated with exposures to PCBs originating in shipboard materials. Thus, the model does not estimate risks

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		from other sources. The uncertainty section will acknowledge this distinction.
9	Section 4.3.1, page 4-13: The 0.01 fraction of the prevailing water current that was used in modeling the interior flow rate should be defined relative to similar literature assumptions.	The Navy did not find relevant literature on flow rates within sunken vessels. The water current in the interior of the ship depends on the exterior water current as well as the number of openings and connections. The proposed sinking plan of the ex-ORISKANY indicates a minimal amount of openings into the ship's interior. We acknowledge the comment as an area of uncertainty and will discuss the potential impacts of varying this assumption in the revised HHRA. Also refer to the response to EPA Specific Comment 4 on the TDM report.
10	Section 4.3.2, page 4-33: Considering the consistent yearly hurricane incidences experienced by Florida, the author should consider catastrophic weather activities (perhaps in the uncertainty section) in the analysis.	Please see response to Specific Comment 6 (c). This issue will be addressed in the revised HHRA.
11	Section 6.2, page 6-3: Divers can be exposed to PCBs in the water column via a limited dermal pathway. The site conceptual exposure model depicted in Figure 6-1 does not illustrate this pathway.	The depiction of this pathway in Figure 6-1 will be clarified to better illustrate that it is a complete pathway for the diver.
12	Section 6.2.3, page 6-5 states "Because of the very low concentrations of PCBs that are expected in the water column at the ex-ORISKANY reef site, exposure to PCBs via this route is expected to pose a minor route of exposure." Sentence should indicate that Section 9.5 contains the dermal risk assessment supporting this claim. In addition, the water ingestion pathway is not mentioned in this section and should be added because it is a possible route of exposure. This section should also mention why the ingestion pathway was not evaluated further.	Incidental ingestion of seawater is unlikely to be a significant exposure pathway given the diving requirements at this depth. The text will be expanded to include a discussion on the oral route of exposure. In addition, Section 6.2.3 will be revised to reference Section 9.5 as containing the appropriate discussion on the dermal route of exposure.
13a	Section 6.2.4, page 6-6: Provide reference that supports the assumption that "fish caught by trolling have shorter residence times at the reef".	The reference will be provided.
13b	Section 6.2.4, page 6-6: Include children as potential human receptor population. This appears in the summary section (6.2.6) but was not mentioned in Section 6.2.4.	The text in Section 6.2.6 will be revised.
14	Section 6.2.6, page 6-7: The exposure scenario considered adult recreational fisherman and children as potential populations exposed via fish ingestion. Pregnant women and the fetus could be potentially exposed to PCB-contaminated fish originated from the ex-Oriskany reef site. A number of studies have reported possible developmental and neurotoxic effects in children from pre-natal or post-natal exposures to PCBs. The authors should include a section discussing such findings	The revised HHRA will contain a qualitative discussion of prenatal exposures and will quantify exposures to nursing infants via breast milk ingestion (also please see the response to General Comment 3 above).

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	and explain why potential adverse health effects from pre-natal and post-natal exposures were not considered in this HHRA.	
15	Section 6.2.7, page 6-9: The document indicates the use of ZOIs of 2 and 5. Because the ZOI is likely the most subjective parameter input entered into the PRAM, the reasoning behind its selection should be thoroughly explained in this section.	A detailed discussion of the choice of ZOI values is provided in Appendix L of the HHRA. The specific values were chosen based on the biology (foraging and behavior and habitat preferences) of representative reef fish species. Additional discussion will be added to Section 6.2.7 summarizing the rationale for the choice of ZOI values used in the HHRA, and the reader will again be referred to Appendix L for the detailed discussion.
16a	Section 6.3.1, pages 6-10 and 6-11: 1st paragraph, 2nd sentence has a typo ("rats" should be "rates").	Comment acknowledged. The sentence will be corrected.
16b	Section 6.3.1, pages 6-10 and 6-11: Last paragraph states "The IR term for total fish is applied to the consumption of each species of fish and shellfish in this HHRA. In other words, species-specific ingestion rates are not assumed, and the total fish ingestion rate is not adjusted to account for the consumption of different species from the site." Is this approach taken because there are no data for shellfish and therefore the fish ingestion rate for finfish is used for every kind of fish? Clarify this approach and include the justification in this section.	The assumption is made that the ingestion rate applies to each species, as opposed to evaluating the mix of species that anglers might consume. The risks calculated using this integrated approach encompass all possible risks one would calculate assuming different mixtures of species in an angler's diet. Also, as the reviewer suggests, insufficient data are available to quantify the fraction each fish species contributes to the diet of anglers consuming fish from the future reef. Divers are not likely to collect much shellfish given their brief time at a reef that will be approximately 200 feet below the water surface. Therefore, use of the ingestion rate for finfish likely overestimates exposure to shellfish. The revised HHRA will provide this more complete discussion of the fish consumption rates used to quantify exposure to PCBs in finfish and shellfish.
17	Section 6.3.2.2, page 6-12: It is atypical that the RME estimate be lower that the CTE. Perhaps the values should have comparable sources.	The site-specific data used in the risk assessment show that less frequent anglers tend to return to the same location, while more avid anglers tend to fish from multiple locations. The FI terms are derived from the angler surveys conducted by representatives from Escambia County and the State of Florida. The results of the survey indicate that individuals who reported fishing the most frequently (RME populations) also fished in more areas and consumed fish caught in all of those areas, thus reducing the FI for any one fishing location. Additional supporting text will be included in the revised HHRA.
18	Section 6.3.3, page 6-13: The ingestion rates used are daily rates averaged over 365 days per year. Clarify whether this implies consumption of fish 365 days per year.	The ingestion rate does not imply consumption of fish 365 days per year. The ingestion rate is an annual average daily ingestion rate. It is calculated by dividing the total amount of fish consumed in one year by 365 days. US EPA guidance typically reports fish ingestion rates in this manner, and these rates do not mean that the consumer is eating fish every day. The revised HHRA will clarify this issue.
19	Section 6.3.4 states that "during the first 90 days after vessel sinking,	While there are uncertainties regarding the predicted PCB concentrations in

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	the primary human PCB exposure will be for recreational divers through direct skin contact with water while diving. Water PCB concentrations are at their maximum in the first few weeks after vessel sinking". Due to high concentrations of PCBs during the first days after sinking, divers should be protected and therefore access to the ex-Oriskany reef site should be restricted until such high concentrations decrease.	water during the first 90 days post-sinking, it does not appear necessary to restrict diving during this period because (1) the predicted water concentrations are very low (4E-9 mg/L in the lower water column, 3E-14 mg/l in the upper water column), and (2) the amount of time a diver could spend near the ship is likely to be very short because of the proposed sinking depth of the vessel. Our discussion in the HHRA concerning the diver scenario concludes that there is a low degree of exposure because of the limited duration of submergence for typical recreational dives at the proposed depth. Thus, it is unlikely that a diver would be exposed to unacceptably high concentrations of PCBs while diving.
20	Section 6.3.6, page 6-14: The exposure duration used for the adult population was 30 yrs (default value), which is based upon the time spent at a single residence. The "Revised Human Health Risk Assessment, Hudson River PCBs Reassessment RI/FS" (November 2000; page 103) has a statement referring to this exposure: "While Superfund risk assessments typically use the length of time that an individual remains in a single residence as an estimate for exposure duration, such an estimate is not likely to be a good predictor of angling duration, because an individual may move into a nearby residence and continue to fish in the same location, or an individual may choose to stop angling irrespective of the location of their home". Using US Census data, the Hudson River HHRA estimated the range of residence durations within 6 counties surrounding the Mid-Hudson River as the basis to determine the exposure duration. The Hudson River HHRA reported a reasonable maximum exposure (RME) of 40 years based on the approach explained above. Because the default value has its limitations, is it possible to calculate a data-driven exposure duration value using the approach discussed in the Hudson River HHRA? Human health risks could change if such calculation yields a value greater than 30 yrs.	It is possible to attempt such a calculation; however, the calculation will be subject to uncertainty. For example, we cannot separate data for marine anglers, particularly those likely to fish the proposed reef, from other members of the population. We searched data from the National Oceanic and Atmospheric Administration's Marine Recreational Fisheries Statistical Survey and found no relevant data for recreational anglers in this region. However, uncertainty regarding the exposure duration assumption was addressed explicitly in the HHRA in Section 9.3.5, where risk estimates are presented assuming an exposure duration of 45 years.
21	Section 6.3.8, page 6-15 should include a reference.	The reference, *Risk Assessment Guidance for Superfund* (USEPA 1989), will be cited in the revised HHRA.
22	No comment provided.	
23	Section 7.2.3.1, page 7-3 should indicate whether averaging the RfDs for Aroclor 1254 and Aroclor 1016 in the CTE scenario is standard. Provide references.	Although averaging the RfDs is not "standard", it was done in this case due to uncertainty concerning the mixture of PCBs expected to occur in fish in the vicinity of the ex-ORISKANY. However, predicted congener patterns in species consumed by people resemble Aroclor 1254 more than Aroclor 1016;

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		therefore, the revised HHRA will use the RfD for Aroclor 1254 for both the CTE and RME scenarios.
24	Section 7.4.3, page 7-7: The Hudson River HHRA used a CSF = 1.5E+05 $(mg/kg\text{-}d)^{-1}$ to calculate the cancer risks associated with dioxin-like PCBs. The author should document (and apply) that approach in this document. But even if the CFS is used, concentrations of dioxin-like PCBs in fish are unknown and therefore the cancer risk analysis cannot be done. This section should mention this information so it is clear that the analysis cannot be performed even though a preliminary CSF is available.	The approach for quantifying risk from dioxin-like PCBs is provided in the HHRA (See section 7.4.3). As noted in Section 9.4.3, and noted by the reviewer, PRAM was not parameterized to quantify fish tissue concentrations; therefore, human health risk for fish consumers from dioxin-like PCB congeners was not quantified. Specifically, the bulk material estimates conducted for the ex-ORISKANY did not include quantification of dioxin-like PCB congeners and, although, these congeners were quantified in the leachate of the leach study, leach rates were not calculated. The dioxin-like PCB congener believed to be the most potent carcinogen among all PCB congeners, PCB #126, was not detected in leachate; therefore, it is not possible to quantify a leach rate for this congener. The discussion in Section 7.4.3 will be expanded to note that, although a preliminary slope factor is available for 2,3,7,8-TCDD and this value can be used to evaluate the potential carcinogenicity of dioxin-like PCBs, the analyses are not available to predict the concentrations of dioxin-like PCBs in fish and no risk evaluation will be performed for this class of PCBs for the ex-ORISKANY.
25	Section 8.1 indicates that background concentrations at the reef site were not considered in the risk estimates. This introduces uncertainty in the PRAM-derived risk estimates which should be acknowledged in the uncertainty analysis of the HHRA.	The HHRA was performed using a predictive model, PRAM, which estimates incremental risks associated with residual PCBs on the ship. The model does not estimate risks from other sources. This uncertainty will be discussed in the revised HHRA, and the Navy will consider modifying PRAM to incorporate background concentration data where such data are available under future reefing scenarios.
26	Table 4-2: The table's footer should include a description of the "Jackknife" and "Bootstrap" means meanings and/or mathematical formulas.	"Jackknife" and "Bootstrap" methods are used to calculate exposure point concentrations for datasets that are not fit either a normal or lognormal distribution. A footnote will be included to provide a brief description of these methods and to direct readers to one or more of the following references: Davidson, A.C., and D.V. Hinkley. 1997. *Bootstrap Methods and their Application.* Cambridge Series in Statistical and Probabilistic Mathematics. Cambridge University Press, Cambridge, UK. Efron, B. and G. Gong. 1983. A leisurely look at the bootstrap, the jackknife, and cross-validation. Am. Statistician. 37:36-48. EPA, 1997. *The Lognormal Distribution in Environmental Applications*.

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		Publication EPA/600/R-97/006, December.
27	Table 4-3: The r2 values are very variable. The leaching studies reported several homolog series with r2 < 0.30. The document should define how this impacts the validity of the PRAM.	For those regressions with low R^2, or where there were few detections, the maximum value was used. This approach is more likely to overestimate PCB uptake by biota and subsequent risks to anglers. A description of this approach, and its potential impacts on risk estimates, will be included in the revised HHRA.
28	Table 4-5: The web link to access the Dictionary of American Naval Fighting Ships does not work.	We apologize for the typographical error in the HHRA. The correct link is: http://www.hazegray.org/danfs/carriers/cv34.htm

Response to Appendix A of SAB Comments on Ex-Oriskany Artificial Reef Project: Human Health Risk Assessment (HHRA). June 2005 (Draft Final).

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1	It would help to see one more paragraph in the executive summary that identifies the most important factors in the overall assessments (based on both sensitivity and uncertainty) and why the reader should believe that the values used for these factors in the model are correct (or conservative). This information is provided in some detail in the various documents and appendixes but as part of the Executive Summary the authors should bring these findings forward. For example, I (Randy) would like to know up front that the bulkhead insulation and/or cable are most important source(s) of PCB and the grouper contributes most to human exposure because it is assumed to be exposed to 20% vessel interior water.	The revised HHRA will summarize the results of a detailed sensitivity and uncertainty analysis on PRAM, part of a larger QA/QC program, that is currently ongoing. The overall plan consists of several steps: • Verifying PRAM equations, calculations, and units • Making corrections to PRAM • Developing a sensitivity analysis matrix across all input parameters • Constructing and evaluating "uncertainty" scenarios based on the results of the sensitivity analysis The output of the sensitivity analysis is a matrix that ranks model inputs relative to output expressed on a fish concentration basis for each guild (predicted risks are linear with respect to fish concentration). The matrix will reflect the elasticity of each input parameter, and is constructed by varying each input parameter by a fixed percentage, and then dividing the percent change in the output to the percent change in the input. The target output will be the top level predator fish in each community (e.g., TLIV pelagic, TLIV benthic and TLIV reef). This is done because we assume that individual parameters will likely have a differential impact on each fish community depending on the specific equations used to predict uptake. The result is a relative ranking of parameters in matrix form. Finally, a second, smaller matrix reflects the elasticity of the human exposure parameters to predicted fish concentration. Since the equations in that model are all linear, it is done at the end after we know what parameters contribute most to predicted fish concentrations. We will do this analysis for the abiotic and biotic compartments, and we will systematically address every single input for the sake of completeness. Some input parameters, for example, Log K_{ow}, are strongly correlated if not completely linked to other parameters. Therefore, it is not appropriate to simply vary Log K_{ow} by 10% without simultaneously changing K_{oc} (and K_{doc}) as well, since changing K_{ow} without changing K_{oc} might lead to different predicted fish concentrations than varying one or the other alone. We know the partitioning parameters are correlated. Another example is growth rate and respiration. There may be others and these will be identified prior to the

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		analysis. Following the sensitivity analysis, we will use the matrix to develop scenarios that include uncertainty bounds for parameters that show high elasticity (e.g., small changes in the input lead to large changes in the output). Determining appropriate uncertainty ranges for input parameters will require some literature searching as well as Team discussions, for example, in terms of the leach rate and source term (e.g., how much of each material remains on-board). Although the original analysis used the 95% UCL of the regression (or indeed the maximum) for the leach rate, both the EPA comments as well as the SAB identified uncertainties that may not be quantified from the data itself but for which there may be a reasonable approach incorporating first principles and evidence from the literature. We will work with other Team members as appropriate to determine reasonable uncertainty bounds. The results of these analyses will be summarized in the executive summary, likely in table form, along with discussion of the key factors that influence the cancer risks and non-cancer hazard indices. Such factors include which materials are likely to release the most PCBs and which exposure assumptions have the most influence on PCB uptake by biota.
2	Comment requires no response.	
3	Comment requires no response.	
4	Breast-fed infant exposure pathways should be undertaken in the risk assessments.	We will revise the HHRA to include this exposure pathway.
5a	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • Release estimates	The revised report for the Leachate Study will include a table listing sources of uncertainty in the experiment itself and in extrapolating experimental results to field conditions. This table will discuss the quantitative effect and/or bias introduced by each source of uncertainty. To help the reviewer better understand the degree of confidence in leach rate estimates, the revised HHRA will include a summary of this table and associated discussion.
5b	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • Particle settling	Particle settling is not considered a major source of PCB input to the sediment near the ship because the particles are very small detritus/dead plankton. Given the relatively small size, low expected settling velocity, and relatively strong current in the area, limited settling would be expected in the vicinity of the ship. In a flow current, particles would enter the reef system from upstream of the ship while downstream particles would tend to be re-suspended and deposit away from the ship. With any reasonable settling time, PCB-contaminated particles would tend to erode away from the site, while clean

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	COMMENT	RESPONSE
		particles from some distance upstream would tend to deposit at the site. We will revise the HHRA text to discuss this source of uncertainty and to include any relevant data and information from the scientific literature.
5c	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • The time the fish spend inside the vessel and the interior concentrations. This is a source of uncertainty.	We agree that the time fish spend inside the vessel is a source of uncertainty, and an important one given that fish exposures to interior vessel water strongly influences the fish tissue concentrations and, consequently, the risk estimates. The Navy has not identified any published marine/reef studies in which this parameter was measured. Therefore, the Navy relied on the following anecdotal sources of information: 1) the personal observations of Florida marine biologists who dive to the reefs in Escambia County and who report that there appears to be an inverse relationship between biota prevalence and interior darkness/distance from the outside hull or wall; and 2) videographic evidence that fish swim in and out of reefs that contain exterior walls or hulls. Because the amount of time fish spend inside a vessel can vary, the uncertainty analysis will be expanded to include a discussion of how modifying this assumption would affect the results of the HHRA.
5d	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • Exploration of other sites which compare the Total PCBs and the congener assessment. Address interior and exterior waters (sampling and methods are problematic), looking at patterns and the fish populations will be informative in framing the bounds needed to address the more toxic PCBs.	A discussion will be included in the HHRA text regarding the uncertainty associated with calculating risks from exposure to total PCBs vs. calculating risks from exposure to dioxin-like PCB congeners, referring to relevant scientific literature and risk assessments as appropriate. For example, we are aware of several environmental studies/risk assessments that have calculated risks from both total PCBs and dioxin-like PCB congeners measured in fish, and any such results that are relevant to the ex-ORISKANY will be discussed in the revised HHRA.
6	The ZOI dimensions seem reasonable, and a 2 to 5 multiplier (of the ex-Oriskany's volume) is adequate. Factors of 2-2.5 for near-field foragers and 4-5 for less reef-related fish are reasonable. However, it is possible that a "near-field forager" may reside primarily on the down-current side of the vessel essentially residing in the "plume" while the ZOI approach distributes the foraging distance around the vessel. The ZOI also distributes the plume into a volume encircling the vessel. It is unclear whether this distribution based on range is appropriate.	Appendix L in the HHRA and Appendix F in the June 2005 PRAM document provides a detailed assessment of the ZOI. The current structure of both PRAM and TDM are such that there is no "down-current" side of the vessel. The assumption is that the current moves the PCBs throughout the "boxes" or "ellipses" and that there is fairly instantaneous and complete mixing. Actual foraging locations of the near-field foragers is an uncertainty, which will be addressed in the HHRA.
7	Comment requires no response.	

References

Bohnsack, J.A., D.E. Harper, D.B. McClellan, and M. Hulsbeck. 1994. Effects of reef size on colonization and assemblage structure of fishes at artificial reefs off southeastern Florida, U.S.A. *Bull. Mar. Sci.* 55:796-823.

Clark, S. and A.J. Edwards. 1994. Use of artificial reef structures to rehabilitate reef flats degraded by coral mining in the Maldives. *Bull. Mar. Sci.* 55:724-744.

Coll, J., J. Moranta, O. Renones, A. Garcia-Rubies, and I. Moreno. 1998. Influence of substrate and deployment time on fish assemblages on an artificial reef at Formentera Island (Balearic Islands, western Mediterranean). *Hydrobiologia* 385:139-152.

Cummings, S.L. 1994. Colonization of a nearshore artificial reef at Boca Raton (Palm Beach County), Florida. *Bull. Mar. Sci.* 55:1193-1215.

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USEPA. 1989. *Risk Assessment Guidance for Superfund (RAGS). Volume I: Human Health Evaluation Manual (Part A) (Interim Final).* EPA/540/1-89002. US Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

USEPA. 2000. *Phase 2 Report, Revised Human Health Risk Assessment, Hudson River PCBs Reassessment RI/FS.* U.S. Environmental Protection Agency, http://www.epa.gov/hudson/revisedhhra-text.pdf.

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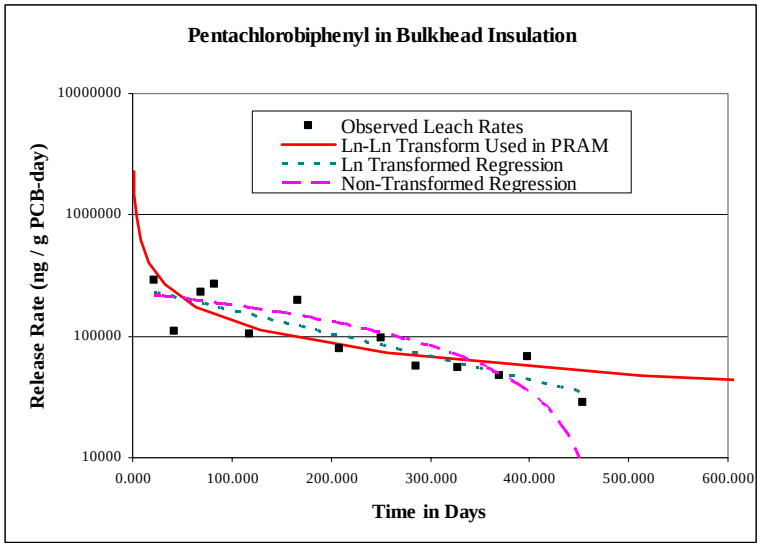
Walker, B.K., B. Henderson, and R.E. Spieler. 2002. Fish assemblages associated with artificial reefs of concrete aggregates or quarry stone offshore Miami Beach, Florida, USA. *Aquat. Living Resour.* 15:95-105.

Document 3 - Response to EPA's December 2, 2005 Second Round of Comments on Ex-ORISKANY Artificial Reef Project: Human Health Risk Assessment (HHRA). June 2005 (Draft Final).

Comment	COMMENT	RESPONSE
1	Each artificial reef has its own characteristics and may undergo different development processes. Provide information such as reef size, reef depth, reef communities, and type of artificial reef, as part of the discussion of the scientific literature supporting the two-year maturity assumption. Make the case to answer how these studies are relevant to making inferences about the ex-ORISKANY reef site.	The discussion of the reef development to be expanded to include specific information from studies of artificial reefs on reef characteristics and the time of development of the biological components of the reef likely cannot be completed prior to issuance of final documents for the ex-ORISKANY. The Navy believes the best course of action is to defer this for inclusion within the National Permit Workgroup unless stated otherwise. The purpose of the expanded text would be to document the expected reef progression over the initial two-year period after vessel sinking. Although most of the published literature that describes reef development concerns small and very shallow near-shore reefs, the revised discussion would focus on reports or personal communications that describe larger and deeper artificial reefs that are located off the coast of southwest Florida, in Gulf waters, or in South Atlantic waters because these reefs more closely approximate conditions expected at the ex-ORISKANY reef. Some of the new information that may be added to the report will come from the following references that were mentioned in the initial response to comments from EPA on the Draft Final HHRA: Bohnsack, J.A., D.E. Harper, D.B. McClellan, and M. Hulsbeck. 1994. Effects of reef size on colonization and assemblage structure of fishes at artificial reefs off southeastern Florida, U.S.A. *Bull. Mar. Sci.* 55:796-823. Clark, S. and A.J. Edwards. 1994. Use of artificial reef structures to rehabilitate reef flats degraded by coral mining in the Maldives. *Bull. Mar. Sci.* 55:724-744. Coll, J., J. Moranta, O. Renones, A. Garcia-Rubies, and I. Moreno. 1998. Influence of substrate and deployment time on fish assemblages on an artificial reef at Formentera Island (Balearic Islands, western Mediterranean). *Hydrobiologia* 385:139-152. Cummings, S.L. 1994. Colonization of a nearshore artificial reef at Boca Raton (Palm Beach County), Florida. *Bull. Mar. Sci.* 55:1193-1215. Golani, D. and A. Diamant. 1999. Fish colonization of an artificial reef in the Gulf of Elat, northern Red Sea. *Environ. Biol. Fishes* 54:275-282. Sherman, R.L., D.S. Gilliam, and R.E. Spieler. 1999. A preliminary examination of depth associated spatial variation in fish assemblages on small artificial reefs. *J. Appl. Ichthyol.* 15:116-121.

Comment	COMMENT	RESPONSE
		Walker, B.K., B. Henderson, and R.E. Spieler. 2002. Fish assemblages associated with artificial reefs of concrete aggregates or quarry stone offshore Miami Beach, Florida, USA. *Aquat. Living Resour.* 15:95-105. The publications by Bohnsack et al. (1994) and Walker et al. (2002) describe the colonization and development of small structured reefs in shallow nearshore waters off the southeast coast of Florida. Although the sizes and depths of those reefs are not at the same scale as the planned ex-ORISKANY reef, the publications are the most applicable peer reviewed articles on artificial reefs in waters of the southeastern US. A preliminary summary of results and observations from the above cited reports was presented in our initial response to comments from EPA on the Draft Final HHRA. That summary pointed out that observations of artificial reefs constructed from a variety of materials have indicated rapid colonization by organisms such as algae, barnacles, and fish within a few weeks of immersion. For fish assemblages in particular, the review by Bohnsack *et al.* (1994) noted that fish colonization of artificial reefs off southeastern Florida was very rapid, and within two years post-deployment, fish assemblages were abundant and diverse. A very recent technical report, released from the University of West Florida within the past six weeks, (*Patterson, W.F. and M.A. Dance. 2005. The Refuge Effect of Unpublished Artificial Reefs Deployed on the Northwest Florida Shelf: Year 1 Final Report. Department of Biology, University of West Florida, Pensacola, Florida. October 31*) describes an ongoing study that focuses on artificial reefs in the East Escambia Large Area Artificial Reef Sites (LAARS), which is the location of the planned ex-ORISKANY artificial reef. Assembling information from these sources to demonstrate that the ex-ORISKANY reef will be sufficiently developed at two years such that the biological assemblage model, particularly for fishes, would be reasonable for use with steady-state modeling of PCB transfer through the food web, likely cannot be completed prior to issuance of final documents for the ex-ORISKANY. The Navy believes the best course of action is to defer this for inclusion within the National Permit Workgroup unless stated otherwise.
3	In addition to including a brief description of the sampling protocol, the document should also contain text language explaining how the protocol is designed to collect representative samples from PCB-containing materials aboard the ex-ORISKANY. Details of the sampling protocol should be in the PCB Source Term Estimates Document (Appendix D, HHRA document).	The PCB sampling performed on the ex-ORISKANY was done in accordance with the NAVSEA PCB ADVISORY 95-1 (Protocol) dated 21 September 1995. The Navy has provided the Protocol to EPA Region 4, and will include it as part of the Source Term Estimates document. Also see our response to General Comment 2 of the Source Term Estimates report.
5b	The Navy's response does not address the question. Although the response reveals how the calculation was performed, it does not reveal exactly <u>why</u> a natural log transformation approach was selected	A natural log (ln) transformation of the leach rate data was selected because it produced the best curve fit of the observed data and yielded the highest leach rate estimates among the regression models that we tested. The Navy will add this text to the HHRA narrative.

Comment	COMMENT	RESPONSE
	for the leach rate data. It would be prudent for the Navy to add further language to the HHRA document to inform readers of the rationale.	The leach rate study reported a time series of homolog release rates for each material tested. Regression analyses were then applied to release rate data of each PCB-containing material in order to derive a release rate during the steady-state period modeled by PRAM. The regression analyses used in PRAM were based on ln-ln transformed data sets of release rates. The data sets, regression analyses, and predicted steady-state release rates used in the PRAM are presented in Appendix A of the PRAM document. As an example of the regression analyses, the regressed leach data for pentachlorobiphenyl in bulkhead insulation are presented below:  In the above graph, the observed leach rates from the leach rate study are plotted as the black squares. Also presented are three regression analyses performed on the leach rate data: linear (non-transformed), semilog (ln transformed), and ln (ln-ln transformed). The non-transformed linear regression analysis predicts a release rate of zero by day 469 after sinking. The semilog (ln transformed) regression predicts a slower decline in release rate compared to the linear regression. The ln-ln transformed regression results in a higher release rate at day 365 than does the semilog (ln transformed) regression. Thus, the ln-ln transformed regression generally predicts a higher leach rate throughout the period modeled by PRAM (greater than 730 days after sinking) than the other regressions. Subsequently, the ln-ln transformed regression leach rate predicted at 730 days was used in the PRAM steady-state model. Further discussion of the application of the regression analysis release rates is presented in the PRAM document.
6a	Although the Navy included a good explanation about seasonal variability in the pycnocline depth and justified the selection of a pycnocline depth at	EPA's comment indicates that our explanation (provided in our response to EPA's November 2005 comments) regarding seasonal variability and its affect on the depth of the pycnocline is acceptable. We will include this discussion as part of the uncertainty assessment in the revised HHRA.

Comment	COMMENT	RESPONSE
	15 meters, it is unclear if this information will be incorporated in the HHRA document. This reviewer recommends adding the supporting information to the HHRA document.	
6b	This comment asked about information supporting the assumption that PCBs are released within the ship volume at one minute intervals and mix instantaneously into the interior wall. Although there are no publications supporting this assumption, the Navy's response to this question provided the reasoning behind why modelers chose to work with 1-min intervals over other options (e.g. 1-sec intervals). This reviewer recommends adding text to the TDM document to explain why modelers selected 1-min intervals for the TDM program.	We agree with EPA's comment and will add the rationale for the selection of 1-min intervals to the TDM report.
20	Navy's response is acknowledged and there is no need to calculate a data-driven exposure duration value.	Based on EPA's comment, the Navy will not conduct any calculations using other exposure durations. However, Section 9.3.5 of the June 2005 HHRA does address this issue as part of the uncertainty assessment where risk estimates are presented assuming an exposure duration of 45 years. This analysis will remain in the revised HHRA.
23	Make sure that the revised HHRA includes the justification for using Aroclor 1254's RfD instead of the average for both the CTE and RME scenarios.	We originally averaged the RfDs for Aroclor 1254 and Aroclor 1016 because of the uncertainty concerning the mixture of PCBs expected to occur in fish in the vicinity of the ex-ORISKANY. However, the predicted homolog patterns in species consumed by people more closely resemble Aroclor 1254 than Aroclor 1016 (See Figure 7-1 in the June 2005 Draft HHRA). Risks will not be recalculated using the RfD for Aroclor 1254 Comment will be deferred for inclusion within the National Permit Workgroup unless stated otherwise.
24 and SAB 5d	These comments reflect concerns regarding the need for a quantitative dioxin-like PCB assessment to be included in the HHRA. Overall, this PRAM-based Artificial Reefing approach should be thorough and include a dioxin-like PCB approach. Such would increase confidence in the protectiveness of final reefing decisions. The typical dual approach is suggested and is generally defined in the "Guidance for Assessing Human Health Risks from PCBs at Waste Sites" (63 FR 35383; June 29, 1998 Final Rule; 64 FR 69358 [June 24, 1999]). This added precaution is	The Navy did not quantify human health risk from dioxin-like PCB congeners because (1) the bulk material estimates conducted for the ex-ORISKANY did not include quantification of dioxin-like PCB congeners and therefore (2) PRAM was not parameterized to quantify fish tissue concentrations of the congeners. Congeners (with the exception of PCB-81) were quantified in the leachate of the leach study; however, as shown in the following table, two of the three dioxin-like PCB congeners that EPA refers to as being of primary interest (i.e. PCB-126 and PCB-169) were not detected in leachate from any of the PCB-containing materials. Therefore, no leach rates can be calculated for these congeners, which have the highest toxic equivalency factors.

<table>
<tr><th>Comment</th><th>COMMENT</th><th>RESPONSE</th></tr>
<tr><td></td><td>recommended because dioxin-like PCBs may be present and vary in concentration in materials from ship to ship. Dioxin-like PCBs may also result from weathering, degradation, transformation, and/or enhancement processes. Even if PCB concentrations are below a specified action level, dioxin-like congeners may still pose a risk. The primary PCB congeners of interest are PCB #'s 77, 126, and 169.</td><td>
<table>
<tr><th>Dioxin-like PCBs</th><th>TEF</th><th>Detected in Leach Rate Study?</th></tr>
<tr><td>PCB-77: 3,4,3’,4’-TeCB</td><td>0.0001</td><td>Yes</td></tr>
<tr><td>PCB-81: 3,4,4’5-TeCB</td><td>0.0001</td><td>Not included in LR study</td></tr>
<tr><td>PCB-126: 3,4,5,3’,4’-PeCB</td><td>0.1</td><td>No</td></tr>
<tr><td>PCB-169: 3,4,5,3’,4’,5’-HxCB</td><td>0.01</td><td>No</td></tr>
<tr><td>PCB-105: 2,3,4,3’,4’-PeCB</td><td>0.0001</td><td>Yes</td></tr>
<tr><td>PCB-114: 2,3,4,5,4’-PeCB</td><td>0.0005</td><td>Yes</td></tr>
<tr><td>PCB-118: 2,4,5,3’,4’-PeCB</td><td>0.0001</td><td>Yes</td></tr>
<tr><td>PCB-123: 3,4,5,2’,4’-PeCB</td><td>0.0001</td><td>Yes</td></tr>
<tr><td>PCB-156: 2,3,4,5,3’,4’-HxCB</td><td>0.0005</td><td>Yes</td></tr>
<tr><td>PCB-157: 2,3,4,3’,4’,5’-HxCB</td><td>0.0005</td><td>Yes</td></tr>
<tr><td>PCB-167: 2,4,5,3’,4’,5’-HxCB</td><td>0.00001</td><td>Yes</td></tr>
<tr><td>PCB-189: 2,3,4,5,3’,4’,5’-HpCB</td><td>0.0001</td><td>Yes</td></tr>
<tr><td colspan="3">Van den Berg et al. 1998. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs, for humans and wildlife. Environmental Health Perspectives 106(12):775-792.</td></tr>
</table>

Comment will be deferred for inclusion within the National Permit Workgroup unless stated otherwise.</td></tr>
</table>

Response to Appendix A of SAB Comments on Ex-Oriskany Artificial Reef Project: Human Health Risk Assessment (HHRA). June 2005 (Draft Final).

	COMMENT	RESPONSE
1	It would help to see one more paragraph in the executive summary that identifies the most important factors in the overall assessments (based on both sensitivity and uncertainty) and why the reader should believe that the values used for these factors in the model are correct (or conservative). This information is provided in some detail in the various documents and appendixes but as part of the Executive Summary the authors should bring these findings forward. For example, I (Randy) would like to know up front that the bulkhead insulation and/or cable are most important source(s) of PCB and the grouper contributes most to human exposure because it is assumed to be exposed to 20% vessel interior water.	The revised HHRA will summarize the results of a detailed sensitivity and uncertainty analysis on PRAM, part of a larger QA/QC program, that is currently ongoing. The overall plan consists of several steps: • Verifying PRAM equations, calculations, and units • Making corrections to PRAM • Developing a sensitivity analysis matrix across all input parameters • Constructing and evaluating "uncertainty" scenarios based on the results of the sensitivity analysis The output of the sensitivity analysis is a matrix that ranks model inputs relative to output expressed on a fish concentration basis for each guild (predicted risks are linear with respect to fish concentration). The matrix will reflect the elasticity of each input parameter, and is constructed by varying each input parameter by a fixed percentage, and then dividing the percent change in the output to the percent change in the input. The target output will be the top level predator fish in each community (e.g., TLIV pelagic, TLIV benthic and TLIV reef). This is done because we assume that individual parameters will likely have a differential impact on each fish community depending on the specific equations used to predict uptake. The result is a relative ranking of parameters in matrix form. Finally, a second, smaller matrix reflects the elasticity of the human exposure parameters to predicted fish concentration. Since the equations in that model are all linear, it is done at the end after we know what parameters contribute most to predicted fish concentrations. We will do this analysis for the abiotic and biotic compartments, and we will systematically address every single input for the sake of completeness. Some input parameters, for example, Log K_{ow}, are strongly correlated if not completely linked to other parameters. Therefore, it is not appropriate to simply vary Log K_{ow} by 10% without simultaneously changing K_{oc} (and K_{doc}) as well, since changing K_{ow} without changing K_{oc} might lead to different predicted fish concentrations than varying one or the other alone. We know the partitioning parameters are correlated. Another example is growth rate and

	COMMENT	RESPONSE
		respiration. There may be others and these will be identified prior to the analysis. Following the sensitivity analysis, we will use the matrix to develop scenarios that include uncertainty bounds for parameters that show high elasticity (e.g., small changes in the input lead to large changes in the output). Determining appropriate uncertainty ranges for input parameters will require some literature searching as well as Team discussions, for example, in terms of the leach rate and source term (e.g., how much of each material remains on-board). Although the original analysis used the 95% UCL of the regression (or indeed the maximum) for the leach rate, both the EPA comments as well as the SAB identified uncertainties that may not be quantified from the data itself but for which there may be a reasonable approach incorporating first principles and evidence from the literature. We will work with other Team members as appropriate to determine reasonable uncertainty bounds. The results of these analyses will be summarized in the executive summary, likely in table form, as requested in this comment.
2	Comment requires no response.	
3	Comment requires no response.	
4	Breast-fed infant exposure pathways should be undertaken in the risk assessments.	We will revise the HHRA to include this exposure pathway.
5a	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • Release estimates	The revised report for the Leachate Study will include a table listing sources of uncertainty in the experiment itself and in extrapolating experimental results to field conditions. This table will discuss the quantitative effect and/or bias introduced by each source of uncertainty. To help the reviewer better understand the degree of confidence in leach rate estimates, the revised HHRA will include a summary of this table and associated discussion.
5b	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • Particle settling	Particle settling is not considered a major source of PCB input to the sediment near the ship because the particles are very small detritus/dead plankton. Given the relatively small size, low expected settling velocity, and relatively strong current in the area, limited settling would be expected in the vicinity of the ship. In a flow current, particles would enter the reef system from upstream of the ship while downstream particles would tend to be re-suspended and deposit away from the ship. With any reasonable settling time, PCB-contaminated particles would tend to erode away from the site, while clean particles from some distance upstream would tend to deposit at the site. We will revise the HHRA text to discuss this source of uncertainty and to include any relevant data and information from the scientific literature.

	COMMENT	RESPONSE
5c	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • The time the fish spend inside the vessel and the interior concentrations. This is a source of uncertainty.	We agree that the time fish spend inside the vessel is a source of uncertainty, and an important one given that fish exposures to interior vessel water strongly influences the fish tissue concentrations and, consequently, the risk estimates. The Navy has not identified any published marine/reef studies in which this parameter was measured. Therefore, the Navy relied on the following anecdotal sources of information: 1) the personal observations of Florida marine biologists who dive to the reefs in Escambia County and who report that there appears to be an inverse relationship between biota prevalence and interior darkness/distance from the outside hull or wall; and 2) videographic evidence that fish swim in and out of reefs that contain exterior walls or hulls. Because the amount of time fish spend inside a vessel can vary, the uncertainty analysis will be expanded to include a discussion of how modifying this assumption would affect the results of the HHRA.
5d	The accuracy of the PRAM's inputs to the human health risk via the individual congeners and the total PCB exposure has some issues that should be described as part of at minimum a qualitative description of the caveats and uncertainties. • Exploration of other sites which compare the Total PCBs and the congener assessment. Address interior and exterior waters (sampling and methods are problematic), looking at patterns and the fish populations will be informative in framing the bounds needed to address the more toxic PCBs.	A discussion will be included in the HHRA text regarding the uncertainty associated with calculating risks from exposure to total PCBs vs. calculating risks from exposure to dioxin-like PCB congeners, referring to relevant scientific literature and risk assessments as appropriate. For example, we are aware of several environmental studies/risk assessments that have calculated risks from both total PCBs and dioxin-like PCB congeners measured in fish, and any such results that are relevant to the ex-ORISKANY will be discussed in the revised HHRA.
6	The ZOI dimensions seem reasonable, and a 2 to 5 multiplier (of the ex-Oriskany's volume) is adequate. Factors of 2-2.5 for near-field foragers and 4-5 for less reef-related fish are reasonable. However, it is possible that a "near-field forager" may reside primarily on the down-current side of the vessel essentially residing in the "plume" while the ZOI approach distributes the foraging distance around the vessel. The ZOI also distributes the plume into a volume encircling the vessel. It is unclear whether this distribution based on range is appropriate.	Appendix L in the HHRA and Appendix F in the June 2005 PRAM document provides a detailed assessment of the ZOI. The current structure of both PRAM and TDM are such that there is no "down-current" side of the vessel. The assumption is that the current moves the PCBs throughout the "boxes" or "ellipses" and that there is fairly instantaneous and complete mixing. Actual foraging locations of the near-field foragers is an uncertainty, which will be addressed in the HHRA.
7	Comment requires no response.	

References

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Response to USEPA Comments on:
"Oriskany – Key Outstanding Risk Assessment Issues"
From Ms. Beverly Banister, USEPA (6 August 2004)

	COMMENT	RESPONSE
	General Comments (Paraphrased) Included in Cover Letter to CAPT JM Jones	
1	USEPA requests copies of PRAM software and documentation.	Copies of the PRAM (Version 1.3) software were provided to EPA and the State of Florida, prior to the 12 August 2004 meeting in Atlanta. PRAM incorporates a number of equations, physical constants, and biological parameters, in order to model dispersion of PCBs into the environment, uptake and bioaccumulation by biota, and risk to human health from the ingestion of fish. The description of PRAM equations, input parameters, scientific literature sources for each of the specific equations, constants, and input parameters used were provided in Chapter 5 of the SHHRA. In addition, source documents cited in the PRAM write-up and relevant sections of texts were converted into electronic files (PDF files) and posted on the URS FTP website on 20 August 2004. Additional changes to the PRAM documentation were incorporated, as documented in our responses to the comments titled "Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels" (C. Barber, 15 September 2004) (Provided Separately). PRAM has recently been updated to version 1.4c to incorporate EPA comments, and has been fully documented in a separate document " Prospective Risk Assessment Model (PRAM) Version 1.4c Documentation" (NEHC/SSC-SD 2005). The software has been submitted to the agencies along with this documentation.
2	USEPA requests a copy of Resolve/ ESCO technical plan of 4 Nov 04 in order to evaluate the contractor's adherence to the BMP.	It should be noted that the technical plan is a process document, rather than a quantitative inventory of materials to be removed. As such, the Resolve/ESCO technical plan may not be very useful if the EPA's intent is to QA the BMP with respect to liquid and solid PCB-containing materials. Regarding potentially liquid PCB containing materials, removals were Quality Assured by NAVSEA contractor Tom Pape (CACI, Inc.) on 25-30 July 2004 while the ship was being prepared in Corpus Christi, TX. Craig Brown (EPA Region 4) also intends to shipcheck the ex-ORISKANY in the near future. The scope of Tom Pape's previous shipcheck as tasked by PMS 333 was:

	COMMENT	RESPONSE
		1. Conduct a walkthrough of the vessel to ensure all probable liquid filled PCB items have been removed. 2. Review contractor's (Resolve Marine Group/ESCO Marine) waste manifests for disposal of PCB Bulk Product Waste and review categories of materials disposed of as PCB Bulk Product Waste. Verify quantities noted in progress reports. 3. Document the process contractor uses to identify and dispose of probable liquid-filled PCB Items. Document the quantity of material disposed of as liquid-filled PCB items and where they were disposed. 4. Investigate the "caulking" material found on the Flight Deck, estimate the quantity and physical characteristics of the material, and identify sample locations for a representative sampling of the material to determine if the material contains PCB's at regulated concentrations and if wooden deck components have been contaminated by contact with these materials. 5. Note the presence of cellulose/asbestos material in machinery spaces while conducting the PCB inspection of the vessel. Tom Pape's findings regarding liquid PCB materials were: The inspection revealed that all items identified in the NISMO Bremerton Inventory and labeled as PCB Items had been removed. However, a few additional items were not included in the inventory nor labeled by NISMO personnel; these items were located in the radar and communications equipment in the "island" of the vessel, in the CIC, and in the Radar Equipment Room (B-312-C). These items where physically marked with blue spray paint for easy identification and their location communicated to the contractor for removal and disposal. Regarding solid PCB-containing materials, this included removal of accessible fiberglass bulkhead insulation and electrical cabling from the interior of the island, removal of electrical cabling from the exterior of the island, and removal of exfoliating paint from throughout the ship. SUPSHIP was asked to provide photos of the completion of the Florida diver safety work, but they have not yet been provided. Craig Brown has indicated to the Navy that mitigation of the ex-ORISKANY is not an issue related to the SHHRA/risk-based disposal approval process. In 2004, based on findings of the leach rate study (SSC-SD, 2004) and PRAM 1.3 findings that the PCBs in bulkhead insulation (BHI) presents the greatest potential for environment release/ transport, and human health risks among all PCB-containing materials onboard of the ex-ORISKANY, the Navy conducted the removal of approximately 72.6% of the mass of BHI was removed (Pape, 2004) (CACI report).

	COMMENT	RESPONSE
3	USEPA requests the results of the PCB sampling of the flight deck materials. EPA Region 4 expressed concerns that contamination may have resulted from PCB hydraulic fluids in the hydraulic catapults.	Copies of the sample results have been provided to EPA Region 4 and EPA OPPT. EPA has been advised that Navy is proceeding with the removal and disposal of this material IAW PCB Disposal Regulations. EPA has been advised that the axial flight deck was replaced with an angular flight deck in 1958, concurrently with the replacement of the hydraulic catapults with steam driven catapults, and also that the catapults are only located in the forward end of the flight deck.
Specific Comments		
1	**Model Uncertainties** - There are significant uncertainties associated with use of the Prospective Risk Assessment Model (PRAM) for making risk judgments about the ex-Oriskany. These uncertainties are evident because empirical data for the ex-Vermillion (which was estimated to have about one-third of the amount of PCBs on it than the ex-Oriskany) show that fish tissue concentrations for the White Grunt are higher than those estimated by the model. This discrepancy needs to be explained and accounted for to ensure that there is no unreasonable risk associated with the PCBs to be left on the ex-Oriskany. The model must be sufficiently conservative to ensure that risk management decisions are protective of populations ingesting Gulf of Mexico reef fish species representative of the White Grunt. (Note that EPA has requested copies of the PRAM along with its documentation/user manual.) In the absence of data that can be used to gain a better understanding of the uncertainties leading to the differences between model predictions and empirical data from the ex-Vermillion, it may be necessary to incorporate an uncertainty factor into the model that may be used to provide some assurance of its conservativeness.	It is noted that in the SHHRA for the ex-ORISKANY site, PRAM version 1.3 predicted PCB concentrations in trophic level 3 and trophic level 4 (Vermilion Snapper and Black Sea Bass) that are similar in comparison to the empirical data from the ex-VERMILLION reef for the Vermillion Snapper and Black Sea Bass. The recently revised version of PRAM (version 1.4c) also predicts PCB concentrations in this range. This indicates that PRAM can predict a reasonable range of PCB concentrations that could be found in fish tissue associated with the ex-VERMILLION. Observational studies conducted by Robert Turpin, Escambia County Marine Resources Division (ECMRD), have shown that White Grunt is not a likely catch at the ex-ORISKANY, although other species which are likely to be found at the ex-ORISKANY site, such as the Grey Triggerfish, could occupy a similar niche at the reef and exhibit similar feeding habits and trophic level. The Grey Triggerfish is a predominant species for the “White-Grunt like” trophic level in the North Gulf of Mexico and is also a targeted species of recreational fisherman. Detailed follow-up comments on the PRAM were received from USEPA (“Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels” (C. Barber, 15 September 2004)) that address in greater detail the uncertainties associated with the model. These issues were further discussed in the Technical Working Group (TWG) meeting that was held in Atlanta on 23-24 September 2004. Detailed responses to these concerns, including relevant information discussed at the TWG meeting, are presented in our responses to the comments titled “Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels” (C. Barber, 15 September 2004) (Provided Separately).
1a	Some of the potential sources of uncertainty in the PRAM include the following:	We acknowledge that there were statistical differences for fish tissue concentrations of PCBs between the target reef and the reference reef.

	COMMENT	RESPONSE
	Background Sources - Based on the Navy's data, it does not appear that background PCBs account for the difference between fish concentrations predicted by the PRAM and those observed in White Grunt from the ex-Vermillion, as suggested by the Navy. The source of these differences needs further investigation.	Assuming that the White Grunt at the ex-VERMILLION site were subject to the same background exposure, as compared to the reference site, there may be other unknown source terms, fate and transport pathway(s), or exposure pathway(s) at the ex-VERMILLION specifically applicable to the White Grunt but not Black Sea Bass and the Vermilion Snapper. EPA has put a number of suggestions forward with regard to possible ways that the White Grunt tissue concentration issue can be investigated, especially as compared with the PRAM model results. For example, at the 12 August 2004 meeting, we discussed the possibility that the trophic level assigned to the White Grunt (in the PRAM model) may not be correct, and that it should be reviewed in the context of scrutinizing its food web. Another suggestion was that a monitoring program could be conducted, to determine Grey Triggerfish tissue concentrations over time. These issues were discussed in greater detail in the 23-24 September 2004 TWG meeting. The primary purpose of these suggestions is to find a way to corroborate the empirical White Grunt data from the ex-VERMILLION with PRAM predictions. As stated in the response to comment 1 above, PRAM version 1.4c predicts concentrations in trophic level III and IV reef fishes, including the Grey Trigger fish and grouper, respectively. Therefore, we believe that the White Grunt question can be explained based on the fate/transport and water-diet exposure pathways, although one would never be certain of the major contributing factors for the PCB levels in the White Grunt. For the ex-ORISKANY, we will continue to work with the EPA on addressing this very intriguing question.
1b	Some of the potential sources of uncertainty in the PRAM include the following: **Zone of Influence (ZOI)** - The PRAM was run utilizing ZOI values of 3, 5 and 10. The SHHRA indicated that the ZOI value is the most sensitive parameter in the PRAM. In order to adequately evaluate the uncertainty associated with the model, a wider range of ZOIs should be used (i.e., also running PRAM at ZOIs of 1 and 2). At what ZOI value does the model predict fish tissue concentrations that are consistent with the White Grunt data for the ex-Vermillion?	A number of issues related to ZOI were raised in USEPA's 15 September 2004 comment set on PRAM, and discussed in detail in the September 23-24, 2004 TWG meeting. Please see our responses to the comments titled "Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels" (C. Barber, 15 September 2004) (Provided Separately) for our responses to comments 2.1, 2.2, and 2.3 of the 15 September 2004 comments. Based on recommendations of the TWG, a review of the scientific literature was performed to identify ZOI ranges that could reasonably be expected to be representative of typical "reef fish" behavior. The recommendation, based on this review, was made to evaluate fish for ZOIs of 2 and 5, and accepted by the members of the TWG. The detailed review article has been included as Appendix F of the "Prospective Risk Assessment Model (PRAM) Version 1.4c Documentation

	COMMENT	RESPONSE
		(NEHC/SSC-SD, 2005).
1c	Some of the potential sources of uncertainty in the PRAM include the following: **Biodegradation of PCB-containing Materials** - If the leach rates used in the PRAM are based on leaching studies using an abiotic system (i.e., accounting for factors such as temperature and pressure, but not factors that could enhance leaching such as biodegradation of the PCB-containing materials), it may be possible that leaching is underestimated in the model. Is it also possible that the food web of the White Grunt includes species involved in the biodegradation process, accounting for the higher PCB levels observed in the White Grunt?	This is an issue that has been discussed in a previous REEFEX TWG meeting. The decision was made at that time to limit the study to the more controllable abiotic leaching conditions (what we termed "baseline" leaching, or leaching based only on chemical properties of the system). In the leach rate study's initial experimental design phase that incorporated EPA-OPPTS input (Dr. John Smith), the possible biological impacts were considered. These impacts included both a possible increase in leach rate due to biodegradation of shipboard solid materials and a possible decrease in leach rates due to biological growth. Both of these processes would take a longer period of time to potentially impact leach rates and, as a result, the leach rate study did not incorporate either of these competing processes into the experimental approach (a short-term process). There is no empirical evidence available that the rate of PCB release will increase if shipboard solid materials biodegrade in the marine environment, nor is there any empirical evidence available that indicates leach rates are suppressed by biological fouling in marine environments. We can only hypothesize that both can occur and that the relative magnitudes of these competing effects likely cancel each other out. The leach rates used for PRAM very conservatively assume that leaching occurs at a constant rate over the long term, rather than at a decreasing rate dictated by the empirical data. It is plausible that the use of leach rates in such a conservative way will offset possible leach rate increases/decreases associated with biological activity. In order to release PCBs at a higher rate, it would require a catastrophic event to occur on a timescale shorter than the experimental timescale of the leach rate studies. Because biodegradation is not a catastrophic or fast event, requiring much longer timescales than can be tested in the laboratory, the magnitude of potential leach rate increases is expected to be very much below the leach rate values used in PRAM and is more likely to be decreased even further if leach rate suppression due to biological fouling is considered. This issue was discussed at the 23-24 September 2004 TWG meeting, as well as related issues, such as direct diffusion of PCBs into encrusting organisms. We believe that it is unnecessary to incorporate biodegradation of the source material into the already established leach rates for use in the PRAM model for the ex-ORISKANY SHHRA at this time. If the effects of biodegradation on leach rate need to be defined and incorporated into PRAM, the competing effects of biological fouling should also be defined and incorporated. The

	COMMENT	RESPONSE
		magnitude of the leach rate enhancement due to biodegradation is very likely minimal compared to leach rate suppression due to bio-fouling and will not explain the White Grunt results. Even if some physico-chemical parameter such as leach rate or source loading term can be manipulated to account for much higher bioaccumulation (the White Grunt data), bioaccumulation in other species (the Vermilion Snapper and Black Sea Bass) would be over-predicted. Finally, this concern is somewhat addressed by these considerations:, (1) any such release will be quickly advected away from the exposure boundary, and (2) PRAM assumes steady-state and infinite source of PCBs, i.e., continuing release of PCBs, which is highly conservative. This issue is now recognized and discussed as an uncertainty factor in the PRAM documentation.
1d	Some of the potential sources of uncertainty in the PRAM include the following: **Reservoir PCBs** - Does PRAM account for cumulative exposure over time that results from not only the continuous leaching of PCBs from materials on the ship, but also the "buildup" of PCBs in sediments as the mass of PCBs is released over time? That is, since PCBs degrade so slowly, do reservoir sources develop in the sediment that increase exposure among certain fish species? Is it possible that higher concentrations in the White Grunt may be the result of a higher level of exposure to recycled PCBs (i.e., reservoir sources from earlier releases, possibly in the sediments; exposure to White Grunt may be higher because of their position in the food web) than other fish species, thus accounting for their higher fish tissue concentrations.	The issue of a possible significant impact from a detritus food web, which is currently not included in the PRAM food chain or the site conceptual model, was discussed at the 12 August 2004 TWG meeting. The Navy noted that a significant impact was not likely, for a variety of reasons. We noted that recycling of PCBs from dead animals to sediment is not likely to be a major PCB transport pathway. Carcasses are typically subject to scavenging and the bioaccumulation effect on the scavengers or detritivores feeding on this material. Living animals feeding on living or dead organisms are most likely the true reservoir for PCBs. Also, the PRAM does include a Total Organic Content (TOC) input parameter as part of the abiotic environment characterization. The TOC value is important to the dispersion model, because the TOC content of sediment determines the degree to which PCBs adsorb to the sediment. In sandy ocean bottoms, the TOC is low. The default TOC value used in PRAM is higher than would be expected in a sand-only bottom (thus we believe a conservative estimate of TOC content was used for the ex-ORISKANY). If it is hypothesized that a significant amount of detritus could accumulate around a sunken ship, then it must be recognized that there would be a concomitant increase in the TOC in the sediments around the ship. Sediment sampling at the ex-VERMILLION was not conducted; however, the SCDNR evaluation of the area surrounding the ex-VERMILLION reef indicated that the bottom was sandy, probably with low TOC content. As discussed at the 23-24 September 2004 TWG meeting, a future improvement of PRAM may include the addition of a detrital/scavenger component to the food web evaluation in PRAM to simulate high organic carbon/PCB rich pools (sediment and biota), if it is determined to be necessary. In the interim, we would conduct additional evaluation of this potential effect (sediment build-up

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		and eventual uptake by biota via the food web) by the current PRAM model by running the model with increasing concentrations of PCBs in the sediment (increasing TOC values) and present the findings in the uncertainty section of the revised SHHRA (now titled the ex-ORISKANY HHRA). In addition, prior to the 23-24 September 2004 meeting, we conducted an emission rate study that indicated that if various PCB material loadings on the ex-VERMILLLION were assumed, then PRAM predicts fish tissue concentrations equivalent to the White Grunt levels seen at the ex-VERMILLION.
1e	Some of the potential sources of uncertainty in the PRAM include the following: **Bioaccumulation** - The PRAM may not adequately account for bioaccumulation for the various types (e.g., trophic levels) of reef fish. A determination needs to be made as to whether it is the factors that affect bioaccumulation or the leach rates that account for the differences in fish tissue concentrations from the ex-Vermillion and those estimated by PRAM. In addition, the PRAM appears to estimate a single fish tissue concentration for "reef fish" that does not account for variability among species.	A number of issues related to bioaccumulation were raised in USEPA's 15 September 2004 comment set on PRAM, and discussed in detail in the 23-24 September 2004 TWG meeting. Please see our responses to the comments titled "Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels" (C. Barber, 15 September 2004) (Provided Separately) for our responses to comments 1.1 through 1.4 of the 15 September 2004 comments.
1f	Some of the potential sources of uncertainty in the PRAM include the following: **Model Validation** - PRAM should be tested with the range of mass loading estimates provided for the ex-Vermillion. Such an effort would be helpful in assessing uncertainty. Once sinking of the ex-Oriskany occurs and enough data are collected for the ex-Oriskany, PRAM should be further validated and calibrated to ensure that it accurately predicts fish tissue concentrations and risks.	The issue of model testing/validation/verification/corroboration was raised in USEPA's 15 September 2004 comment set on PRAM, and discussed in detail in the 23-24 September 2004 TWG meeting. Please see our responses to the comments titled "Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels" (C. Barber, 15 September 2004) (Provided Separately) for responses to comment 3.5 and conclusion comment 4 of the 15 September 2004 comments.
2	**Risk Characterization Based on Comparison to ex-Vermillion Risks** - Risks for the ex-Vermillion and ex-Oriskany are not compared in the SHHRA. It is important to be able to evaluate not only the differences between individual parameters, but also the multiplicative effects of these differences on the risks for the ex-Oriskany site (i.e., using data from the SHHRA for the (1) mass loading of PCBs, (2) fish ingestion rate, and (3) fraction ingested term for the ex-Oriskany site, as compared to the ex-Vermillion site).	On 18 May 2004, EPA Region 4 and EPA OPPT representatives concurred with the approach of two independent lines of evidence for the ex-ORISKANY effort, (a) a qualitative/semi-quantitative evaluation of the comparability of potential exposures and level of mitigation between the two ships via the SHHRA, and (b), a semi-quantitative evaluation of the potential risks on ex-ORISKANY using the PRAM model. In previous ex-ORISKANY TWG conference calls on the same issue, we maintained that a quantitative risk comparison could not be made since there is no hard data on the specific PCB

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		loading on the ex-VERMILLION but rather a range of possible values. On further consideration and to be responsive, we agreed in the 12 August 2004 meeting that we will make a quantitative comparison for all three fish species (White Grunt, Black Sea Bass, and Vermilion Snapper), and present the evaluation findings with a discussion of uncertainty using the ratioing approach. However, it should be noted that the EPA ratioing approach assumes linearity or proportionality between the two ship reefs. It is a highly simplified and non-site-specific approach for evaluating risks. PRAM predicts PCB concentrations in the environment and in fish based on the leach-rate of PCBs from various PCB-containing materials and their respective loading. The ratioing approach assumes that the mass or mass/volume ratio for the ex-VERMILLION can be used to extrapolate, by the principle of proportionality, PCB concentrations in fish at the ex-ORISKANY. This is a gross assumption; it does not depend on the specific quantity or leach rates of individual types of materials, e.g., BHI is more leachable than electrical cable, and is expected to contribute more to total PCB release despite its much lower quantity than the cable onboard of the ex-ORISKANY. Also, it is noted that the evaluation is non-site-specific. Thus, we feel that the rationing methodology is fatally flawed due to our inability to ascertain the amount of PCB-containing material and their distributions onboard the ex-VERMILLION within reasonable limits of uncertainty. Note also that previously submitted responses to these and related comments relate back to results predicted by the previous version 1.3 of PRAM. However, PRAM 1.4c has been developed in collaboration with the USEPA via the TWG to address concerns regarding the predictive ability of the model. PRAM v. 1.4c as used in the revised HHRA for the ex-ORISKANY is now a fugacity level III model, with other component revisions such as incorporation of a pycnocline, that is designed to address concerns about predicting PCB concentrations in water and fish tissue. Thus, we cannot justify continued comparisons of the two vessels via the ratioing method in light of the use of a substantially revised model (PRAM, version 1.4c) for the ex-ORISKANY HHRA. .In addition, we agreed that we should include the fish ingestion risks for a child receptor into PRAM. The outputs of PRAM that include the child receptor risks, in additional to adult risks, are reported in the ex-ORISKANY HHRA (revised SHHRA)
2a	**Mass Loading -** Note that although PCBs that will leach from the ex-	We agree that the ex-ORISKANY will contain more PCBs than is thought to

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	Oriskany will be diluted in a bigger volume of water, based on the Navy's estimates, the PCB mass per unit volume (lbs/ft^3) is expected to be about 2 times higher for the ex-Oriskany than for the ex-Vermillion.	have been on board the ex-VERMILLION when it was sunk, however, mass and volume alone are not the only contributing factors to PCB release rates. The leach rates of the various PCB-containing materials are equally as important. For example, although the greatest mass of PCBs on board the ex-ORISKANY is present in electrical cabling, because this material releases PCBs very slowly (relative to materials such as bulkhead insulation), PCBs in cable are not a primary source of PCB release to the environment. In addition to the uncertainties associated with the mass of PCBs present on the ex-VERMILLION at the time of sinking, and the distribution of these PCBs in various shipboard materials, a further reason that a ratioing evaluation will not be conducted is because of the use of the new version of the model (PRAM, version 1.4c) in this HHRA. Response to Comment 2 also discusses this issue.
2b	**Fish Ingestion Rate -** As indicated by the Navy, the fish ingestion rate is higher for the ex-Oriskany site than for the ex-Vermillion site.	We acknowledge that the fish ingestion rate for the ex-ORISKANY site is likely to be higher than for the ex-VERMILLION site, based on information supplied in the Exposure Factors Handbook (USEPA, 1997),. However, as discussed in response to Comment 2, we do not feel it is appropriate to compare the ex-VERMILLION and ex-ORISKANY exposure scenarios. PRAM version 1.4c has been developed in collaboration with the USEPA via the TWG, and applies site-specific exposure information for the fish ingestion exposure scenario, which was obtained from surveys of anglers that fish at artificial reefs located near the proposed ex-ORISKANY reef site. Also see response to comment 2.
2c	**Fraction Ingested (FI Term) -** As indicated by the Navy, the FI term is higher for the ex-Oriskany site than for the ex-Vermillion site. Relying on empirical White Grunt data from the ex-Vermillion and then scaling it up to what might be expected for the ex-Oriskany based on the amount of PCBs remaining on the ships at sinking and the relative size of the ships, EPA predicted the risk values provided in Table 1 (for the ex-Oriskany, this would correspond to risk from consuming White Grunt or similar species such as Grey Triggerfish). **[*The example Table provided by USEPA in the original comment letter is attached to the end of this comment/response document*]** As you can see from this table, the estimated cancer risk posed by dioxin-like PCB congeners alone is *greater than* the upper-bound of the	We acknowledge that the FI term for the ex-ORISKANY site is likely to be higher than for the ex-VERMILLION site, based on information gathered from angler surveys, and documented in the SHHRA in an appendix to the revised HHRA. As discussed above, we believe that the ratioing approach is flawed due to our inability to ascertain the amount of PCB-containing material, their distributions onboard the ex-VERMILLION, and their leach rates within reasonable limits of uncertainty, and that the revised PRAM v. 1.4c addresses many of the modeling uncertainties of the previous version (see response to comment 2). Regarding risks associated with dioxin-like PCB congeners, the only value shown to be greater than the upper-bound range of 1E-06 to 1E-04 was associated with a direct mass-to-mass comparison between the two ships. The difference in volume, and its impact on PCB dispersion to the surrounding reef environment was not considered. In our 12 August 2004 meeting with

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	risk range of 1E-06 to 1E-04. Since dioxin-like congeners may not account for all of the PCB cancer risk posed by mixtures of PCB congeners, the predicted cancer risk is probably higher (i.e., one could reasonably add the dioxin-like PCB congener and PCB cancer risks together, with the understanding that there may be some double counting of risk).	USEPA, USEPA agreed that a comparison based strictly on total PCB mass was not appropriate, and that the ratioing evaluation should be based on a comparison of mass as a function of volume (as labeled "PCB Mass (lbs/ft^3)" in the example table provided by USEPA). Also regarding dioxin-like PCBs, it should be noted that EPA's Risk Assessment Guidance for PCBs recommends that dioxin-like PCB congeners be assessed only as another line of evidence in the uncertainty section of the risk assessment. The ex-ORISKANY HHRA (revised SHHRA) discusses the uncertainty associated with evaluating total PCB concentrations rather than risks from various dioxin-like PCBs.
3	**Fish Species Assumptions** - In EPA's June 25, 2004, comments, it was noted that empirical data for White Grunt at the ex-Vermillion were higher than the modeled fish tissue concentrations. The Navy noted in their response to EPA that "...measured concentrations for species preferred by anglers (Black Sea Bass and Vermilion Snapper) from the ex-Vermillion site are similar to those in reef fish predicted for the ex-Oriskany site by the PRAM." While it is true that PRAM appears to do a better job predicting fish tissue concentrations for the other two species tested at the ex-Vermillion, it was our understanding that White Grunt was also selected at the ex-Vermillion site because it too was a species preferred (i.e., caught and eaten) by anglers. Also, the White Grunt is intended to be representative of other species that may accumulate PCBs in a similar manner that might be consumed by anglers. Thus, consideration of the White Grunt data is essential.	Both the Navy and EPA are concerned about any impact that PCB bulk products may have on fish at an artificial reef. While the White Grunt is not expected to be a predominant species at the ex-ORISKANY site, as mentioned previously, the Grey Triggerfish is considered a logical species to fill the same ecological niche as the White Grunt. Since the Grey Triggerfish may be considered comparable to the White Grunt, with respect to the trophic level and dietary preferences, its is agreed that it is appropriate to be concerned about the likely PCB concentrations that could occur in the Grey Triggerfish. Further, we recognize that it is an important issue that should be properly addressed. Given that White Grunt caught at the ex-VERMILLION reef had higher PCB levels (by approximately an order of magnitude) than the Black Sea Bass and the Vermilion Snapper, and that this increase is unexplained, a post-sinking monitoring program for this fish (or a comparable species, such as the Grey Triggerfish) may be appropriate. This issue was discussed in detail in the 23-24 September 2004 TWG meeting, including this as a primary reason for refining PRAM (e.g., fugacity level III, division of the water column into two regions, water-diet matrix, and re-examining the ZOI that must be modeled). A method of evaluating PRAM results with respect to the White Grunt levels found at the ex-VERMILLION was suggested by EPA (see Barber comments on PRAM, i.e., to run a sensitivity analysis to see if PRAM, using assumed sources loading parameters for the ex-VERMILLION, could predict fish tissue levels equivalent to those found in the White grunt). The Navy conducted this analysis (an emission study), presented the results in the November TWG meeting, and found that if various PCB loadings on the ex-VERMILLION were assumed, then PRAM can predict fish tissue concentrations equivalent to the White Grunt found at the ex-VERMILLION. Also please note that the

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		previous modeling results were based on the earlier version of PRAM, which has been substantially revised in version 1.4c to address concerns about the accuracy of predicted PCB concentrations in fish tissue.
4	**Dioxin-like PCBs** - The SSHRA does not address the dioxin-like PCBs using PRAM. Dioxin-like PCBs were the risk drivers for the ex-Vermillion but were not evaluated by the PRAM for the ex-Oriskany (only "PCBs" in a more general sense were evaluated). Thus, it is very likely that the PRAM-based risks for the ex-ORISKANY are underestimates. This should be addressed in the SHHRA, at a minimum, using the comparative approach discussed in Issue Number 2 above.	Conversion factors can be developed using the ex-VERMILLION reef data to convert total PCB levels in fish to dioxin-like exposure levels, albeit with some uncertainty. In the 12 August 2004 meeting with EPA, we agreed that we would conduct such an evaluation in the SHHRA, However, given our inability to ascertain the amount of PCB-containing material and their distributions onboard the ex-VERMILLION, and the fact that the PRAM version 1.4c is now a fugacity level III model, as discussed in response to comment 2, we no longer believe that a comparative approach is appropriate.
5	**Fish Advisory Guidance** - As indicated in comment 1 above, the Prospective Risk Assessment Model (PRAM) used to evaluate the impacts of sinking the ex-Oriskany found that human health cancer risks and non-cancer hazards were acceptably low for all "reef fish." However, empirical data for a similar artificial reef (the ex-Vermillion) are in direct conflict with this result. Specifically, the PRAM was used to estimate the uptake of PCBs by "reef fish" and subsequent consumption by recreational fishermen. The PRAM's predicted cancer risk from "reef fish" was 1E-06 (under reasonable maximum exposure or RME conditions). However, when this result is compared to the three species of reef fish sampled at the ex-Vermillion, it is clear that not all reef fish are equal with respect to their tendency to bioaccumulate PCBs and that the PRAM may not be adequately accounting for this fact. Of those three species sampled at the ex-Vermillion, two showed risk results that were comparable or lower than the PRAM's result for reef fish (1E-06 for Black Sea Bass and 5E-07 for Vermillion Snapper). However, PCB concentrations in White Grunt were *substantially higher* than these two other reef species (e.g., 0.3 ppm average total PCBs in White Grunt versus 0.014 ppm average total PCBs in Vermillion Snapper and 0.04 ppm in Black Sea Bass). This is strong evidence that the PRAM may not adequately predict the potential	The EPA Fish Advisory Guidance document recommends using a similar risk paradigm as was used in the ex-VERMILLION HHRA; however, it contains more conservative assumptions when compared to the EPA's Risk Assessment Guidance (RAGS), including: (1) exposure over 70 years vice 30 years and (2) 100% of the fish ingested is assumed to come from the reef (i.e., there is no site-specific Fraction Ingested term). The ex-ORISKANY HHRA follows the methodology recommended by the EPA's Risk Assessment Forum; i.e., a site-specific risk assessment. In this context, the risk equations in the ex-ORISKANY HHRA incorporate a Fraction Ingested (FI) term, based on site-specific information about marine anglers' consumption patterns, and exposure is assumed to occur over 30 years. The regulatory agencies responsible for issuing fish advisories are the State, or the Food and Drug Administration (FDA), specifically for fish that is sold across state lines. The decision as to whether or not a regulatory agency would issue a fish advisory is a risk management decision that takes into factors like scientific judgment, social, economic, and political factors. The ex-VERMILLION HHRA is a site-specific risk assessment based on the EPA's Risk Assessment Guidance (RAGS) and concludes no unacceptable human health risks. The thresholds referenced for a fish advisory by EPA Region 4 are generic and non-site specific values (0.019 ppm [wet weight] or 0.166 ppm

[1]EPA's National Guidance for Assessing Chemical Contaminant Data for Use In Fish Advisories (see http://www.epa.gov/ost/fishadvice/volume2/v2ch4.pdf).

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	impact of a PCB-laden ship carcass on sportfish tissue concentrations. Indeed, the SHHRA acknowledges this fact, noting (page 5-13) that: ...it is observed in actual sampling of fish tissues from the ex-Vermillion that the PCB levels found in the While Grunt are higher than in other reef fishes, i.e., Black Sea Bass and Vermillion Snapper. It is believed that, among other reasons (e.g., background contribution), the higher White Grunt PCB tissue concentration found near the ex-Vermillion may be due to an alternate dietary composition than what is presently within the PRAM. According to ECMRD, White Grunt is not prevalent at the East Escambia County LAARS; however, the Gray Trigger Fish, that could occur at the ex-Oriskany reef, may have similar tendency to accumulate PCBs as the White Grunt due to its dietary preferences (ingestion of encrusting benthic macroinvertebrates.) Based solely on the total PCB levels in White Grunt at the ex-Vermillion, a "DO NOT EAT" fish advisory for this species is expected based on EPA fish advisory methodologies.[1] Based on the risk estimates in Table 1, one would also expect the ultimate establishment of a DO NOT EAT fish advisory for the species corresponding to White Grunt at the ex-Oriskany site (Grey Triggerfish or similar species). In summation, available information indicates that the PRAM may be inadequate regarding its ability to adequately characterize PCB uptake in fish across species of interest.	[dry weight]). As discussed in the 12 August 2004 meeting, we expressed that it would be appropriate for the Navy, in the ex-ORISKANY HHRA, to address the potential State of Florida regulatory and risk management options, including issuance of a fish advisory. Our understanding is that the State is the cognizant party to determine whether a fish advisory is necessary, and that the state will evaluate all factors, including the risk assessment findings and fish consumption patterns of the receptors of concern.
6	**Child Receptor Not Analyzed** - There does not appear to be an evaluation of the child receptor in the ex-Oriskany risk assessment. Since sport fishermen commonly feed their families with their catch, the child receptor scenario should be considered.	The lack of a child receptor in the SHHRA was an inadvertent omission. A child receptor was previously evaluated as part of the ex-VERMILLION HHRA. The ex-ORISKANY HHRA (revised SHHRA) incorporates the same child scenario used for the ex-VERMILLION, using site-specific information (fish ingestion rates, fraction ingested, etc.) where appropriate.

	COMMENT	RESPONSE
7	**Ecological Risk** - There is no ecological risk analysis for the ex-Oriskany, and EPA is concerned that the conclusion of the existing eco risk analysis for the ex-Vermillion (i.e., acceptably low risk) is incorrect. For example, the average PCB concentration of total PCBs in White Grunt is 0.3 ppm. However, EPA has developed wildlife protection values for fish tissue concentrations protective of wildlife that rely on fish for most of their diet. The wildlife protection value for PCBs is 0.16 ppm.[2]	Although it appeared that USEPA accepted the use of the ex-VERMILLION SERA for evaluation of the ex-ORISKANY during the 18 May 2004 ex-ORISKANY, it is acknowledged that there are now reservations in making this broad extrapolation. Pursuant to discussion held in the 23-24 September 2004 meeting with USEPA in Atlanta, another Screening Ecological Risk Assessment (SERA) has been performed for the ex-ORISKANY. This supplemental ERA compares benchmark values, developed as part of the SERA for the ex-VERMILLION, to tissue concentrations at the ex-ORISKANY site, as predicted by PRAM. The Wildlife Protective Value (WPV) is essentially equivalent to the benchmarks used in the SERA for protection of dolphins, ospreys, and diving ducks. The benchmarks used in the SERA are slightly different than the WPV because the benchmarks for dolphins, ospreys, and diving ducks are scaled to the body weights and dietary requirements of organisms that would actually feed and forage on the reef. The WPV is a generic benchmark based on the most sensitive wildlife species among birds (Kingfisher, Herring Gull, and Eagle) and mammals (Otter and Mink) and is not scaled to account for organisms found on the reef. It is noted that when the WPV benchmark is placed within the SERA report benchmarks, it falls under the threshold screening value (TSV) and above the Dolphin value, therefore approximating the most conservative benchmark but actually slightly above it.

[2]USEPA. 1997. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: National Sediment Quality Survey. EPA 823-R-97-006. U.S. EPA. Washington D.C. pp. B14-B15.

Response to USEPA Region 4 Comments on "PRAM Issues"
(Source: Ms. Beverly Banister, USEPA Region 4, 17 September 2004)

Table 1. Comparative Risks*

	Ratio of ex-ORISKANY to ex-Vermillion[b]	HHRA ex-Vermillion PCB Risk[d]	Estimated ex-ORISKANY PCB Risk[e]	HHRA ex-Vermillion Dioxin Risk[d]	Estimated ex-ORISKANY Dioxin Risk[e]
Reasonable Maximum Exposure (RME) Exposure Conditions					
PCB Mass (tons)[a] IR (g/day) FI (unitless) TOTAL[c]	3.14 1.64 1.70 8.76	1.10E-5	9.63E-5	2.34E-5	2.05E-4
PCB Mass (lbs/ft^3)[a] IR (g/day) FI (unitless) TOTAL[c]	1.95 1.64 1.70 5.44	1.10E-5	5.98E-5	2.34E-5	1.30E-4
Central Tendency (CT) Exposure Estimate					
PCB Mass (tons)[a] IR (g/day) FI (unitless) TOTAL[c]	3.14 1.53 1.79 8.59	1.05E-6	9.01E-6	2.75E-6	2.36E-5
PCB Mass (lbs/ft^3)[a] IR (g/day) FI (unitless) TOTAL[c]	1.38 1.53 1.79 3.79	1.05E-6	3.98E-6	2.75E-6	1.04E-5

[a] Taken from the footnote on page 3-4 of the SHHRA.
[b] Calculated by dividing the value from the ex-ORISKANY by the corresponding value for the ex-VERMILLION.
[c] Total ratio was calculated by multiplying the ratios for each of the three factors (i.e., PCB Mass ratio * IR ratio * FI ratio).
[d] Risk from ingestion of White Grunt from the HHRA for the ex-Vermillion; slope factor of 2 $(mg/kg/day)^{-1}$ used.
[e] Calculated by multiplying the risk from the HHRA times the total ratio; slope factor of 2 $(mg/kg/day)^{-1}$ used.

* This rationing methodology is fatally flawed due to our inability to ascertain the amount of PCB-containing material and their distributions onboard the ex-VERMILLION within reasonable limits of uncertainty. As described in Section 6 of the ex-ORISKANY HHRA, each material has different leach rates with patterns of homologs releases specific to their rates. The PCB mass for the ex-VERMILLION was an extrapolation of an extrapolation. Previously submitted responses to these and related comments relate back to results predicted by the previous version 1.3 of PRAM. A new version PRAM version 1.4c has been developed in collaboration with the USEPA via the TWG (see response to comment 2). Thus, we cannot justify continued comparisons via the rationing method in light of the development of a new version of the model (PRAM, version 1.4c)

Response to USEPA Region 4 Comments on "PRAM Issues"
(Source: Ms. Beverly Banister, USEPA Region 4, 17 September 2004)

COMMENT	RESPONSE
PRAM Issues (paraphrased)	**General Response: To address the comments raised by ORD and Region 4 regarding the model, the Navy has completed a revision of PRAM, completed testing and QA/QC check, and provided documentation of the model. The Navy has also revised and reissued the July 04 SHHRA document, which is now called the HHRA for the ex-ORISKANY.**
The fish bioenergetic algorithms are probably overly simplistic. These algorithms are not consistent with formulations found in commonly used bioenergetic models such as the Wisconsin Bioenergetics Model.	PRAM was designed to be simple, using commonly applied methods, and is considered to be robust. Respiration algorithms were taken directly from the Wisconsin Bioenergetics Model. The growth model used in PRAM, derived from a balanced energy equation, is comparable, if not identical, to the simple linear growth equation used in the Wisconsin Fish Bioenergetics Model (Hewitt and Johnson 1992) for freshwater fish. Linear growth equations are commonly used. In a recent review paper (Barber, 2003) it was noted that, growth rates reported by the studies analyzed in the paper were *always* described using a linear growth model (pg. 1985). While this review paper provided a rationale for recommending that bioconcentration models use a more complex fish growth rate algorithm, we are not sure how significant a parameter this may be to PRAM predictions. The PRAM models fish growth in a generic, or average, way, in order to predict fish bioconcentration at a trophic level, rather than for individual fish species. Additionally, the PRAM models bioaccumulation and bioconcentration based on both water exposure and dietary uptake. To the extent that dietary uptake is considered the more significant source of PCBs for fish living at a reef for their entire lifespan, the importance of using a more complex growth algorithm in PRAM (which may more closely approximate growth rates in individual species) is uncertain. We satisfactorily discussed and explained our basis and rationale for use of the growth rate algorithm in our model. This issue has been resolved with no changes on the existing growth model necessary.
Bioaccumulation algorithms should be re-evaluated in light of recent	Biouptake and subsequent bioaccumulation of PCBs can occur via food intake

COMMENT	RESPONSE
review papers. For example, the algorithms used by PRAM for modeling the elimination/excretion of PCBs by fish have been shown to be poor predictors of this important bioaccumulation process when used as is without model calibration.	(ingestion) or direct dermal contact, or across respiratory exchange membranes (i.e., the gills). The primary uptake route for fish is through the food chain (ingestion). Direct dermal contact and uptake across the gill are relatively minor pathways. A review of the detailed comments provided by Dr Craig Barber in his 15 September 2004 comments indicates that the primary algorithm of concern was related to gill exchange. The gill exchange algorithm used in PRAM differs from the "best fit" model, per the Barber (2003) study, by only 6%. The relative difference in predictability for all of the gill exchange models evaluated is from 4 to 16% (for uptake and elimination, respectively). In our opinion, such findings may not provide sufficient reason to invalidate the use of the algorithm used within the PRAM. It should be noted that, while the gill exchange algorithm remains unchanged, PRAM version 1.4c incorporates new gill exchange rates, based on marine species instead of fresh species, and the gill rates have been corrected for PCBs per comments from Dr Barber (see response to comment 1.1 from USEPA 15 Sept 2004 comments), with minor revisions to his recommended algorithms to reflect proper unit conversions (Section 2.7.2.4, PRAM Documentation, NEHC/SSC-SD, 2005). The issues of gill exchange, direct dermal contact (specifically related to encrusting organisms), and food chain were discussed in the 23-24 September 2004 TWG meeting. We intend to work closely with EPA to ensure that the revised PRAM adequately addresses these issues. Note that the last comment/response in this attachment addresses the issue of model calibration/corroboration/testing.
The theoretical foundations and conceptual model for the PRAM fate and transport models must be fully documented and defended. PRAM's current equations appear to be inconsistent with mass balanced, fugacity-based models that can be objectively reviewed and defended.	It was not our intent to be parsimonious or presumptive, in the description of PRAM (i.e., for not providing an in-depth defense of the fugacity model in the SHHRA document). Rather, from the continued stages of PRAM development we purposively sought a "pre-defended" model, one that we believed had already received EPA endorsement (in that it was applied in the Great Lakes Water Quality Initiative [USEPA 1995]). As such, we believed the fugacity model developed by Mackay was widely known, and widely accepted as an adequate model, for modeling PCB fate and transport at the resolution needed for the PRAM human health risk assessment predictions. Version 1.3 of PRAM is a fugacity based, Level II, equilibrium model. Based

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	on further discussions with Dr. Craig Barber (USEPA) and Dr. Keith Little (RTI), it was concluded that a fugacity based, Level III, equilibrium model would provide a more robust evaluation. As such, PRAM 1.4c has been revised as a Level III model. Documentation for PRAM version 1.4c has been prepared (NEHC/SSC-SD, 2005) as a separate document from the human health risk assessment to provide a detailed, defensible discussion of the abiotic fate-transport modeling approach (fugacity equations) and other components used in the model.
The implicit conceptual model used by PRAM is overly simplistic. In particular, it only considers advective transport of PCBs within the zone of influence (ZOI); no diffusive transport is considered.	PRAM was designed to be simple. Diffusion out of the PCB-containing materials is the driving force for PCB release. However, diffusion between the media "boxes" within the PRAM was considered to be a minor transport vector, as advection is several orders of magnitude greater. Nevertheless, based on discussions with the EPA and others, it is recognized that the level II fugacity equations used in PRAM version 1.3 may not address the impedances associated with diffusion between the model compartments. As discussed in the previous response (above), PRAM version 1.4c has been modified as a Level III equilibrium model. Diffusive transport is now addressed directly as a separate transport mechanism in the revised PRAM model.
Encrusting biota that will bioaccumulate leaching PCBs should be added to the PRAM fate and transport module.	Encrusting biota are included within the PRAM but their exposure is limited to water exposure and not "direct-contact," with passive diffusion into their tissues. As discussed in the November TWG meeting in Atlanta, direct absorption of PCBs into encrusting organisms from the outer surface of the ship is considered a minor exposure route at most. The exterior of the ship, where most of the encrusting organisms are likely to attach, is not believed to contain PCBs. Interior compartments, while containing potentially significant levels of PCBs in some materials, do not provide prime habitat for encrusting organisms. As such, encrusting organisms on the ship's interior are likely to provide only a small fraction of the overall diet of predatory fish that could be consumed by humans, and would be expected to contribute little to the overall PCB loading in the fish. A discussion of this pathway has been included in the uncertainty section of the ex-ORISKANY HHRA.
An objective and defensible method for designating the ZOI of a reefed vessel must be developed.	We agree that the ZOI needs to be objectively defined relative to the physical constraints of the vessel and surrounding environment, as well as the biological community being modeled. The Navy, working closely with modelers and biologists in the Technical Working Groups (TWGs), has defined two ZOIs for use in the ex-ORISKANY HHRA that are thought to best represent uptake of PCBs released from the reef into the biological community. A ZOI of 2

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	(equivalent to 15 meters) is used to model uptake into reef-associated organisms, while a ZOI of 5 (approximately 50 meters) is used to evaluate less-reef-associated species. The basis and rationale for developing the ZOI approach has been documented, based on a review of literature and biological habitat considerations, in a paper by Dr. John Conner (NEHC, 2005). This paper has been attached as Appendix F of the "Prospective Risk Assessment Model (PRAM) version 1.4c Documentation, May 2005, Draft Final".
The PRAM parameterization for fishes is very subjective and insufficiently researched. For example, pelagic predators are parameterized by data for lake whitefish (coregonids) which are freshwater planktivores. Similarly, reef predators are parameterized as largemouth bass.	The fish and invertebrate parameterization within the PRAM was based on our research of studies that provided a full data set that included energy budgets and temperature-dependent respiration rates. As pointed out by Connolly (1990), the exact species may not be overly important when the species selected is representative of the organisms within the trophic level, and results using alternate species will therefore not be significantly different. We recognize that the use of parameterization values based on freshwater species added a level of uncertainty to PRAM version 1.3. Parameterization values used in PRAM version 1.4c have been revised, and are now based on marine species.
There is a major quality assurance issue with the total PCB water concentrations reported on the PRAM *Estimate* output worksheets and their associated *Supplemental Info* output worksheets. In particular, concentrations of individual PCB homologs appear to exceed total PCB concentrations by three orders of magnitude between the two sheets.	Comment acknowledged. We most sincerely regret our oversight in forwarding PRAM (Version 1.3) to EPA as an in-progress review product. The disparities EPA observed, between the PCB concentrations reported in the *Estimate* output worksheet and the *Supplemental Info* output worksheet, resulted because two of the "scenario analysis" modules in PRAM had not been revised to reflect the specific dimensions, PCB source terms, etc. for the ex-ORISKANY. Therefore, results associated with the updated *Risk Calculation* module in PRAM ver. 1.3 were not consistent with the results associated with the non-updated *Calculate Amount of Material* module. This problem has been resolved, as PRAM ver. 1.3 has been updated and revised to become PRAM ver. 1.4c.
There are numerous inconsistencies between units specified for equations in the SHHRA dated June 18, 2004, and the PRAM model itself. There is a real concern that such errors and inconsistencies in the PRAM's written description are real or potential indicators that similar errors and inconsistencies may have been propagated to the model's mathematical code.	Comment acknowledged. We agree that this is a valid concern on EPA's part. For PRAM 1.4c, we have conducted testing and QC checks, including mass balance algorithms. Regardless, we strive to reach the goal of perfection, and continue to look forward to any comments EPA may have on the model. Documentation of the testing /QC is presented in PRAM Documentation (NEHC/SSC-SD, 2005). We also maintained a log on revisions made to the draft before it is finalized for this submission to the EPA.
PRAM predictions must be tested or corroborated. More specifically, a validation study should be performed to see if PRAM could predict the white grunt data for the ex-Vermillion.	Through the TWG, the Navy collaborated with the agencies to satisfactorily resolve issues or concerns expressed by the EPA and State of Florida. These issues included:

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	- Determining the feasibility of defining the ZOI in terms of home ranges and/or dietary preferences or habitation preferences of fish species - Comparing the BAFs calculated by PRAM to BAFs cited in the literature - Applicability or relationship of PCB fish concentrations predicted by PRAM and fish sampling results from the ex-VERMILLION reef - Evaluating the potential impacts of PCB pulses that may occur in or around the sunken vessel prior to the system reaching steady-state/equilibrium conditions - Evaluating pulse PCB loading of sediment/biota during early stages of reef history - Evaluating the potential for higher PCB loading in encrusting organisms and potential diffusion into tissue from direct contact with ship materials - Conducting additional literature research to identify and evaluate studies of marine fish species that can be used to parameterize PRAM (for predator and reef fish) - Updating PRAM to include a child-receptor scenario in the risk assessment - Updating PRAM to allow output of additional parameters such as assimilation efficiencies, BAFs, and BCFs. With regard to corroborating PRAM ver. 1.4c, we will look forward to working with the agencies, especially the State of Florida who has a robust reef monitoring program in place for its artificial reefs. The Navy evaluated PRAM in terms of its ability to predict specific data set from the ex-VERMILLION reefin an "Emission Rate" studyto see if PRAM could predict the white grunt data for the ex-VERMILLION. A brief description of this effort was provided at the 23-24 September meeting. This study demonstrated that white grunt-like fish tissue loadings could be predicted by PRAM, based on a variety of assumed PCB loadings within the ex-VERMILLION. PRAM version 1.4c outputs for the ex-ORISKANY site also predict fish tissue concentrations for trophic level III (triggerfish) and IV (grouper) reef fish similar to those seen in White Grunt from the ex-VERMILLION.
SERA Issues (Paraphrased)	**Note: The Navy has revised the ex-VERMILLION SERA to address the comments and suggestions provided by ORD and Region IV and have reissued the document (The Ecological Risk of Using Former Navy Vessels to Construct Artificial Reefs: An Initial and Advanced Screening Level Ecorisk Assessment. Final Report May 22, 2005, Space and Naval Warfare**

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	Systems Center, San Diego, CA, 597pp.) The Navy has also prepared a separate document to address the ecological risks from sinking ex-ORISKANY (An evaluation of ecological risks associated with sinking the ex-ORISKANY to create an artificial reef within the Escambia East Large Area Artificial Reef Site, Florida. Draft Report, June 2005, Space and Naval Warfare Systems Center, San Diego, CA).
Use of residue data derived solely from analysis of fillets from the supplemental fish sampling potentially underestimates ecological risk and is not sufficiently conservative. Whole body burdens should have been used in screening calculations. In the absence of those data, the risk assessment may require development of statistical relationships between fillet and whole body concentrations to support conservative analyses.	A procedure to estimate whole body PCB residues was developed and a spreadsheet with the assumptions, equations, and calculations for the supplemental fish data was reviewed as satisfactory by ORD. The calculations for whole body tissue residues were higher than the estimates derived solely from analysis of fillets and these data have been incorporated into the revised report. Because the fillets were analyzed with “skin on” the increases were not drastic. The calculations for whole body tissue residues, the bounds associated with those estimates, and uncertainty in the estimates have also been included in the revised report.
The discussion of screening methods, possible interpretations, and assessment uncertainties in the SERA is unclear and incomplete, resulting in and inadequate understanding of the ecological risks. A more neutral and transparent description of methods and results, and of the strengths and limitations of what was done, is required to support the assessment conclusions.	The SERA report was revised to more clearly communicate the strengths and limitations of the assessment. Specific comments provided by ORD were also addressed in the revised document. Furthermore, recommendations and suggestions for improvements on the SERA received from ORD were also incorporated into the ecorisk assessment prepared for the ex-ORISKANY.
The summary conclusions offered in the document are not supported by the results of the assessment. Certain findings suggest the need to conduct more refined assessments of risks posed by PCBs and other chemicals to the reef community.	The SERA report has been revised and improved to address specific comments and suggestions received from ORD and Region IV. In addition, an advanced screening for potential effects from PCBs was also conducted. The advanced screening was warranted because some PCB concentrations exceeded the initial screening levels and because of the importance of evaluating potential toxicological effects from PCBs to support the risk management process.

Response to USEPA Comments on:
"Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels"
By Dr. M. Craig Barber, USEPA/ORD/NERL/ERD (15 September 2004)

	COMMENT	RESPONSE
1. Review of PRAM Bioaccumulation and Bioenergetic Algorithms		
1.1	The algorithms used for gill uptake and excretion (i.e., Equations 28 and 45) should be either calibrated or replaced. In a recent review of the performance of 10 of the most widely used/cited gill exchange models (Barber [2003]) demonstrated that the formulations used by PRAM to describe these processes were the least accurate, uncalibrated algorithms reviewed. That is, these algorithms exhibited the largest deviations from the ideal model fit of observed equals predicted (see results for Model 8 in Tables 13 and 14 in Barber 2003).	Regarding Equation 28 (for gill uptake [Ku_i]): This equation, from Connolly (1991) was evaluated as one of the ten-gill exchange models evaluated by Barber (2003). For the ten models evaluated, the range in performance, as represented by the r^2 (pg. 1978) is from 0.655 to 0.694, for routine respiration, with 1 equal to a perfect correlation between predicted and observed results. For standard respiration, the range in performance, as represented by r^2, was between 0.671 and 0.720. Stated another way, the relative difference in predictability for all models evaluated is from 4 to 16%. In our opinion, we believe that the findings do not provide sufficient reasons to invalidate the use of the algorithm used within the PRAM. Moreover, we note that Barber (2003) states that "With such small differences between r^2s, there seems to be very little difference between any of the models analyzed, with respect to their predictive abilities." The author also states, "what is equally important is that none of the models examined could be identified as the most inaccurate or worst model for all analyses considered." We do recognize and appreciate the sophisticated analyses conducted by Barber (2003) in systematically comparing the structure and quantitative behavior of ten of the most widely cited fish bioconcentration models. And we agree that the uptake rate equation (Equation 28) used in PRAM is from Connolly (1995), which Barber describes as essentially "isomorphic to the model proposed by Norstrom et al. and Neely," in that Connolly assumed that the permeability ratio could be estimated by the ratio of uptake assimilation efficiencies. Regarding the EPA recommendation that this gill uptake equation should be "calibrated," several changes have been made to PRAM. Respiration efficiency values used in the previous version of PRAM, based on freshwater fish, have been replaced with values for marine species, and the uptake rates have been corrected for PCBs per the recommendations in Barber (2003).

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		With respect to the elimination rate (Ke), Equation 45 was not used in the PRAM, but rather presented in the text of the SHHRA as an equation reviewed and rejected for use in the PRAM. The elimination rate constant used in the PRAM is calculated using equation 47 (used by Thomann (1989), Fisk et al. (1998) and Woodburn et al. (2003)). We regret the confusion and have revised the PRAM documentation.
1.2 (a)	The claim that PRAM is a "most" conservative formation because chemical assimilation efficiencies used by the model are upper bounds of the results of Gobas et al. (1988), Thomann (1989), and Fisk et al. (1998) is not well founded. See text following Equation (44) on page 5-12 and Figure 5-4. Assimilation efficiencies cited and used by PRAM are <u>not</u> fundamental uptake parameters but rather are net exchange parameters whose values depend on exposure conditions and on the growth, feeding, and gill exchange capacities of the fishes of interest. See, for example, Barber (1991, 2001, 2003, 2004, Barber in preparation). "Constant" assimilation efficiencies, for example, can be shown to decrease as a function of exposure duration.	We were unable to find the citation noted by the reviewer (i.e., that PRAM is a "most" conservative model). In the text following Equation 44 (page 5-12), we state that, "the curve fit in Figure 5-4 appears to be adequate and conservative, since virtually all of the empirical data fall below the prediction line." We were simply stating that the PRAM model uses conservative assumptions. We were unable to find any specific description or definition within the PRAM or its documentation to the effect that assimilation efficiencies are "uptake parameters"; the Navy agrees that these are not uptake parameters. The "constant" assimilation efficiencies used in PRAM do not decrease over time as a function of exposure duration. We welcome specific recommendations and collaboration with EPA to improve PRAM where changes will increase confidence in the predictions.
1.2 (b)	Additionally, the assimilation efficiencies presented in Figure 5-4 are calculated using very different methods. Fisk et al. (1998), for example, calculated assimilation efficiencies by fitting the dietary uptake model of Bruggeman et al. (1981) to growth-corrected whole-body concentrations. One can easily verify that such assimilation efficiencies, for all other conditions are equal, are always less than assimilation efficiencies estimated from <u>unadjusted</u> whole-body concentrations, i.e., data analyzed by Gobas et al. (1988) and Thomann (1989).	The assimilation efficiencies presented in (plotted on) Figure 5-4 are from a variety of sources, based on a review of the raw values as reported in the literature, and we recognize that the various assimilation efficiency values were calculated, by the various researchers, using very different methods. We compiled and evaluated these values in the context of the descriptive algebraic functions as they relate to chemical K_{ow}. The functional relationship between K_{ow} and assimilation were evaluated in that context. Our purpose was to derive a functional algorithm that would ensure that PRAM was conservatively estimating the assimilation of PCBs in fish. While it may be true that the Fisk et al. (1998) values are less than those reported by Gobas et al. (1988), Thomann (1989), and Woodburn et al. (2002), the final regression we conducted shows *all* of the observed values

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		(whole-body and growth-normalized) fall below the prediction line. This was the acceptance criterion, where the goal was to assure that assimilation was not underestimated. To reiterate, we do not claim that PRAM is the "most conservative" assimilation model, only that it uses conservative algorithms. We welcome specific recommendations and collaboration with EPA to improve PRAM where changes will increase confidence in the predictions.
1.3	The growth model used by PRAM has been seldom used in the literature. Moreover, the mathematical ramifications of this model are not demonstrated by statistical analyses of fish growth data. PRAM assumes that growth/production, feeding, respiration, and excretion are simple linear fractions of the fish's total energy budget that is estimated directly from the fish's oxygen consumption. Thus, this formulation predicts that allometric exponents for a fish's specific rate of oxygen consumption and growth should be approximately equal. This prediction, however, is seldom observed. The mean exponent for weight-specific growth rates summarized in Table 1 for common reef-associated fishes in the southeastern US and Gulf of Mexico is -0.858. The mean allometric exponent for weight-specific growth rates calculated by Barber (2003) for 68 species of freshwater fish was -0.675. Both of these exponents are significantly different from the exponents typically reported for the weight-specific rates of oxygen consumption by fish that are typically on the order of -0.2.	The growth model used in PRAM, derived from a balanced energy equation, is derived from the simple linear growth equation used in the Wisconsin Fish Bioenergetics Fish Model (Hewitt and Johnson 1992) for freshwater fish where growth is calculated with the following equation: Growth rate = C – (R + S) – (F + U) Where: C = metabolic energy consumption (feeding rate), R = respiration, S = specific dynamic action, F = fecal excretion, and U = urinary excretion The Wisconsin Fish Bioenergetics Fish Model is an often-cited reference for modeling bioenergetics such that it was considered useful in the construct in the PRAM. We understand the EPA's position, presented in the section of Barber (2003) entitled "Improving Bioconcentration Models", that one area of improvement for current and future bioconcentration models is a more accurate prediction of fish growth and biotransformation. As noted in the equation: $BCF = k_1/(k_1/W + \gamma + k_m)$ where γ and k_m denote the fish's specific growth rate and chemical's biotransformation rate, respectively, if a fish's growth dominates the denominator, then the fish's BCF may appear to be independent of any physical property.. However, it is also noted in Barber (2003) that, "when growth rates were reported by the studies analyzed growth was *always described* using the simple linear growth model." While we agree that this may be an area of improvement for future

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		bioconcentration models, we note that PRAM is constructed to predict fish concentrations (and subsequently human health risks) for various trophic levels of fish, as opposed to modeling at a species-specific level. PRAM was developed for use as a predictive risk assessment tool, using accepted equations that have been elsewhere applied, as opposed to being developed as a refinement to existing models. If EPA believes that a more sophisticated model for growth is needed in PRAM, in particular for application of PRAM at a National approval level, we would welcome specific recommendations and would like to work collaboratively with EPA to determine the most appropriate growth rate model for PRAM.
1.4a	To evaluate how PRAM bioaccumulation predictions might differ from the predictions of a more process-based bioaccumulation model, BAFs (Bioaccumulation Factors) predicted by PRAM were compared to the range of BAFs predicted by the BASS bioaccumulation and fish community model. See Barber (1996, 1998, 2001, 2004). ….. For example, the $\log_{10}$ BAF for total PCBs in white grunt was estimated to range from 5.89 to 6.45. Table 5 summarizes BAFs for total PCBs predicted by PRAM for the ex-ORISKANY using the model's default parameterization. …… The mean $\log_{10}$ BAF for reef foragers and predators calculated from these PRAM predictions is 5.89. Although this value agrees well with the lower bound of the preceding BASS prediction for white grunt, this agreement may be coincidental since these BASS and PRAM predictions use different K_{ow}s and physiological and ecological fish data.	Although we understand that agreement in BAFs, between those predicted in PRAM and the reviewer's own model "may be coincidental", we find this corroboration encouraging. Moreover, we greatly appreciate that the reviewer conducted this in-depth comparative analysis. Per discussions with EPA at the recent meeting in Atlanta, EPA also suggested that we may improve PRAM by building in more "output" parameters, including the bioaccumulation factors calculated by PRAM (such that future reviewers will have these values readily available for comparison). Navy has agreed to improve PRAM in this manner prior to resubmitting the revised model for further EPA evaluation/review.
1.4b	More important, there is an undetermined QA issue with the BAFs calculated using the water and fish concentrations summarized in Table 5. In particular, these concentrations are summary values reported for total PCBs on the PRAM *Estimate* output worksheet. Inner vessel water concentrations reported for the individual PCB homologs on the *Supplemental Info* output worksheet, however, can exceed their corresponding total concentrations on the *Estimate* output worksheet by three orders of magnitude.	Comment acknowledged. We most sincerely regret our oversight in forwarding PRAM (Version 1.3) to EPA without better explanations for the users. The disparities EPA observed, i.e., between the PCB concentrations reported in the *Estimate* output worksheet and the *Supplemental Info* output worksheet, were because two of the "scenario analysis" modules in PRAM had not been revised to reflect the specific dimensions, PCB source terms, etc., for the ex-ORISKANY. Three "analysis" options/modules are included within the PRAM: the first is

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		the risk / hazard module, which calculates risk and hazard given an input of the loads of PCB-containing material onboard; the second (the module used by the reviewer) is intended to solve for an allowable mass of a specific PCB-containing material, given a set risk level; and the third is used to estimate risk / hazard given a range of PCB containing material onboard. Only the first module was modified from Version 1.2 of the PRAM for use in the SSHRA for the ex-ORISKANY and the apparent transcription error was a direct result of the modification. We recognize the "transcription error" raised a QA concern for PRAM. We fully intend to update the latter two modules and will conduct a thorough mathematical review and tests to ensure that no similar issues exist within PRAM prior to submitting the revised product to EPA for further evaluation/review.
1.5 Editorial Remarks regarding PRAM Biological Model Algorithms		
1.5.1	Equation 35 is incorrect as written. In particular, the term (1 - *%moisture*) must be replaced with (1 – *fraction* $_{moisture}$) or (1 – *proportion* $_{moisture}$).	The formulas in the text have been revised.
1.5.2	Equation 38 is dimensionally wrong as written. The units of I must be changed to [$kg_{lp} \bullet kg_{lp}^{-1} \bullet d\text{-}^{1}$].	The dimensions on the ingestion equation have been revised.
1.5.3	The sentence preceding and describing Equation 39 must be modified to define *fdiet* as a fraction or proportion; *fdiet* cannot be a percentage in Equation 39.	The sentence was modified to reflect a fraction and not a percentage.
1.5.4	In Equation 39 the upper indices to the summations should be *n* not *j*.	The summation term has been revised corrected.
1.5.5	In Equations 38, 39, and 40 the caloric content of prey items is defined with units [kcal/kg_{lp}]. However, when changing this parameter in PRAM the units are listed as [kcal/g-dry body wt]. Is this a unit inconsistency or a typographical error?	The caloric density reported in the USEPA Exposure Factors Handbook is in dry-weight and was converted to kcal per kilogram lipid within the PRAM. The intent of presenting the data this way was to make it easier to find the values within the source document. This has been made clearer in the revised PRAM documentation.
1.5.6	There are many units inconsistencies between the equations in the SHHRA and their description with the PRAM *Review Governing Equations for the Model*. Some equations, as noted in comment 1.5.4, have incorrect upper summation indices while the counterparts of other (e.g., Equation 38) have been incorrectly rewritten.	Comment acknowledged. The PRAM help files had not been updated from Version 1.2 to reflect the changes made for Version 1.3. The screens containing the governing equations within the PRAM have been revised. See our response to comment 1.5.2.

COMMENT		RESPONSE
2. Review of PRAM Fate and Transport		
Preface (Abbreviated form Comments provided)	There are at least two fundamentally different ways to formulate a fugacity-based model for the fate and transport of PCBs within the ZOI of a reefed vessel. The first of these is formulating PCB fate and transport as a homogeneous, first-order, linear differential equation in which the PCB source material is a static variable or compartment of the system of interest. The second formulation is a nonhomogeneous, first-order, linear differential equation in which the PCB source material is treated as an external forcing function of the system of interest. Importantly, the form and nature of the solutions of these two system models are fundamentally different.	Version 1.3 of PRAM is a fugacity based, Level II, equilibrium model. Based on further discussions with Dr. Craig Barber (USEPA) and Dr. Keith Little (RTI), it was concluded that a fugacity based, Level III, equilibrium model would provide a more robust evaluation. As such, PRAM 1.4 has been revised as a Level III model. .
2.1	Although the PRAM Equation 19 is dimensionally correct, its applicability to modeling PCBs in the reefed vessel ZOI must be explained and defended. Likewise, Equations 20-24 must be explained from a process-based perspective. This reviewer cannot understand how thay are applicable to the analysis at hand. PRAM is basically using the nonhomogeneous system model represented in Equations (10) and (11) with all diffusive transport coefficient D_i set to zero. That is, only advective processes drive the compartmental loading/burdens of the ZOI. In this case, the steady-state fugacity of the water is simply (15). Not only does this solution disagree with PRAM Equations 19 and 21, but it also predicts, all other things being equal, a much higher steady-state water fugacity. PRAM's formulation of Equations 19 through 24 must be explained and defended if its predictions are to be believed.	In view of the detailed descriptions provided in Barber (2003), of the structures and quantitative behaviors of various bioconcentration models, PRAM Equation 19, presented in the SHHRA, does indeed appear unexplained/undefended. Moreover, in the section preceding Equation 19, the "D values" used in the fugacity model, that were constructed/defined by Mackay et al., are simply introduced by definition; i.e., "Media-specific D-values incorporate transport and transformation processes with the fugacity capacities of the media or phase (e.g., Mackay et al., 1995)". Further explanation, such as was provided in Barber (2003) (pgs. 1969-1970) is not presented, nor was there any attempt made to compare the strengths/limitations of this model with other bioconcentration models. Similarly, between Equation (19), which defines Fugacity (F) in terms of its relationship to the D values (as well as PCB mass [emission rates]), we "transition", rather abruptly, (i.e. without further discussion) to the equations that show how PCB concentrations for the various media compartments are calculated, based on the fugacity capacity of that compartment. Prior to presenting any of these equations, i.e. on page 5-3, following Equation (7), we provided the following statement "see also Mackay et al., 1995 for a general review of the methodology." We acknowledge that there may be some impedances associated with this approach, and would be interested in pursuing this further with EPA It was not our intent to be parsimonious or presumptive, in the description of PRAM (i.e., for not providing an in-depth defense of the fugacity model) in

COMMENT		RESPONSE
		the SHHRA. Rather, from the continued stages of PRAM development we purposively sought a "pre-defended" model, one that we believed had already received EPA endorsement [in that it was applied in the Great Lakes Water Quality Initiative (USEPA 1995)]. As such, we believed the fugacity model developed by Gobas and Mackay was widely known, and widely accepted as an adequate model for modeling PCB fate and transport at the resolution needed for the PRAM human health risk assessment predictions. As noted previously, PRAM version 1.4 has been revised as a fugacity based Level III equilibrium model, compared to PRAM version 1.3, which was a Level II fugacity based model. Equations presented in the PRAM documentation have been updated to be consistent with the Level III approach. The term D used in PRAM version 1.3 was a transfer parameter that included both diffusive and advective transport. PRAM version 1.4 now incorporates separate diffusion coefficients and advective transport values.
2.2	Regardless of whether the source of PCBs from the reefed ship is an internal static variable or an external forcing function, it is absolutely critical to objectively define and defend the dimensions of the ZOI. The ZOI dimensions must be defined objectively by considering both the physical boundary layers around the reefed ship based on hydrodynamic and diffusion kinetics, and the biological dimensions of the home ranges of the reef-associated fishes that will bioaccumulate PCBs from the near vessel water and from contaminated vessel-encrusting biota.	We agree that the ZOI needs to be objectively defined relative to the physical constraints of the vessel and surrounding environment, as well as the biological community being modeled. The Navy, working closely with modelers and biologists in the Technical Working Groups (TWGs), has defined two ZOIs for use in the ex-ORISKANY SHHRA that are thought to best represent uptake of PCBs released from the reef into the biological community. A ZOI of 2 (equivalent to approximately 15 meters) will be used to model uptake into reef-associated organisms, while a ZOI of 5 (approximately 50 meters) will be used to evaluate less-reef-associated organisms.
2.3	PRAM only models PCB fate and transport between water, total suspended solids (TSS), dissolved organic carbon (DOC), sediment, and air. Biota that will encrust the reefed vessel should or must be added to the model. Encrusting biota must be added for two important reasons. First, encrusting biota would be expected to have tremendously large diffusive transport coefficients (see Equation (5)). As such, encrusting biota would be expected to accumulate significant fractions [of] the leaching PCBs before they can be	The PRAM not only models PCB fate and transport between water, total suspended solids (as organic carbon), dissolved organic carbon (DOC), sediment, and air, but also between these media and in-faunal sediment-associated macroinvertebrates, epi-faunal sediment-associated macroinvertebrates, benthic foraging first-order carnivores, benthic second-order predators, pelagic phytoplankton, zooplankton, pelagic forage fish, pelagic predators, reef-associated foraging invertebrates, reef-associated 1st – order carnivorous fish, reef-associated 2nd – order carnivorous fish, and sessile (encrusted) filter-feeders.

	COMMENT	RESPONSE
	transported out of the ZOI by advection. In essence, encrusting biota could act like a capillary retention column for PCBs leaching from the reefed vessel. Secondary, these encrusting biota will obviously serve as the basis of the reef food web. Their contribution by leaching PCBs could dramatically offset projected PCB accumulations in higher reef-associated organisms.	As discussed in the November TWG meeting in Atlanta, direct absorption of PCBs into encrusting organisms from the outer surface of the ship is considered a minor exposure route at most. The exterior of the ship, where most of the encrusting organisms are likely to attach, is not believed to contain PCBs. Interior compartments, while containing potentially significant levels of PCBs in some materials, do not provide prime habitat for encrusting organisms. As such, encrusting organisms on the ship's interior are likely to provide only a small fraction of the overall diet of predatory fish that could be consumed by humans, and would be expected to contribute little to the overall PCB loading in the fish. A discussion of this pathway has been included in the uncertainty section of the SHHRA.
2.4 Editorial Remarks regarding PRAM Non-Biological Model Algorithms		
2.4.1	The units of fugacity capacity are incorrectly cited as $mol \cdot m^{3}$ / Pa. The correct units are $mol \cdot m^{-3} \cdot Pa^{-1}$.	The fugacity capacity units have been revised.
2.4.2	Units of the left-hand side of Equation 20 do not match the units of the right-hand side of the equation, i.e.,….	The Equation has been changed to reflect the correct molecular weight conversion (presently stated as mol / g, this will be changed to g / mol, which will correct the unit error).
2.4.3	Same units issue for Equation 21	See response to 2.4.2
2.4.4	Same units issue for Equation 22	See response to 2.4.2
2.4.5	Same units issue for Equation 23	See response to 2.4.2
2.4.6	Same units issue for Equation 24	See response to 2.4.2
3. PRAM Quality Assurance (QA) and Parameterization Issues		
3.1	The PRAM parameterization for fishes is very subjective and insufficiently researched. For example, pelagic predators are parameterized by data for lake whitefish (coregonids) which are freshwater planktivores. Similarly, reef predators are parameterized as largemouth bass, and benthic predators, that include active species such as groupers (Figure 5-6) are parameterized as flounders that are sedentary.	The fish and invertebrate parameterization within the PRAM was based on our research for a full data set that included energy budgets and temperature-dependent respiration rates. As pointed out by Connolly (1990), the exact species may not be overly importantif the species selected is representative of the organisms within the trophic level, results using alternate species will not be significantly different. We recognize that the use of parameterization values based on freshwater species added a level of uncertainty to PRAM version 1.3. Parameterization values used in PRAM version 1.4 have been revised, and are now based on marine species.
3.2	Lipid fractions described in the SHRRA are not consistent with the 3% default values shown in the PRAM model for all biota.	The "default values" for lipid fraction that are currently displayed within the PRAM (i.e., in the "Default Values" column) are specific to the earlier, Version 1.2, of the PRAM; in this column, the constant 3% value for lipid fraction is shown. In the adjacent, "In Use" column, the specific lipid

COMMENT		RESPONSE
		fractions that were used in the ex-ORISKANY assessment are displayed. As the reviewer has noted, the lipid fractions described in the SHRRA are not consistent with the default values displayed in PRAM. This inconsistency will be rectified before the next submittal.
3.3	Relationships between PRAM default PCB values for K_{ow} and K_{oc} are not consistent with published QSAR relationships. In particular, it is generally assumed that K_{oc} .. = 0.4 K_{gas} (See Karlckhoff (1981) and Seth et al. (1999).) The proportional constant for PRAM default values vary from 0.00966 to 0.141 for tetra-, penta-, hexa-, and hepta-PCBs.	USEPA guidance (1995) was consulted in the development of the PRAM. This guidance recommended the use of empirical K_{ow} and K_{oc} values over estimated values. Thus we searched for measured values in the scientific literature. The K_{ow} and K_{oc} values used in PRAM for the various PCB homolog groups were derived from empirical values for specific PCB congeners. Statistical analyses were conducted to derive proportional constants for the various PCB homolog groups. Documentation of this process was not provided in the SHHRA, but is provided as attachment 1. Attachment 1 compares the K_{ow} and K_{oc} values used in PRAM with the published QSAR values.
3.4	There is a major QA issue with the total PCB water concentrations reported on the *Estimate* output worksheet and the individual PCB water concentrations reported on the *Supplemental Info* output worksheet. In particular, concentrations of individual PCB homologs may exceed total concentrations by three orders of magnitude.	Comment acknowledged. We most sincerely regret our oversight in forwarding PRAM (Version 1.3) to EPA as an unfinished product. As explained above (comment 1.4b), the disparities EPA observed, between the PCB concentrations reported in the *Estimate* output worksheet and the *Supplemental Info* output worksheet, resulted because two of the "scenario analysis" modules in PRAM had not been revised to reflect the specific dimensions, PCB source terms, etc. for the ex-ORISKANY. The Navy acknowledges that the PRAM, once fully updated and revised, consistent with agreed upon improvements, will need a QA/QC review. QA/QC review is being performed prior to re-submittal of the PRAM.
3.5	PRAM must be tested/validated/verified/ corroborated. More specifically, a validation study should be performed to see if PRAM can predict the white grunt data for the ex-VERMILLION. This could be done as a sensitivity analysis, since exact estimates of PCBs on the ex-VERMILLION are unavailable.	To respond to this EPA recommendation, which was verbally relayed in telephone conferences prior to the receipt of written comments, such a sensitivity analysis has been conducted, and has been documented and submitted to the EPA. Specifically, we used a backward calculation to determine what PCB emission rate would have been required at the ex-VERMILLION reef to produce the fish tissue concentrations that were found in the White Grunt samples collected at the ex-VERMILLION reef. As the overall PCB emission rate at a ship-artificial reef is a function of the amount of PCB-containing materials remaining on the vessel, the proportional distribution of those materials, the concentrations of PCBs in each type of material, and the

COMMENT		RESPONSE
		material-specific leach rates, we then disaggregated the emission rate by varying the proportionate amounts of each PCB-containing material assumed to have been onboard the ex-VERMILLION. Initial results, using PRAM in this application, show that the white grunt data can be predicted based on a variety of assumed PCB loadings within the ex-VERMILLION. This sensitivity analysis demonstrated that PCB loading in fish, as a result of assumed leaching from solid PCB-containing materials onboard the vessel, is highly dependent on the amount of those materials that have relatively high leach-rates, and not very dependent on the amount of those materials that have relatively low leach rates.
Conclusions		
1	This reviewer believes that the PRAM risk assessment model should not be accepted in its present form as part of any weight-of-evidence evaluation for the permitting of the reefing of decommissioned US Navy vessels that contain PCB source materials.	The Navy believes that the PRAM represents a viable and important tool in developing a weight-of-evidence for the decision-making process regarding the sinking of the ex-ORISKANY and other decommissioned vessels. The algorithms in PRAM Version 1.4 have been revised to address technical concerns identified by the TWG. The documentation for PRAM Version 1.4 describes these algorithms in detail.
2	Theoretical modeling philosophies aside, this reviewer is extremely concerned with the discrepancies and errors in the model's documentation.	The PRAM documentation has been expanded and revised to address EPA's concerns.
3	Although it may seem like an unfair conclusion, this reviewer believes that errors and inconsistencies in the written descriptions of a model are real or potential indicators that similar errors and inconsistencies may have been propagated in the model's mathematical code. The problems noted in comments 1.4 and 3.4 justify this concern.	Comment acknowledged. The Navy and it's contractors have assembled a technical team to review the PRAM Version 1.4 documentation and coded algorithms to address this concern.
4	PRAM must be validated or corroborated in some fashion before it is accepted as an adequate model for the fate, transport, and bioaccumulation of PCBs from reefed vessels. Presently, no should [such] testing has been documented.	The Navy is evaluating a variety of means of satisfying this issue of corroborating / testing of the PRAM simulations with reported results in the scientific literature. The Navy is looking forward to working with the EPA in defining what acceptance criteria are appropriate and functional for such corroboration and/or testing.

Attachment 1 - "Review of the PRAM Risk Assessment Model for Evaluating the Reefing of Decommissioned US Navy Vessels" By Dr. M. Craig Barber USEPA/ORD/NERL/ERD (15 September 2004)

Comment 3.3.
Relationships between PRAM default PCB values for Kow and Koc are not consistent with published QSAR relationships. In particular, it is generally assumed that

$$K_{oc} = \approx 0.4\ K_{ow} \qquad (21)$$

See Karickhoff (1981) and Seth et al. (1999). The proportional constant for PRAM default values vary from 0.00966 to 0.141 for tetra-, penta-, hexa-, and hepta-PCBs.

Response:

The following table presents the log10K_{ow} and log10K_{oc} default values in the PRAM. As the commentor indicates, there is a significant range of values for the K_{oc} : K_{ow} proportionality constant, ranging from 0.028 to 0.141 for the tetra-chlorobiphenyls (Tetra-CBs) through hepta-CBs and are generally smaller than the proportionality value of 0.411 provided by Karickhoff (1981) and referenced in the comment.

Parameter	Mon-CB	Di-CB	Tri-CB	Tetra-CB	Penta-CB	Hexa-CB	Hepta-CB	Octa-CB	Nona-CB	Deca-CB
log10Kow =	4.474	5.236	5.521	5.922	6.495	6.976	7.190	7.696	8.351	9.603
log10Koc =	3.663	4.058	4.625	4.654	4.935	6.080	6.340	6.455	6.965	7.941
Koc/Kow	0.155	0.066	0.127	0.054	0.028	0.127	0.141	0.057	0.041	0.022

We were not able to reproduce the ratio of 0.00966 from the comment, but do not believe that this will materially affect the discussion or response.

Karickhoff also provided an equation based on a linear regression of Log K_{ow} against Log Koc.

$$\text{Log } K_{oc} = 0.989 \log K_{ow} - 0.346$$

The comment also references Seth et al (1999) as a source of a quantitative structure-activity relationship (QSAR) equation. They provided the following equation:

$$\text{Log } K_{oc} = 0.81 \log K_{ow} + 0.09$$

Values for Log Koc and for K_{oc}/Kow derived from these equations from Karickhoff and Seth are compared to those used in the PRAM in the following Tables.

Log Koc	Mon-CB	Di-CB	Tri-CB	Tetra-CB	Penta-CB	Hexa-CB	Hepta-CB	Octa-CB	Nona-CB	Deca-CB
Pram	3.663	4.058	4.625	4.654	4.935	6.080	6.340	6.455	6.965	7.941
Karickhoff	4.079	4.832	5.114	5.511	6.078	6.553	6.765	7.265	7.913	9.151
Seth	3.714	4.331	4.562	4.887	5.351	5.741	5.914	6.324	6.854	7.868

Koc/Kow	Mon-CB	Di-CB	Tri-CB	Tetra-CB	Penta-CB	Hexa-CB	Hepta-CB	Octa-CB	Nona-CB	Deca-CB
Pram	0.155	0.066	0.127	0.054	0.028	0.127	0.141	0.057	0.041	0.022
Karickhoff	0.403	0.395	0.392	0.388	0.382	0.378	0.376	0.371	0.365	0.353
Seth	0.174	0.124	0.110	0.092	0.072	0.058	0.053	0.042	0.032	0.018

The log K_{oc} values selected for use in the PRAM are generally lower than those derived from equations from either Karickhoff or Seth. The equations from Karickhoff and Seth both were derived from a variety of hydrophobic organics. Several other papers (Di Toro (1985), Endicott et al (1990), Kenaga and Goring (1980) and Lyman (1990) have presented similar QSAR equations. These equations area presented below.

$$\log K_{oc} = 0.983 \log Kow + 0.00028 \qquad \text{Di Toro (1985)}$$

$$\log K_{oc} = 0.442 \log Kow + 3.54 \qquad \text{Endicott et. Al (1990)}$$

$$\log K_{oc} = 0.544 \log Kow + 1.377 \qquad \text{Kenaga and Goring (1980)}$$

$$\log K_{oc} = 0.442 \log Kow + 3.54 \qquad \text{Lyman et al (1990)}$$

These equations have commonly been used for estimating K_{oc}s for PCBs. For example, EPA (2000) has used the Endicott equation to study the effect of partitioning of PCBs among different phases in evaluating the effect of zebra mussels on bioavailability of PCBs. The Lyman equation is used in the Risk-Integrated Software for clean-ups (RISC) described below for estimating K_{oc} values for PCBs for which experimentally determined K_{oc}s are not available. Zeng et al (1997) have used the Kenaga and Goring relationship in studying PCB congener bioaccumulation patterns in Sea Urchins (*Lytechinus pictus)* with equilibrium partitioning predictions and empirical relationships obtained for other marine species. The Di Toro equation has been used by US EPA for estimating K_{oc} values that were used in calculating sediment quality criteria (for non-ionic organic contaminants (EPA 1993).

When these equations are applied to the Kow values used in the PRAM, a set of representative calculated Log K_{oc} values is obtained. Figure 1 presents a comparison of these calculated values for Log K_{oc}. Also plotted in this figure are the Log K_{oc} values used in the PRAM. As can be seen in Figure 1, the values used in the PRAM generally fall about in the middle of the range of values calculated from these published QSAR equations. Thus, the default values used in the PRAM are considered to be consistent with published QSAR equations for PCBs.

The K_{oc} values used in the PRAM were derived in two ways. For the mono-CB through hexa-CB homologous series, there existed K_{oc} measurements in the literature for congeners in these homologous series from which to calculate a K_{oc} value to use in the PRAM. For the PRAM, the K_{oc} values from Chou and Griffin (1986) were used to calculate Koc values for each of these homolog groups. The K_{oc} values used for these homolog groups correspond to the geometric mean of the K_{oc} values measured for the individual congeners within an homologous series. Insufficient measurements of K_{oc} were found in the literature to allow determination of representative values for K_{oc} for the hepta- octa-CB, nona-CB and deca-CB homologous series. Therefore, a QSAR approach was taken to estimating these values. The equation used was one developed by Lyman (1990).

$$\textbf{Log } K_{oc} = 0.779 \log K_{ow} + 0.46$$

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

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

Thus, EPA selected measured K_{oc} values for use in the reassessment when they were available and used the values derived by QSAR methods in those cases in which measured data were not available. This is identical to the approach adopted in selecting the default parameters in the PRAM.

The approach used in the PRAM is also consistent with that used in Risk-Integrated Software for clean-ups (RISC). RISC is software developed by Lynn Spence and BP Oil, Ltd for performing human health risk assessments for contaminated sites. Fate and transport models are available to estimate receptor point concentrations in groundwater and other media. Experimentally measured K_{oc} values were used for many chemicals in the database. The following references were used as a source of K_{oc} values (by order of preference):

1. EPA's Soil Screening Guidance: Technical Background Document (EPA 1996b).
2. EPA: Basics of Pump and Treat Groundwater Remediation Technology (EPA 1990)

Consistent with the approach in the PRAM, the RISC model uses the equation listed above from Lyman (1990) for estimating K_{oc} for some compounds for which a measured K_{oc} is not available.

Thus, we believe that the K_{oc} values used in the PRAM are adequately representative of the PCB partitioning. As described in the dioxin reassessment report (EPA 2003), experimentally determined K_{oc} values were used when available and the use of QSAR relations was restricted to those situations for which there were insufficient empirical K_{oc} data available. We believe that these values should be used in the PRAM, but recognizing that other partitioning models might be preferred by the end-user, we have programmed in the ability to easily substitute other K_{oc} values or K_{oc}/Kow QSAR equations.

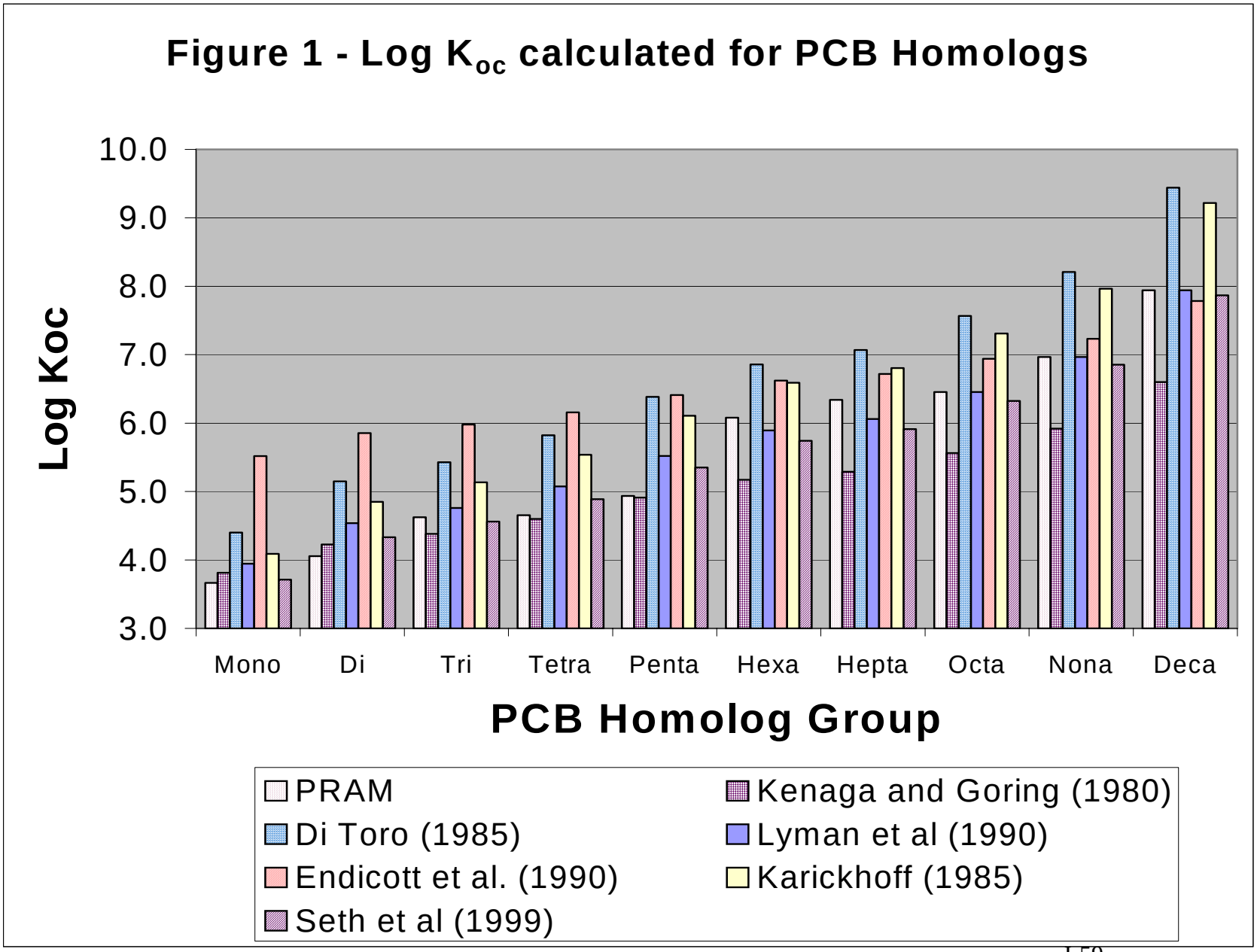
Figure 1 - Log K_{oc} calculated for PCB Homologs
Log Koc
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
Mono
Di
Tri
Tetra
Penta
Hexa
Hepta
Octa
Nona
Deca
PCB Homolog Group
PRAM
Kenaga and Goring (1980)
Di Toro (1985)
Lyman et al (1990)
Endicott et al. (1990)
Karickhoff (1985)
Seth et al (1999)

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Appendix K

Resolving the Zone of Influence (ZOI) Issues

Resolving the Zone of Influence (ZOI) Issues – A Proposed Approach for REEFEX Based on Science and Judgment

Prepared for

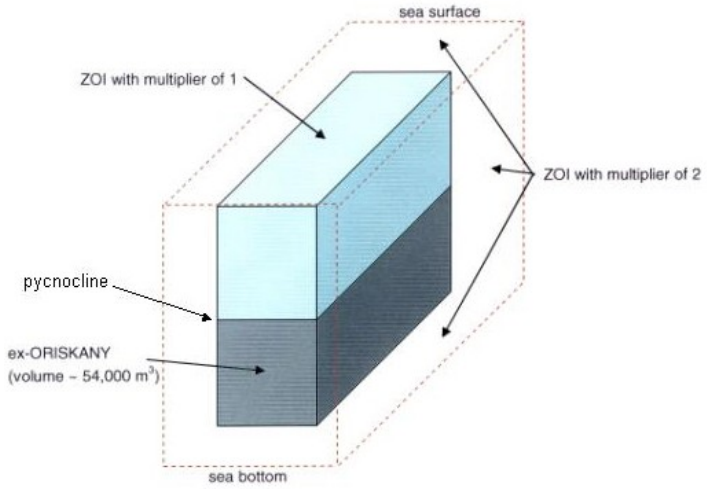
Navy Environmental Health Center, Portsmouth, VA

Prepared by
John V. Conner, Ph.D., URS Corporation, Baton Rouge, LA

Introduction

One significant outstanding question regarding the Prospective Risk Assessment Model (PRAM) for use in the Navy artificial reef program (REEFEX) is development of a "zone of influence" (ZOI) to provide multidimensional spatial boundaries for exposure estimation. Currently, the ZOI is based on the concept of an "exposure volume," consisting of a column of water extending from the seafloor to the surface.[1] The lateral dimension of the column is derived via a factor multiplied by the volume of the ex-ORISKANY (which is roughly 54,000 cubic meters). That is, at a multiplier of one (1) the lateral extent of the ZOI is essentially zero and the exposure volume becomes that of the column extending between the upper surface of the vessel to the water/air interface (i.e., the volume of the vessel subtracted from the total volume of the column.)

Using a multiplier of two (2), the "diameter" of the column is increased by about 30 meters, producing a horizontal aqueous space of about 15 meters from the vertical edges of the vessel. This allows for a common space for exposure to benthic invertebrates, demersal fish, and nektonic animals occupying the water surrounding the vessel (both laterally and above) and occupying the sediment surrounding the vessel (see Figure 1 below).



Conceptual representation of Zone of Influence (ZOI; a.k.a. exposure volume). Diagram to rough scale.

Figure 1

[1] There was agreement between the EPA and the Navy in the Nov 17-18, 2004 TWG meeting that the water column above the seafloor should be divided into two regions, i.e., water above and below the thermocline (pycnocline) with the pycnocline occurring approximately 55 feet below the sea water surface.

Habitat and Dietary Composition as Factors for Determining ZOI

The ZOI multiplier value used in the draft Supplemental Human Health Risk Assessment (SHHRA) for the ex-ORISKANY (July, 2004) (i.e., a ZOI multiplier value of 5) was rather subjective, in that the value was chosen on the basis of statistical information concerning the degree of change in PCB concentrations as a function of increasing ZOI multiplier value. The ZOI multiplier value was not based on biological factors, such as, habitat, movement, and foraging areas of the organisms being evaluated. In this paper we present summary information regarding biological factors related to potential PCB biouptake that should be considered in choosing an appropriate ZOI multiplier value(s), and ZOI recommendations for the ex-ORISKANY. Additional information describing the composition of fish assemblies that might be associated with the artificial reef ex-ORISKANY, and information of relevance to establishing spatial boundaries for those assemblies, is presented in Attachment 1 to this paper.

Verticality

Among the many factors perceived to influence the composition and local distribution of fish assemblages associated with both natural and artificial structures in marine environments, "verticality" is clearly significant (e.g., many of the listed references based on studies by D.R. Stanley and C.A. Wilson [and others cited therein]). The verticality issue is comparatively straightforward, as it must include the entire water column height. Many types of fish reside throughout the height of the water column; others would use various layers throughout the column. Most of the plankton-feeding fishes (e.g., vermilion snapper) tend to feed on the upper zone of the water column. The same is true for most of the pelagic predators in pursuit of schooling forage fishes (e.g., anchovies and herring; Bortone 2004). The upper zone is also important for production of the phytoplankton that "rain down" to lower layers to provide a significant fraction of the energy for their inhabitants. Inclusion of space for habitats (and their biotic occupants) lateral to the vessel must also be considered.

The aforementioned and many other studies, such as one compilation focusing on natural hard bottom habitats in the general vicinity of the proposed ex-ORISKANY site (Thompson *et al.* 1999), indicate substantial variability in biotic community composition with both sea depth and "shape" of submerged structures.

Considering the available relevant literature and the extraordinarily unusual size and shape of ex-ORISKANY, it seems (to this writer, at least) nearly impossible to predict community composition and/or structure in much detail, albeit abundances and availability of certain food fish in relation to each other are more predictable[2]. For purposes of PRAM, however, the uncertainty of detailed taxonomic composition is moot. The habitats provided by the vessel will almost certainly be exploited by a wide range of transient and (at least effectively) resident fishes. Some of the latter will tend to be associated with relatively short depth ranges in the context of the immense height of the vessel, including areas lateral to the hull (i.e., in its "shadow" for purposes of this discussion).

The shadow-dwellers (resident fishes that tend to be associated with areas lateral to the hull for short distances) will be a mixture of fishes that tend to feed on encrusting organisms and thus are tightly associated with the structure *per se* (e.g., gray triggerfish; Beaver 2004), as well others that tend to forage on or near the seafloor adjacent to the structure (e.g., red snapper; Gallaway *et al.* 1999; Ouzts and Szedlmayer 2003). For example, there are several studies suggesting that such fishes can have substantial impact on the benthic communities adjacent to both natural and artificial submerged structures (e.g., Frazer and Lindberg 1994; Lindquist *et al.* 1994; Steimle and Figley 1996; Nelson and Bortone 1996; Bortone *et al.* 1998).

[2] Per personal communication with Jon Dodrill, Florida FWCC (01-05-05), food fishes listed in Attachment 1 (GMFMC [2003] table), that are most likely to be more abundant than others at the ex-ORISKANY are: red snapper, vermilion snapper, gag, scamp, gray snapper, gray triggerfish, greater amberjack, almaco jack, red grouper. Others may be present at some time or another but are much less common (i.e., Warsaw, black grouper, speckled hind, goliath grouper [protected], etc) while some, like yellowtail snapper, may be outside their normal geographic range in this area.

Horizontal Extent

So, how much lateral space is enough? What is the minimum lateral aqueous space that would satisfy the needs of the shadow-dwellers? One might argue that a relatively long distance is necessary to capture a large fraction of the foraging areas of various legitimately "reef-associated" fishes. But that particular distance is essentially un-documented for the vast majority of reef fish.

From a review of what is hoped to be a representative sample of relevant literature (see References), it appears that there are two general types of studies that constitute lines of evidence for at least an order of magnitude for the foraging distance. These types are: (1) density estimates based on surveys, especially those using dual-beam hydroacoustic technology (e.g., the series of studies reported by Stanley and/or Wilson); and (2) tagging studies, especially those related to movements among fragmented habitats (e.g., Bardach 1958; Springer and McErlean 1962; Low and Waltz 1991; Chapman and Kramer 2000).

The density-estimate data suggest that for a variety of submerged structures there tend to be recognizable boundaries of fish aggregations in the range of 20 to 50 meters from the structures.[3] Most of the tagging studies tend to show that many of the more common species (hence the ones for which more data are available) seldom, if ever, move more than a few to several tens of meters, at least over the timeframe of the particular study. Note that, of course, there are tagging records that document movements of fishes on the scale of hundreds of kilometers, but most of these (e.g., sturgeon, salmon) are not related to species that are known or considered reef-associated (at least as adults).[4] Another consideration is a factor mentioned in some of the Stanley and/or Wilson series of studies, which is the typical maximum range of vision in fish. This factor, among others, may influence how far fish tend to range from their shelter or habitat. This distance is about 15 meters in clear water (Gerking 1994), and would obviously be smaller with increasing turbidity.

Discussion / Recommendations

Based on the foregoing, it seems reasonable to use a single exposure volume to minimize complexity. Hence, a ZOI multiplier between two and five for the ex-ORISKANY is recommended, if there is a consensus regarding degree of conservatism. For the ex-ORISKANY, doubling the ZOI (using a ZOI multiplier value of 2) would provide about 15 meters of lateral aqueous space from the vertical sides of vessel, which would correspond to some of the lower estimates of "reef-fish" aggregation sizes (as well as the range of visibility of the 'typical' fish). Quadrupling the ZOI (using a ZOI multiplier value of 4) would roughly double the lateral dimension (to ~40 meters from the vertical sides of the vessel), which would correspond roughly with some of the higher density discontinuity observations. Using a ZOI multiplier of five (5) would correspond to a approximately 50 meters from the vertical sides of the vessel, which would capture the range indicated by studies using density estimates. Stated another way, a multiplier of two would likely "capture" at least some fraction of the foraging

[3] The distances of 20 and 50 meters approximately correspond to ZOIs of about 2.5 and 5, respectively, for the ex-ORISKANY.

[4] Per personal communication with Jon Dodrill, Florida FWCC (01-05-05), juveniles and subadults of reef associated spcies may be more prone to movement than older adults inhabiting at deeper offshore sites such as the ex-ORISKANY. The older adults (younger adults just over the legal limit, e.g., 3-6 year old red snapper), although with higher site fidelity, are subject to intense fishing pressure such that few of the target food fishes will survive multiple years at the ex-ORISKANY site. The juveniles and subadults, and even young adults, are likely to make permanent non-return movements away from the reef, after weeks/months. Movement is also facilitated by major storm disturbances in the easterly or southeasterly direction. Hence, it is agreed that PRAM ZOI, as recommended, is highly conservative for the targeted food reef fish based on the assumption that are going to spend their entire lives in an imaginary aquarium zone of influence in the immediate vicinity of the ship. The situation is different with strongly reef obligate species (e.g., damsel fishes such as cocoa damsels, cubbyus, tomtates, blennies, belted sandfish, etc.) that are not targeted as food fish. They may well spend an entire life from post larval to "old" age (barring predation or disease) on the ship or even one part of it. Exception would be gray triggerfish- they would be the one food fish probably exhibiting highest consistent site fidelity over a period of years if they survived harvest and natural predation.

range of most of the "reef-fish" aggregation members, whereas a multiplier of five (5) would likely capture most of the foraging ranges of most of the fishes.

Alternatively, one might consider multiple ZOIs, still based on the vessel volume, but accounting for various spatially limited groups of species (e.g., a ZOI based on a multiplier of two for encrustation-grazers such as the gray triggerfish, and ZOI of four to five for less-reef associated fishes, based on the evidence of fish fidelity around submerged structure and a reasonable volume for PCB leaching and transport).

Based on professional judgment, biology, and modeling considerations[5], the recommendations for the ex-ORISKANY, are:

- ZOI for near-field foraging species, such as the gray triggerfish: 2 to 2.5
- ZOI for less reef-associated fish species, i.e., pelagic fishes and benthic fishes: 4 to 5

[5] Use of a ZOI multiplier of 1 would eliminate any hypolimnetic water and any volume of sediment lateral to the ship; thus, this ZOI is not appropriate for modeling exposure to organisms living in these media.

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