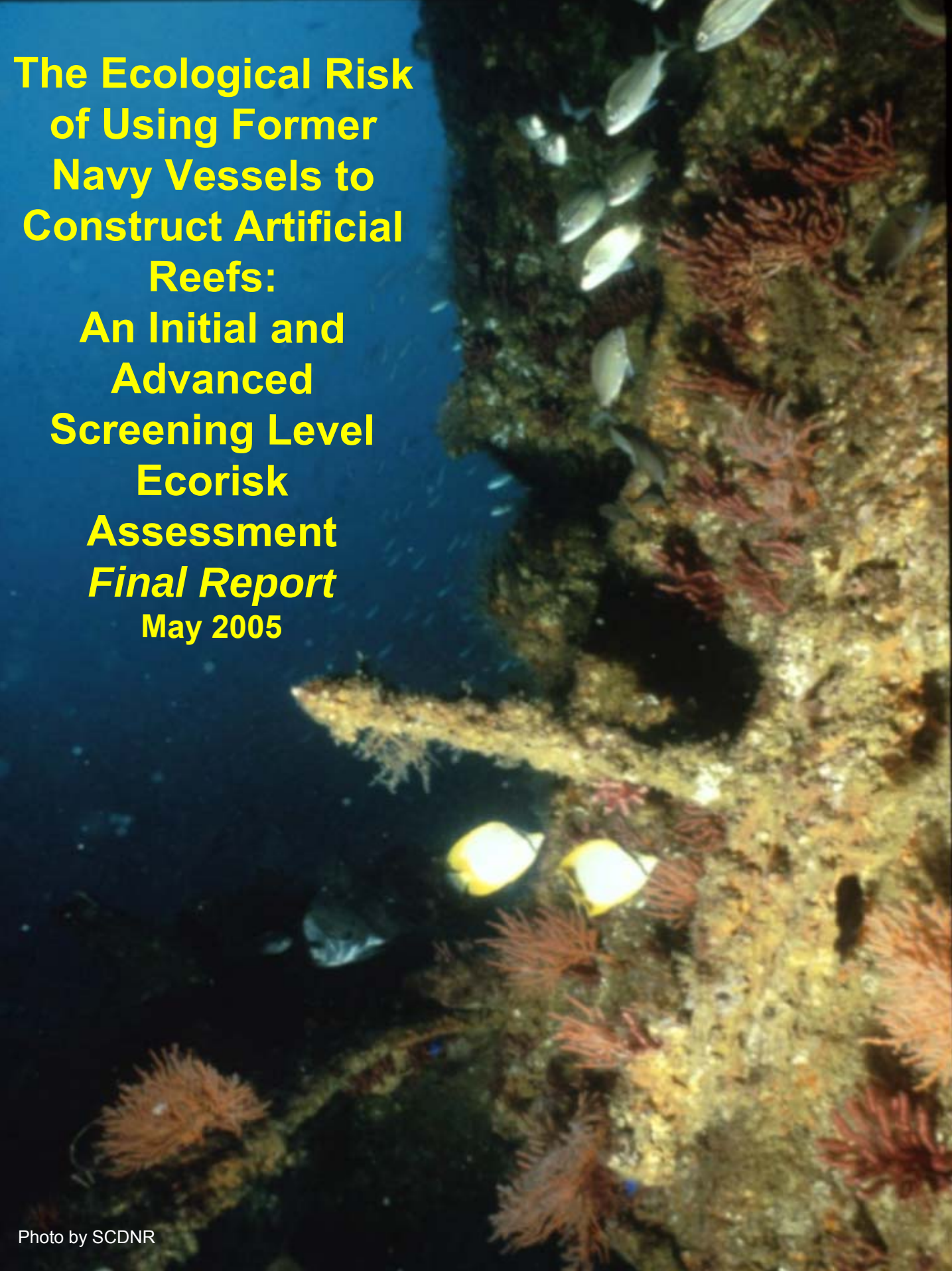
The Ecological Risk of Using Former Navy Vessels to Construct Artificial Reefs: An Initial and Advanced Screening Level Ecorisk Assessment

Final Report

May 2005



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THE ECOLOGICAL RISK OF USING FORMER NAVY VESSELS TO CONSTRUCT ARTIFICIAL REEFS:

AN INITIAL AND ADVANCED SCREENING LEVEL ECORISK ASSESSMENT

FINAL REPORT

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Chief of Naval Operations
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COVER: Demersal fish and reef invertebrates on the ex-VERMILION reef (Photo by SCDNR).

ABSTRACT

Inactive U.S. Navy vessels would make excellent artificial reefs in U.S. coastal waters if preliminary data suggesting that they pose no threat to human health or the environment from contamination can be confirmed. An initial screening-level ecorisk assessment and an advanced screening ecorisk analysis for PCBs was conducted on data from artificial reefs located off the coast of South Carolina to assess the potential toxicological risks from sunken Navy vessels. Contaminants can enter the system from releases from the sunken vessel and inputs from coastal waters. Through transport, uptake, and bioaccumulation, the released chemicals may be present in water, sediment, and biota associated with the reef. The assessment endpoints for this study were the reef community consisting of primary producers, primary consumers, secondary consumers, tertiary consumers, and avian consumers that encompassed the organisms that are resident on the reef as well as predators that may frequent and forage on the reef. Benchmarks were developed for water exposure, sediment exposure, tissue residues, and dietary uptake for the food chain receptors. The data used in the assessment included: (1) polychlorinated biphenyls (PCBs) and metals measured in fish and invertebrate tissues collected from artificial reefs off the coast of South Carolina by the South Carolina Department of Natural Resources (SCDNR study); (2) PCBs measured in fish tissues collected from an ex-Navy ship reef (ex-VERMILION LKA 190) and a reference reef (Navy supplemental fish study); (3) PCBs, metals, and polycyclic aromatic hydrocarbons (PAHs) measured in sediments from a deep water sunken vessel (ex-AGERHOLM DD 826, SINKEX study); and (4) data developed from laboratory leaching experiments on solid materials containing PCBs that could possibly be on ex-Navy warships (leachrate study). Background data for the ecorisk screening was obtained from the Environmental Monitoring and Assessment Program (EMAP) EMAP-Estuaries conducted for the Carolinian Province. The conclusions were based on evidence of potential ecological harm, comparison to reference and background levels, and the reliability of the data.

The initial screening level assessment found negligible risk of water exposure to PCBs estimated from the leachate study and negligible to low risk of sediment exposure for PCBs, PAHs, As, Ag, Cr, Hg, Pb, and Zn, and elevated risk of exposure to Cd, Cu, and Ni was inferred from the SINKEX study. Tissue residue data from the SCDNR study showed that exposure to PCBs, Pb, and Cd in tissues of fish and PCBs and Pb in invertebrates were higher in samples from Navy ship reefs than reference reefs. The data from the SCDNR study suggested negligible risk of exposure to all assessment endpoints except for primary producers and consumers, which had a medium risk of exposure due to elevated levels of Cr, Pb and Cd in fish and elevated Pb levels in invertebrates sampled from the ex-VERMILION reef. Based on the results of the Navy supplemental fish study there was negligible risk of PCB exposure to secondary consumers (demersal fish) and low risk of PCB exposure to primary producers and consumers (plankton and zooplankton), avian consumers (herring gulls and cormorants), and tertiary consumers (dolphins and reef sharks). There was high confidence of negligible to low risk of exposure to PCBs because the Navy's supplemental fish study conducted detailed sampling and analysis for PCBs. The advanced screening analysis for PCBs supported the conclusions that there was low risk of PCB exposure to the reef community. Results from the leachrate study also showed that removing relatively small quantities of bulkhead insulation would greatly reduce the amount of PCBs leached and further reduce the potential risk of exposure to PCBs. The screening-level ecorisk assessment supports a process that will enable risk management decisions to be made regarding beneficial use of decommissioned Navy vessels for reef building projects.

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The final reports, supporting documents, and proceedings of the REEFEX Technical Working Group can be accessed at http://environ.spawar.navy.mil/reefex.

This report is dedicated to the memory of Mark S. Goodrich, *modeler extraordinaire* (April 25, 1957 – January 7, 2005).

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Glossary of Terms, Acronyms, and Abbreviations

Term	*Definition*
Accuracy	The degree of agreement between a measured value and a true, expected value.
Acute Toxicity	The ability of a substance to cause effects resulting in severe biological harm within a short time after exposure to the toxic compound, usually within 24 to 96 hours.
ADL	Arthur D. Little, Cambridge, MA
Ag	Silver
Al	Aluminum
Alkylated	An organic compound with an **alkyl** group attached
Alkyl	A hydrocarbon consisting of *n* carbons and *2n+1* hydrogen molecules (C_nH_{2n+1})
Algae	Microscopic plants which contain chlorophyll and live floating or suspended in water as **phytoplankton** in the **plankton**. They also may be attached to structures, rocks or other submerged surfaces. They are food for fish and small aquatic animals. **Algae** produce oxygen during sunlight hours and use oxygen during the night hours.
Ambient	Environmental or natural surrounding conditions.
ANOVA	Analysis of variance
ANTH	Anthracene - one of a number of **PAH** compounds.
Anthropogenic	Something made by humans, which effects nature.
As	Arsenic
Assessment Endpoint	A component of the ecosystem that may be impacted by the stressors of concern, has ecological and societal value, and represents a component of the ecosystem that can be protected.
Avian Consumers	Birds of prey and waterfowl (ducks, geese, gulls, cormorants, and ospreys), which feed on prey from marine and estuarine waters.
AVS	Acid Volatile Sulfides - A reactive pool of sulfides that will bind with **divalent heavy metals** to form nontoxic and nonmobile compounds. These sulfides are released when sediments are treated with acid and the amount of sulfide released is referred to as **AVS** and the amount of metals that are simultaneously released is referred to as simultaneously extracted metal (**SEM)**.
AXYS	AXYS Analytical Services, Ltd., Sidney, British Columbia, Canada
Background Level	Naturally occurring levels, **ambient** concentrations.
BAF	bioaccumulation factor, "the ratio (in L/kg) of a substance's concentration in tissue of an aquatic organism to its concentration in the ambient water" (U.S. EPA 1995). BAFs are used to account for the trophic transfer of a contaminant in the food chain
B_{CV}	The bioaccumulation critical value is the tissue concentration in an organism that when exceeded suggests that ambient water quality criteria were exceeded.
Benchmark	A specific chemical concentration (in sediment, water, or tissue) or biological response when exceeded has been associated with adverse effects.
Benthic Community	Community of organisms, which spends the majority of their life living within the bottom **sediments** (worm, clam, amphipod, etc.).

Bioaccumulation	The **uptake** and retention of substances by an organism from its food and its surrounding environment. Chemicals that bioaccumulate become more concentrated at each successively higher level of the food chain. Bioaccumulative chemicals can be toxic to organisms at the upper end of a food chain, such as predatory fish, loons, eagles, otters, or humans that eat fish.
Bioassay	Study to measure the effects of a chemical on a living organism.
Bioconcentration	A specific **bioaccumulation** process by which the concentration of a chemical in an organism becomes higher than its concentration in the air or water around the organism.
Biomagnification	A process that results in the **bioaccumulation** of a chemical in an organism at higher levels than are found in its food. It occurs when a chemical becomes more and more concentrated as it moves up through a **food chain**. At the top of the food chain an animal, through its regular diet, may accumulate a much greater concentration of chemical than was present in organism lower in the food chain.
Biota	Animal and plant life.
Bulk Sediment	The total **sediment** concentration (of a chemical) analyzed on a dry weight basis.
Carnivorous	Animals that subsist by feeding on flesh of prey (other animals)
Calibration	A procedure that checks or adjusts an instrument's accuracy by comparison with a standard or reference.
CBR	The concentration of a contaminant in the tissue of an organism that can cause adverse effects to the organism when exceeded.
CCC	Criteria Continuous Concentration (CCC – chronic), an estimate of the highest concentration of a material in the water column to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect
CCME	Candaian Council of Ministers of the Environment
Cd	Cadmium
Chlorophyll	One of a number of green pigments present in plant cells that are essential in the utilization of light energy in photosynthesis.
Chronic Toxicity	The ability of a substance to cause poisonous effects from long-term exposure, usually months or years.
CMC	Criterion maximum concentration (CMC – acute) an estimate of the highest concentration of a material in the water column to which an aquatic community can be exposed briefly without resulting in an unacceptable effect
COC	Contaminants of Concern - chemicals identified as having the potential to cause ecological impacts.
Coliform	A group of bacteria found in the intestines of warm-blooded animals (including humans) also in plants, soil, air and water. Fecal coliforms are a specific class of bacteria, which only inhabit the intestines of warm-blooded animals. The presence of coliform is an indication that the water is polluted and may contain pathogenic organisms.
Colloids	Very small, finely divided solids (particles that do not dissolve) that remain dispersed in a liquid for a long time due to their small size and electrical charge. When most of the particles in water have a negative electrical charge, they tend to repel each other. This repulsion prevents the particles from clumping together, becoming heavier, and settling out.
Conceptual Model	Theoretical representation of a situation.
Conger	Something closely resembling or analogous to something else, see **PCB congener**

Cr	Chromium
Cu	Copper
$D_{BlackDuck}$	The dietary concentration for the consumption of fish and invertebrates by black ducks that is unlikely to be harmful to black ducks.
$D_{Dolphin}$	The dietary concentration for the consumption of fish and invertebrates by dolphins that is unlikely to be harmful to dolphins.
Divalent	A chemical that can exist as an ion with a charge of 2^+ (e.g. Cd^{2+}, Cu^{2+}, Pb^{2+}, etc.).
Dose-Response	A quantitative relationship between the dose of a chemical and an effect caused by the chemical.
Dose-Response Curve	A graphical presentation of the relationship between degree of **exposure** to a chemical (dose) and observed biological effect or response.
D_{Osprey}	The dietary concentration for the consumption of fish by osprey that is unlikely to be harmful to osprey.
EC_{20}	Effect Concentration 20% **-** the concentration of a chemical in air or water which is expected to cause an effect (other than death, e.g. reproductive impairment, reduced growth, biochemical response etc.) in 20% of test animals living in that air or water.
Ecological Receptors	Representative species selected to evaluate the likelihood of adverse impact to the **Assessment Endpoint**.
Ecosystem	An ecological system, a natural unit of living and nonliving components, which interact to form a stable system in which a cyclic interchange of materials takes place between living, and nonliving units.
Eelgrass	A **submerged aquatic plant** (*Zostera marina*) which can form meadows (eelgrass beds) that are capable of trapping sediment and providing habitat for a variety of birds, fish, and invertebrates.
Effects Assessment	The determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration and extent of effects from exposure to a chemical.
Effects Measure	See **Measures of Effects.**
Effluent	Wastewater, treated or untreated, that flows out of a treatment plant, sewer, or industrial outfall into surface water.
Environmental Media	Components of the environment (water, **sediment**, and **biota**) that can accumulate contaminants.
Environmental Release	The introduction of a pollutant into the environment through wastewater discharge, air emission, or volatilization or leaching from soil, landfill, or other contaminated site.
EOD	Explosive Ordnance Disposal
Epibenthic Species	The community of organisms (e.g. lobster, mussel) which spend the majority of their life attached to or in close proximity to the bottom of .a body of water.
Equilibrium Partitioning	The partitioning or distribution of an **organic** contaminant between **bulk** and **pore water** phases of the **sediment**.
EMAP	Environmental Monitoring and Assessment Program
ERL	Effects Range - Low - the concentrations of contaminants below which adverse biological effects would rarely occur.
ERM	Effects Range - Median - concentrations of contaminants above which adverse biological effects would probably occur.
Exposure	Contact with or ingestion of a chemical or physical agent.

Exposure Assessment	The determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration, route, and extent of **exposure** to a chemical.
Exposure Level	The amount (concentration) of a chemical that comes into contact with an organism through the air, water, sediment, or food.
Exposure Scenario	A set of conditions or assumptions about sources, exposure pathways, concentrations of toxic chemicals and populations (numbers, characteristics and habits), which aid in evaluating and quantifying exposure.
Fe	Iron
FLUOR	Fluorene - one of a number of **PAH** compounds.
Fluorescence	The property of absorbing light of a particular wave length and then emitting light of a different color and wave length.
Food Chain	A sequence of organisms, each of which uses the next lower member of the sequence as a food source.
GC/MS SIM	An analytical chemistry method requiring gas chromatography, mass spectroscopy, and selective ion monitoring
GLWQI-Wildlife	Great Lakes Water Quality Initiative criteria for protection of wildlife
Heavy Metal	Any metal with a density of 5.0 or greater, especially one that is toxic to organisms, as **lead**, **mercury**, **copper**, and **cadmium**.
Hg	Mercury
Inorganic	Composed of matter other than plant or animal.
LC_{50}	Lethal Concentration 50% - the concentration of a chemical in air or water which is expected to cause death in 50% of test animals living in that air or water.
LD	Lethal Dose - the amount of a toxic substance required to cause death of an organism under study in a given period of time
LD_{50}	Lethal Dose 50% - the dosage of a toxic substance required to kill one half of the organisms under study in a given period of time
LKA	Landing amphibious cargo ship
LOAEL	Lowest Observed Adverse Effect Level - the lowest dose in an experiment, which produced an observable adverse effect.
LOED	Lowest Observed Effects Dose – the lowest dose in an experiment which produced an observable effect. The dose can refer to the concentration of chemical in the diet or the concentration of the chemical in tissues of the organism.
MARAD	U.S. Maritime Administration
Measures of Effects	Measurements that provide information about effect, impact, or stress on **Ecological Receptors**.
Measures of Exposure	Measurements that quantify the concentration of **COCs** in sediment, water, or biota.
Metal	Any of a class of elementary substances, as gold, **silver**, or **copper**, all of which are crystalline when solid, and many of which are characterized by opacity, ductility, conductivity, and a unique luster when freshly fractured. Metals will yield positively charged ions in aqueous solution of its salts.
Methylated	An organic compound with an **methyl** group attached
Methyl	A hydrocarbon containing one carbon and three hydrogen molecules CH_3

Methylmercury	Any of several toxic compounds formed from metallic mercury by the action of microorganisms and capable of **bioaccumulating** in the **food chain**.
Mg	Milligram - one-thousandth of a gram (0.000035 oz.).)
mg/L	Milligrams Per Liter - a measure of concentration of a dissolved substance. A concentration of one mg/L means that one milligram of a substance is dissolved in each liter of water which is equal to **parts per million** (**ppm**) since one liter of water is equal in weight to one million milligrams. For example: a liter of water containing 10 milligrams of calcium has 10 parts of calcium per one million parts of water, or 10 parts per million (10 ppm).
Mn	Manganese
Molecular Weight	The molecular weight of a compound in grams is the sum of the atomic weights of the elements in the compound.
Mortality	The proportion of deaths to population.
NEHC	Navy Environmental Health Center, Norfolk, VA
Ni	Nickel
NOAEL	No Observed Adverse Effect Level - the highest dose in an experiment which did not produce an observable adverse effect.
NOED	No Observed Effects Dose – the highest dose in an experiment which did not produce an observable effect. The dose can refer to the concentration of chemical in the diet or the concentration of the chemical in tissues of the organism.
NOEL	No Observed Effect Level - in concentration response experiments, the concentration level at which no effects are noted.
Non-Point Source Pollution	Diffuse **pollution** sources that do not have a single point of origin or are not introduced into **receiving waters** from a specific outlet. The pollutants are generally carried off the land by storm water runoff. The commonly used categories for non-point sources are agriculture, forestry, urban, mining, construction, dams and channels, land disposal, and saltwater intrusion.
Organic	Composed of plant or animal matter.
PAH	Polycyclic Aromatic Hydrocarbons - compounds containing more than one benzene ring in its structure.
Particulate	Very small solid particles suspended in water which can vary widely in size, shape, density, and electrical charge. **Colloidal** and dispersed particulates are artificially gathered together by the processes of coagulation and flocculation.
Partition Coefficient	A measure of the extent to which a chemical is divided between the soil/sediment and water phases.
Pb	Lead
PCB	Polychlorinated Biphenyl - any of several compounds that are produced by replacing hydrogen atoms in biphenyl with chlorine. Used in various industrial applications, they tend to accumulate in animal tissues. PCB (or PCBs) is a category, or family, of chemical compounds formed by the addition of Chlorine (Cl2) to Biphenyl (C12H10), which is a dual-ring structure comprising two 6-carbon Benzene rings linked by a single carbon-carbon bond. For more information see: http://www.epa.gov/toxteam/pcbid/defs.htm
PCB congener	A group of 209 individual PCB compounds having from 1 to 10 chlorine atoms attached to biphenyl rings. The name of a congener specifies the total number of chlorine substituents and the position of each chlorine. For example: 4,4'-Dichlorobiphenyl is a congener comprising the Biphenyl structure with two chlorine substituents, one on each of the two carbons at the "4" (also

	called "para") positions of the two rings. For more information see: http://www.epa.gov/toxteam/pcbid/defs.htm
PCB homologs	"Homologs" are subcategories of **PCB congeners** having equal numbers of chlorine substituents. For example, the "Tetrachlorobiphenyls" (or "Tetra-PCBs" or "Tetra-CBs" or just "Tetras") are all PCB congeners with exactly 4 chlorine substituents that may be in any arrangement. For more information see: http://www.epa.gov/toxteam/pcbid/defs.htm
Pelagic Species	The community of organisms (fish, **plankton**), which spend the majority of their life floating or swimming in the water.
PHEN	Phenanthrene - One of a number of **PAH** compounds
Phytoplankton	Microscopic plants (such as **algae**), that forms the basis of the **food chain** in oceans, estuaries, rivers, lakes, and other bodies of water.
Plankton	Aquatic organisms of fresh, brackish, or sea water which float passively or exhibit limited locomotor activity (e.g. **algae**, **phytoplankton**, **zooplankton**).
Point Source	A stationery location or fixed facility from which pollutants are discharged or emitted. Also, any single identifiable source of pollution, (e.g., a pipe, ditch, ship, ore pit, factory smokestack).
Pollutant	Any substance introduced into the environment that adversely affects the usefulness of a resource.
Pore Water	The spaces between sediment particles that are saturated with water.
ppb	Parts Per Billion - a measurement of concentration on a weight or volume basis. One ppb equals one unit of measurement per billion units of the same measurement. One ppb equals one microgram per liter (**µg/L**) for volume or one nanogram per gram (**ng/g**) or alternatively one microgram per kilogram (**µg/Kg**) for weight.
ppm	Parts Per Million - a measurement of concentration on a weight or volume basis. One ppm equals one unit of measurement per million units of the same measurement. One ppm equals one milligram per liter (**mg/L**) for volume or one microgram per gram (**µg/g**) or alternatively one milligram per kilogram (**mg/Kg**) for weight.
Precision	The ability of an instrument to measure a process variable and to repeatedly obtain the same result.
PYRENE	One of a number of **PAH** compounds.
QA/QC	Quality Assurance/Quality Control
Receiving Waters	All distinct bodies of water that receive runoff or wastewater discharges, such as streams, rivers, ponds, lakes, estuaries, and oceans.
Receptor	Any organism or environmental media which is exposed to contamination from a discharge.
REEFEX	The creation of artificial reefs by sinking ex-Navy vessels.
Risk	A measure of the probability that damage to the environment will occur as a result of a given hazard.
Risk Assessment	A qualitative or quantitative evaluation of the environmental and/or health risk resulting from exposure to a chemical or physical agent (**pollutant**); combines **exposure assessment** results with **toxicity assessment** results to estimate risk.
Risk Characterization	Final component of **risk assessment** that involves integration of the data and analysis involved in the **exposure assessment** and the ecological **effects assessment** to determine the likelihood that ecological impacts have or will occur.

Risk Definition - High Risk	Evidence of large and persistent impacts with a high degree of correlation between exposure and effects. Probable impacts are suggested.
Risk Definition - Intermediate Risk	Evidence of localized impacts but weak correlation between exposure and effects measures. Potential impacts are suggested.
Risk Definition - Low Risk	Evidence of exposure and effects but no correlation between exposure and effects measures. Limited impacts are suggested.
Risk Definition - Negligible Risk	Very little evidence of exposure and effects. No impacts ar suggested.
Risk Drivers	Chemicals or processes that may be responsible for causing elevated risk.
Risk Management	The process for evaluating and selecting responses to risk.
S_B	**Benchmark** concentration in **sediment** that is protective of marine organisms.
SCDNR	South Carolina Department of Natural Resoucres
Sediment	Matter which settles to the bottom in oceans, estuaries, rivers, lakes or other waterbodies.
SEM	Simultaneously Extracted Metal - the **heavy metals** associated with the reactive pool of **acid volatile sulfides**. The sulfides are released when sediments treated with acid and the amount of sulfide released is referred to as **AVS** and the amount of metals that are released simultaneously is referred to as **SEM**.
SINKEX	The sinking of ex-Navy vessels as part of weapons testing operations.
SSD	Species sensitivity distributions are cumulative distribution functions, that describe the proportion of a class of organisms that are expected to be affected by a given level of exposure to a contaminant.
sumPCB	The sum of the measured **PCB congeners**.
Superfund	Federal law, which authorizes EPA to manage the clean up of abandoned or uncontrolled hazardous waste sites.
SWMU	Solid Waste Management Unit - an area designated in the Shipyard's Hazardous Waste Permit where hazardous materials may have been stored, treated, or released.
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin (most toxic from of dioxin)
tDDx	Total **DDT** and metabolites (sum of **DDT**, **DDE**, and **DDD**).
TEF	Dioxin Toxicity Equivalent Factor, **TEF** expresses the potency of PCB congeners relative to **TCDD** (i.e., TCDD TEF = 1)
TEQ	Toxicity equivalent quotient (**TEQ**). The TEQ is calculated by summing the products of the concentrations of individual congener [PCBcongener] and their toxicity equivalency factor (**TEF**): **TEQ** = Σ [PCBcongener]$\times$TEF]
T_{Fish}	**Benchmark** concentrations in tissue residues of fish that when exceeded, has been associated with adverse effects.
Threshold	The lowest dose of a chemical at which a specified measurable effect is observed and below which it is not observed.
T_{Invert}	**Benchmark** concentrations for tissue residues of invertebrates that when exceeded, has been associated with adverse effects.
Toxic	A substance that is poisonous to an organism.

Toxic Pollutants	Materials contaminating the environment that cause death, disease. birth defects in organisms that ingest or absorb them. The quantities and length of exposure necessary to cause these effects can vary widely.
Toxic Substance	A chemical or mixture that may represent an unreasonable risk of injury to health or the environment.
Toxicant	A harmful substance or agent that may injure an exposed organism.
Toxicity	The quality or degree of being poisonous or harmful to plant, animal or human life.
Toxicity Assessment	Characterization of the toxicological properties and effects of a chemical, including all aspects of its absorption, metabolism, excretion and mechanism of action, with special emphasis on establishment of dose- response characteristics.
Toxicology	The science and study of poisons control.
tPCB	Total **PCB**, usually determined by the sum of the **PCB homologs**.
Trophic Transfer	The process by which contaminants are accumulated in the **food chain**.
TSV	Tissue screening values are tissue residue of chemicals, below which it is unlikely that adverse effects will occur.
Turbidity	A measure of water cloudiness caused by suspended solids
μg	Microgram - one-millionth of a gram (0.000000035 oz.).)
μg/L	Micrograms Per Liter - one microgram of a substance dissolved in each liter of water. This unit is equal to **parts per billion** (**ppb**) since one liter of water is equal in weight to one billion micrograms.
Uptake	The entrance of a chemical into an organism — such as by breathing, swallowing, or absorbing it through the skin — without regard to its subsequent storage, metabolism, and excretion by that organism.
VOC	Volatile Organic Compound - a photochemically reactive organic compound which evaporates readily under normal temperature and pressure conditions. VOCs are contributors to the formation of ground level ozone.
Volatile	Readily vaporizable at a relatively low temperature.
Water Quality Criteria	The concentration of a constituent in water below which is not considered harmful to aquatic life
Watershed	The land area that drains into a stream. An area of land that contributes runoff to one specific delivery point; large watersheds may be composed of several smaller "subsheds", each of which contributes runoff to different locations that ultimately combine at a common delivery point.
W_B	Water benchmark concentration, usually set to **water quality criteria**
WV_{Fish}	Wildlife protection value derived to be protective of piscivorous birds and mammals (U.S. EPA 1997).
Wetlands	Any number of tidal and nontidal areas characterized by saturated or nearly saturated soils most of the year that form an interface between terrestrial (land-based) and aquatic environments; include freshwater marshes around ponds and channels (rivers and streams), brackish and salt marshes; other common names include swamps and bogs.
Zn	Zinc.
Zooplankton	Animal life of the **plankton**.

Variables Used In Statistical Analysis

Varible Name	Units	Description
SITE	site	target or reference reef
SITEVAR	variable for site	target = 2 or reference reef = 1
SP	species	
SPVAR	variable for species	BSB=1, VS=2, WG=3
ID	ID	unique identifier
ROUND	integer	Analytical chemistry round 1 or 2
LEN	cm	total length
WEIGHT	g wet	Body Weight
FWEIGHT	g wet	fillet weight
LWEIGHT	g wet	liver weight
HSI	%	Hepatosomatic Index (% liver/body weigth)
SEX	text	male, female, or immature
SEXVAR	variable for sex	male=3, female=2, or imature=1
AGE	y	Age in years, estimated from tail length
DRY	%	Fillet dry weight: tissue wet
LIPIDW	%	Fillet (wet) lipid : tissue
LIPIDD	%	Fillet (dry) lipid : tissue
F_PCB	ng/g dry	Fillet tPCB
F_PCBL	ng/g lipid (dry)	Fillet tPCB/lipid
F_LPCB	ng/g (dry)	Fillet log(tPCB)
F_LPCBL	ng/g lipid (dry)	Fillet log(tPCB/ Lipid)
F_PCBWET	ppm Wet Weight	Fillet tPCB
L_PCBm	ng	mass of tPCB in Liver
F_PCBm	ng	mass of tPCB in Fillets
O_PCBm	ng	mass of tPCB in Other Tissues
WB_DRY	g dry/g wet	Whole Body dry to wet ratio
W_PCB	ng/g dry weight	Whole Body tPCB
W_LPCB	log(ng/g dry)	Whole Body log(tPCB)
W_PCBL	ng/g lipid	Whole Body tPCB/lipid
W_LPCBL	log (ng/g lipid)	Whole Body Log(tPCB/lipid)

1. Executive Summary

1.1. Introduction

This document presents the results of an initial and advanced screening level ecorisk assessment to support decisions about future use of former Navy vessels to construct artificial reefs (REEFEX) on the continental shelf of the United States. The problem formulation, conceptual model, and exposure pathways for the risk assessment are described, the methods, benchmarks, and decision criteria for the ecorisk screening are detailed, and the results are presented and discussed.

1.2. Background

Inactive U.S. Navy vessels would make excellent artificial reefs in U.S. coastal waters if preliminary data suggesting that they pose no threat to human health or the environment from PCB contamination can be confirmed. The U.S. EPA has stated that building reefs with ex-Navy vessels would be regulated under Sec. 761.62 Disposal of PCB bulk product waste (40 CFR 761.62(c)). The EPA has the authority to approve risk-based disposal of PCBs (63 FR 35384, June 29, 1998), if a finding of no unreasonable risk of injury to human health and the environment can be made. A joint Navy and EPA Technical Working Group gathered data and performed technical analyses to address concerns about the potential release of PCBs from sunken ships (SINKEX). In July of 1999, the REEFEX Technical Working Group was formed to assess the scientific and technical issues of using former Navy warships to construct artificial reefs. The REEFEX Technical Working Group consisted of representatives from the U.S. EPA, the U.S. Navy, the South Carolina Department of Natural Resources, Florida Department of Environmental Protection, Florida Department of Fish and Wildlife, Florida Department of Health, and Escambia County, FL.

Photo 1. Black sea bass (*Centropristis striatia*) photographed on the ex-Vermilion reef. (Photo by SCDNR)

The anticipated benefits of building reefs with ex-Navy vessels includes enhancing ecological resources by increasing the amount of productive hard-bottom habitat, using artificial reefs as marine protected and conservation areas, or using artificial reefs to provide alternative reefs for recreational fishing and diving so that natural reefs can be protected and conserved (Bell 2001). Artificial reefs can also provide economic benefits to local communities by

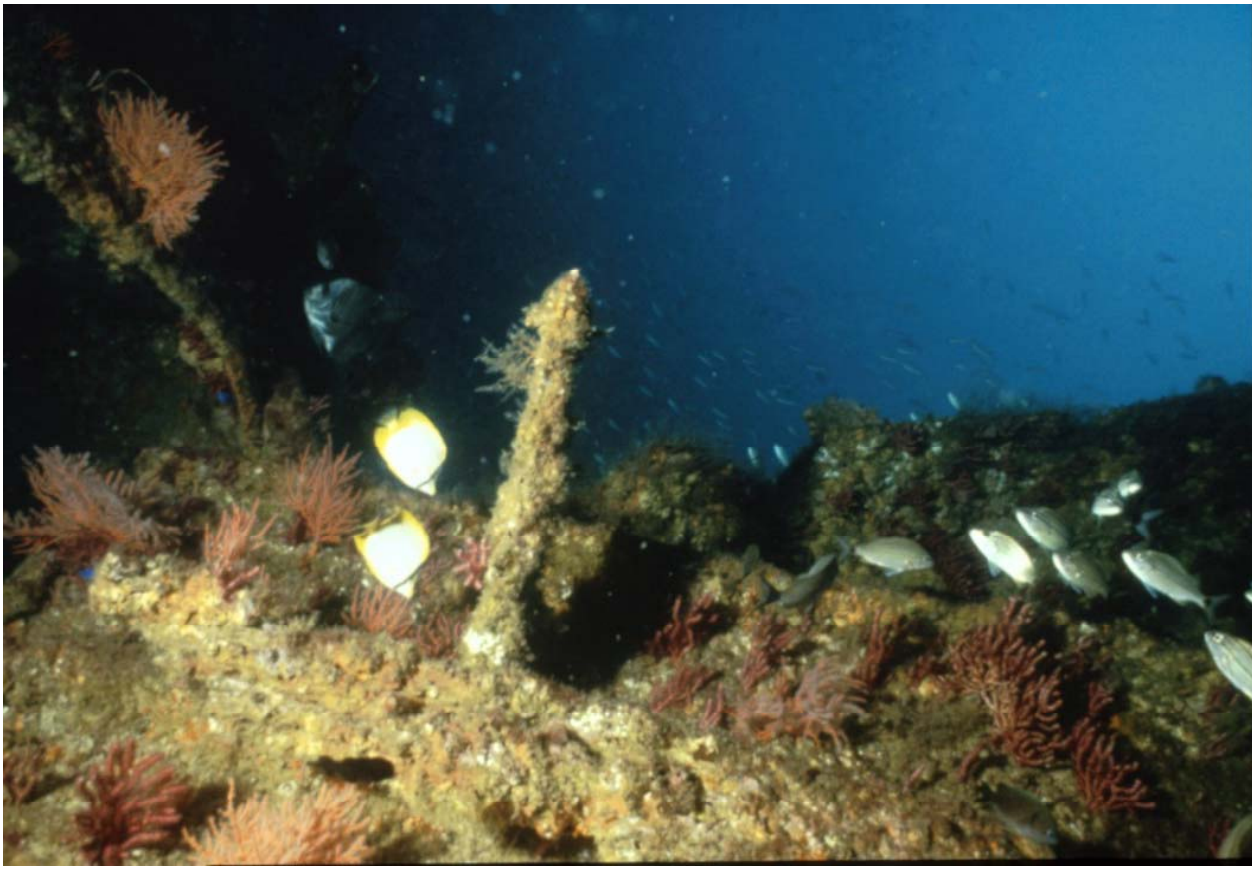

Photo 2. The ex-Vermilion artificial reef (Photo by SCDNR).

increasing tourism and commercial activities associated with fishing and diving on the reef (Enemark, 1999, Hynes et al. 2004). A study by the Rand Corporation (Hess et al. 2001) concluded that reefing would be the most ecologically responsible and economically feasible option for disposing of decommissioned warships. The Rand report estimated that more than $1.5 Billion of taxpayer dollars would be saved if decommissioned ships could be "reefed" instead of "scrapped" (San Diego Oceans Foundation 2002a). By determining the potential ecological and human health risks, better decisions can be made to effectively manage the risks associated with creating reefs from ex-warships.

1.3. Objective

The objective of this ecorisk assessment was to assess the potential toxicological risk of contaminants that may be released from ex-Navy vessels during or after sinking to create an artificial reef. Since data were available on ex-Navy ships and other artificial and natural reefs located off the Coast of South Carolina, a retrospective risk assessment was conducted to determine if there was any evidence of increased toxicological risk to reef-associated organisms that lived, fed, or foraged on ex-Navy ship reefs. The risk assessment does not address the

ecological consequences of creating the reef itself, it is focused on characterizing potential toxicological risks of contaminants that may be released from the ship.

An initial screening-level ecorisk assessment and an advanced screening ecorisk assessment for PCBs were conducted to develop the decision criteria that must be satisfied to conclude a finding of no unreasonable risk. The screening-level ecorisk assessment will support a process that will enable risk management decisions to be made by the EPA and Navy regarding beneficial use of decommissioned Navy vessels for reef building projects.

1.4. Problem Formulation

The study area encompasses an area of the inner continental shelf along South Carolina extending as far north as North Carolina. It includes the locations of the vessels previously sampled off the South Carolina coast by the South Carolina Department of Natural Resources (SCDNR, Martore et al. 1998). The dynamic and heterogeneous nature of the study area called for a regional approach to control for spatial variability (see Figure 2A, 2B). A regional approach provides a broader scientific basis for drawing conclusions than can be obtained from studying a single site and reference location (Seaman and Jensen 2000). The following types of habitats were evaluated: artificial reefs composed of former Navy vessels (Navy Vessel Reef), artificial reefs composed of materials other than former Navy Vessels (Other Artificial Reefs), naturally occurring hard bottom areas (Natural Reefs), and non-reef areas that are representative of regional background conditions (Background[1]).

Contaminants can enter the system through releases from the sunken vessel and inputs from coastal waters. Through transport, uptake, and bioaccumulation (ingestion of food-chain species), the released chemicals will be present in various media, i.e., water, sediment, and biota associated with the reef. The ecological system under consideration for this study is the Reef Community and other organisms that frequent and forage on the reef (see Figure 3). Assessment endpoints were identified to assess risks to ecological receptors. Primary exposure and indirect exposure through bioaccumulation in the food chain can occur to the reef community and reef consumers (see Figure 3). The assessment endpoints were toxicological effects to growth, survival, and reproduction of primary producers (phytoplankton and encrusting algae), primary consumers (zooplankton, epifauna, infauna, and grazing fish), secondary consumers (demersal fish – grunt, snapper, and sea bass; reef invertebrates – lobster, crab, and bivalves; and sea turtles), tertiary consumers (marine mammal, reef shark, and barracuda), and avian consumers (cormorant and herring gull, Figure 3).

1.5. Data Sources

The sources of data used in the screening level ecorisk assessment included data from a study of vessels that were sunk in the late 1980s to create artificial reefs off the coast of South Carolina (Table 1, Martore et al. 1998, SCDNR 2002). Additionally, reef fish were sampled at an ex-Navy ship reef (ex-VERMILION LKA-107) and a reference reef during May-July 2000 and

[1] "Background" refers to areas that are not directly related to reef habitat. Background areas generally consist of sandy, soft bottom substrate (Van Dolah et al. 1994).

analyzed for PCBs (Table 2, NEHC 2000, NEHC 2001). Sediment data was obtained from the study of a deep water sunken vessel, the ex-AGERHOLM (destroyer DD 826) (SINKEX, Gauthier et al. 2005). In addition, data developed from laboratory leaching experiments on solid materials containing PCBs that could possibly be on ex-Navy warships (LEACHRATE, George et al. 2005) were also used to assess exposure from ex-Navy warships. Background data for the ecorisk screening was obtained from the Environmental Monitoring and Assessment Program (EMAP) EMAP-Estuaries conducted for the Carolinian Province (Hyland et al. 1998).

1.6. Screening Methodology

The screening procedure consisted of the following steps:

1. Benchmarks of ecological effects for exposure to water, sediment, and dietary uptake were identified for the assessment endpoints and receptor species evaluated and regional background concentrations of contaminants were determined.
2. Based on available data, estimates of exposure associated (water, sediment, diet) were developed for: (i) Navy Vessel Reefs, (ii) Other Artificial Reefs, (iii) Natural Reefs, and (iv) Regional Background.
3. Estimates of exposure for Navy Vessels Reefs were compared to estimates of exposure associated with (i) Other Artificial Reefs, (ii) Natural Reefs, and (iii) Regional Background and to the appropriate ecological effects benchmarks.
4. If ecological effect benchmarks were exceeded, ecological hazard quotients (HQ) and hazard indices (HI) were calculated for each assessment endpoint and complete exposure pathway.
5. Sources of uncertainty were documented and discussed and gaps in data and information were identified.

1.7. Supplemental Fish Sampling

The limitations of the data from the SCDNR study (Martore et. al. 1998) were discussed among the Technical Working Group members and it was agreed that additional data would be needed to complete the ecological and human health risk assessments. Therefore, based on the recommendations of the Technical Working Group, a supplemental fish sampling study was developed (NEHC 2000) and executed (NEHC 2001) to collect three species of fish commonly caught by sports fishers from an artificial reef constructed from a sunken Navy vessel (Target Reef – ex-VERMILION) and a natural hard bottom reef (Reference Reef).

1.8. Benchmarks of Ecological Effects

Benchmarks of ecological effects were selected to evaluate potential effects to a broad range of reef-dwelling organisms. Benchmark concentrations for water (W_B), sediment (S_B), and tissue residues of fish (T_{Fish}) and invertebrates (T_{Invert}) were selected. The tissue benchmarks were for the bioaccumulation critical value (B_{CV}), tissue screening value (TSV), critical body residues (CBR) corresponding to the no observed effect dose (NOED) and the lowest observed effect dose (LOED) for a fish or invertebrate species, and dietary benchmarks for the consumption of fish by herring gulls, cormorants, dolphins, and reef sharks, and the consumption

of invertebrates by herring gulls, sea turtles, and dolphins (see Table 4 in the main body of the report).

1.9. Decision Criteria

Decision criteria were developed to evaluate the results of the ecorisk assessment. The conclusions were based on the evidence of exceeding benchmarks (Is exposure harmful?), evidence of exceeding reference and background levels (What is exposure relative to reference and background?), and the degree to which data were available to support the assessment. The more harmful and elevated above reference and background the exposure was, the higher the risk (Textbox 1). The reliability of the data was based on how much data were available, how quantitative the data were, and whether the data met the data quality objectives for the assessment (Textbox 2). The data quality objectives included how well the data represented site conditions, spatial differences, temporal or seasonal variations, and responses from the stressors.

1.10. Findings and Conclusions

1.10.1. Supplemental Fish Data

There were physical and physiological differences between the fish from the reference and target reefs. Fish from the target reef had larger livers (see Figure 13B), higher hepatosomatic index (see Figure 20), and fish from the reference reef had significantly less lipid content (see Figure 14A). On a dry weight basis, there were significantly higher PCB levels in

Textbox 1. Decision matrix for determining the ecological risk of exposure.

Is exposure harmful?	What is exposure Relative to Reference and Background?		
	Less	**Similar**	**Higher**
Very unlikely	***Negligible Exposure***	***Negligible Exposure***	***Negligible Exposure***
Unlikely	***Negligible Exposure***	***Negligible Exposure***	***Low Exposure***
Moderate likelihood	***Negligible Exposure***	***Negligible Exposure***	***Medium Exposure***
Likely	***Negligible Exposure***	***Low Exposure***	***High Exposure***
Very likely	***Negligible Exposure***	***Medium Exposure***	***Adverse Exposure***

Textbox 2. Evaluation criteria for data reliability. The data quality objectives included how well the data represented site conditions, spatial differences, temporal variations, and responses from the stressors.

Status of Data	Interpretation	Confidence in Conclusion
No data available	Serious Data Gap	No conclusion possible
Data are anecdotal, undependable, unverifiable, or highly ambiguous	Data Reliability Low	Low
Quantitative data are available but they are limited and or contradictory.	Data Reliability Passable	Low
Quantitative data that meet at least 2 data quality objectives	Data Reliability Good	Medium
Quantitative data that meet 4 or more data quality objectives	Data Reliability High	High

black sea bass, vermilion snapper, and white grunt sampled from the ex-VERMILION reef (see Figure 15). A significant positive regression was obtained for all fish from both reefs between body weight and log of lipid-normalized PCB concentrations.

The regression of data for white grunt from both reefs showed a significant positive slope for increasing PCB levels in larger white grunt and the relationship appeared to differ between the two reefs, such that for a given fish size, target reef white grunt generally had higher total PCB concentrations per gram of lipid than did reference white grunt. A significant positive slope was also detected for vermilion snapper from the combined reefs and target reef, which was probably due to the fact that smaller fish with less PCB were sampled from the reference reef. The black sea bass data did not show the same trend, instead the log of the lipid-normalized PCB concentrations in black sea bass were independent of body weight.

1.10.2. Steady State Leaching of PCBs

Empirical estimates of PCB leaching rates were measured for felt gaskets, electric cable, paint, rubber, foam insulation, oils and greases, bulkhead insulation, and pure Aroclors (George et al. 2004). Based on information available about the types of materials and PCB concentrations estimated to be present on the ex-AGERHOLM (JJMA 1998), low, average and high PCB loading scenarios were developed for the ex-VERMILION. Empirical estimates of PCB leaching rates were used to simulate the leaching of PCBs from the ex-VERMILION and estimate the instantaneous steady state concentration of total PCB around the ship (Figure 4). Because the empirical leaching rate of PCBs from oils and greases was not available, the leaching rate of pure Aroclor 1254 (George et al. 2004) was used in the model as an analogue for PCBs dissolved within residual oils and greases remaining on the ship following purging of fuel tanks and reservoirs (JJMA 1998). The model showed that residual oils and greases and bulkhead insulation were the most important sources of PCB loading. The estimated exposure concentrations were compared to the PCB water benchmarks and multiplied by bioconcentration factors to project the resulting PCB concentration in fish and shellfish. The results showed that

there was negligible risk of exceeding water column or tissue benchmarks for any of the loading scenarios evaluated.

The results from the empirical leaching studies and hypothetical steady state model were used to evaluate the consequences of removing materials from the ship to reduce PCB loading. In general, removing the materials with the highest leach rates would result in the greatest reduction in PCB loading per unit material removed. Based on the empirical upper bound of the leach rate obtained from the solids tested (George et al. 2004) removing 0.001 kg (1 g) of pure Aroclor 1254 would reduce leaching by the same amount as removing 0.004 kg of pure Aroclor 1268, 0.143 kg of bulkhead insulation, 1.855 kg of foam insulation, 3.8 kg of felt gaskets, 5.3 kg of rubber products, 56.5 kg of paint, or 80 kg of electrical cable (Appendix 8). For the solid materials tested in the laboratory leaching experiments, the effect of decreasing PCB loading by reducing the amount of solid materials containing PCBs was evaluated using the steady state model. The steady state model takes into account both the quantity and concentration of PCBs in the materials estimated to be on the ship when it was sunk. Based on the average loading scenario, removing about 150 g of bulkhead insulation would result in about the same reduction in PCB loading as removing about 4 kg of felt gaskets, 30 kg of foam insulation, 200 kg of electrical cable, 300 kg of rubber products, or 500 kg of paint (Appendix 8). Because considerably more effort is required to remove certain types of materials than others, removing relatively small quantities of bulkhead insulation and using extra care to clean up oils & greases in areas where they may of come into contact with PCBs would greatly reduce the amount of PCBs leached and therefore further reduce the potential risk of exposure to PCBs.

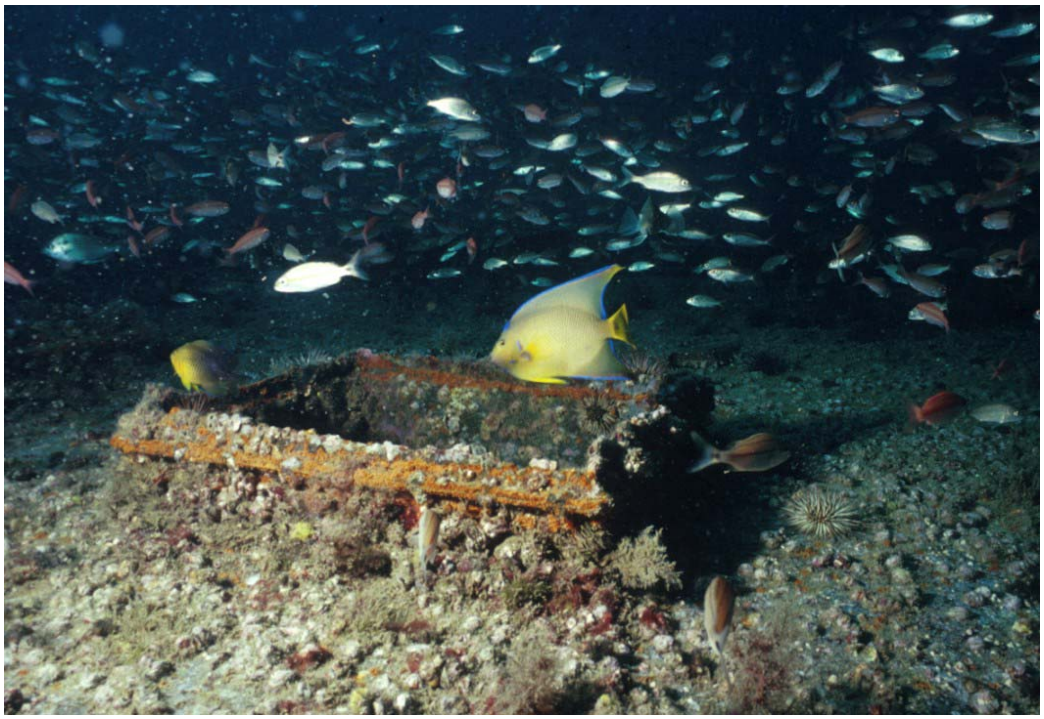

Photo 3. Demersal fish and reef invertebrates on the ex-VERMILION reef (Photo by SCDNR).

1.10.3. Ecorisk Screening – Initial Screening

The initial ecorisk screening consisted of two components a graphical analysis and a hazard quotient analysis for tissue residue data and sediment data. The tissue residue data were obtained from a study of South Carolina's artificial reefs (Martore et al. 1998) and supplemental fish sampling collected from the ex-VERMILION reef (target) and a nearby hard bottom natural reef (reference). The graphical screening analysis was conducted for sediments with data from the SINKEX study of the ex-AGERHOLM (Gauthier et al. 2005). This was necessary because there were no sediment data available for the artificial reefs off the coast of South Carolina. The ex-AGERHOLM was sunk in a relatively isolated, deep ocean environment and the increase in sediment contamination near the ship (within 3 m of ship – inner ring) was evaluated relative to reference data near the site (1 km from ship – outer ring, Gauthier et al. 2005). Sediment data from the inner ring was compared to the sediment benchmarks (see Table 4) and to data obtained from the outer reference ring.

The initial screening level assessment found that the risk of sediment exposure was negligible for PCB, PAH, Cr, Hg, and Pb; low for Ag and Zn; medium for Cd and Cu; and adverse for Ni. Because the sediment benchmarks for Ni are overprotective (Long et al. 1995), the finding of adverse exposure for Ni may be overly conservative. The data reliability for the sediment screening was good, but there was uncertainty associated with the sediment screening due to extrapolating from the deep ocean SINKEX site, so there was a medium level of confidence in the conclusions.

For the graphical analysis of tissue residue data, the data from the SCNDR study (Martore et al. 1998) and the supplemental fish data (Appendix 4.B) were grouped according to Navy Ship Reef, Other Artificial Reef, and Natural Reef (Table 1) and plotted on the same scale as the background data from the EMAP study (Hyland et al. 1998, Appendix 6). The graphical screening analysis for tissue residues included the appropriate tissue benchmarks for the tissue screening value (TSV), bioaccumulation critical value (B_{CV}), critical body residues corresponding to the no observed effect dose (NOED) and the lowest observed effect dose (LOED) for the receptor species, and the dietary consumption of tissue by herring gulls (D_{Gull}), cormorants ($D_{Cormorant}$), sea turtles (D_{Turtle}), and dolphins ($D_{Dolphin}$) (see Table 4). The chemicals that exceeded the most conservative benchmark for each exposure pathway in the food chain were identified as COCs from the screening level risk assessment.

The risk of exposure to multiple chemicals was evaluated by calculating a hazard index (HI) for each complete exposure pathway. The HI represents the potential for ecological effects to occur when an organism is exposed to more than one contaminant simultaneously. For the HI based on water quality criteria, negligible risk was indicated by the data from invertebrate tissue residues and medium risk was indicated by the data from fish tissue residues. There was negligible risk of exposure from all chemicals evaluated for critical body residues in demersal fish and reef invertebrates. The HI analysis of dietary exposure indicated negligible risk of exposure to dolphins, sea turtles, herring gulls, and cormorants for the chemicals evaluated.

Tissue residue data from the SCDNR study (Martore et al. 1998) showed that exposure to PCBs, Pb, and Cd in tissues of fish and PCBs and Pb in invertebrates were higher in samples from Navy ship reefs than reference reefs. The fish tissue residue data reported from the SCDNR

suggested negligible risk of exposure to all assessment endpoints except for primary producers and consumers, which had a medium risk of exposure due to elevated levels of Cr, Pb and Cd measured in the two fish samples from the ex-VERMILION reef. Risk of exposure inferred from data on invertebrate tissue residues (Martore et al. 1998) indicated negligible risk to all receptors except for low risk to plankton due to elevated Pb levels in invertebrates sampled from the ex-VERMILION reef. There was low confidence in the conclusions because the data available were limited to a single study with only two fish samples and nine invertebrate samples from the target reefs.

Based on the results of the Navy's supplemental fish study there was negligible risk of exposure to secondary consumers (demersal fish) and low risk to primary producers and consumers (plankton and zooplankton), avian consumers (herring gulls and cormorants), and tertiary consumers (dolphins and sharks). There was high confidence of negligible to low risk of exposure to PCBs because the Navy's supplemental fish study conducted detailed sampling and analysis for PCBs.

1.10.4. Ecorisk Screening – Advanced Screening for PCBs

Advanced screening for potential effects from PCBs was also conducted. The advance screening was warranted due to the importance of evaluating potential toxicological effects from PCBs that could be associated with ex-Navy ships used to create artificial reefs. Furthermore, the significantly higher than reference concentrations of PCBs detected in the supplemental fish collected from the ex-VERMILION reef (see Section 6.1.2) and the fact that some of these samples exceeded the initial screening benchmarks for PCBs (see Section 6.4) also indicated that the advanced screening would be beneficial to risk managers. The advanced screening consisted of evaluating the distributions of PCB congeners measured in the supplemental fish samples, analyzing the potential toxicity from dioxin-like coplanar congeners, and conducting a probabilistic analysis of PCB exposure. The probabilistic analysis included calculating the probability of exceeding benchmarks of PCB exposure, comparing the PCB exposure distribution observed in fish at the target reef to species sensitivity distributions (SSDs) of effects from residues of PCBs in fish, and calculating the probability of an effect from PCB residues to fish, given the probability of exposure from PCBs in fish residues.

The analysis of homologs and individual congeners showed that there were similar distributions and proportions of PCBs measured at both the target and reference reefs. The samples from the target reef had slightly more lower-chlorinated tetra- and penta- PCBs than the reference reef, but the principal component analysis (PCA) failed to discriminate any indication of a unique source of PCBs between the reefs.

The analysis of exposure to dioxin-like PCB congeners showed that the TEQs calculated for fish tissue were similar between target and reference for black sea bass and vermilion snapper, but were much higher for white grunt from the target reef than from the reference reef. Based on maternal transfer from female to egg, the average TEQs calculated for white grunt fish eggs at the target reef exceeded the NOED (0.3 pg TEQ/g wet weight) and LOED (3 pg TEQ/g lipid) benchmarks for salmon egg mortality. The TEQs calculated for dietary exposure to birds showed that the maximum TEQ for the target reef did not exceed the site-specific cormorant or herring gull NOAEL. The TEQs calculated for dietary exposure to dolphins showed that the

average TEQ calculated for fish from the target reef exceeded the site-specific NOAEL for dolphin and the maximum TEQ from the target reef also exceed the dolphin LOAEL for TEQ.

The probability that harmful exposures would occur was calculated to better quantify the magnitude of ecorisk indicated by the available data. The incremental increase in risk from the target reef was defined as the probability of exceeding a benchmark for the target reef minus the probability of exceeding a benchmark for the reference reef. There was low risk (P=0.05) that the target fish would exceed the TSV benchmark and very low risk (P=0.0003) that the B_{CV} for PCBs would be exceeded. There was low risk that the NOED (P=0.006) or LOED (P=0.0044) for PCB critical body residues in fish would be exceeded in fish from the target reef. The risk of target reef fish exceeding the dietary NOAEL for dolphin was low (P=0.077) and there was very low risk that the dietary LOAEL (P=0.0057) for dolphins would be exceeded. There was also low risk of exceeding the dietary NOAELs for cormorants (P=0.02), gulls (P=0.018), and sharks (P=0.017), very low risk of exceeding the dietary LOAELs for cormorants (P=0.00014) and gulls (P=0.00012), and negligible risk of exceeding the dietary LOAEL for sharks (P<0.0001).

Risk probabilities were also calculated for exceeding TEQ benchmarks to better quantify the magnitude of risk from exposure to dioxin-like PCB congeners. The risk calculation for dioxin-like PCB exposure to fish eggs showed that there was low risk of exceeding the sensitive rainbow trout NOAEL (P=0.093) and LOAEL (P=0.084) for egg mortality. For TEQ effects to lake trout sac-fry larvae there was very low risk of exceeding the NOAEL (P=0.00029) and negligible risk of exceeding the LOAEL (P<0.0001) benchmarks. The risk of dioxin-like PCB exposure to avian receptors was very low for exceeding the NOAEL for herring gulls (P=0.00066) and cormorants (P=0.00075) and negligible (P<0.0001) for exceeding the LOAEL for both gulls and cormorants. There was also medium risk (P=0.242) of exceeding the site-specific dietary NOAEL and low risk (P=0.0365) of exceeding the site-specific dietary LOAEL for dolphins at the target reef.

The probabilistic analysis quantified the potential level of risk to ecological receptors based on the benchmarks and available data. The low risk of exceeding the TSV and very low risk of exceeding the B_{CV} was interpreted to mean that there was very low risk of potentially harmful PCB exposure to primary producers and consumers of the reef community. The very low risk of exceeding the NOED and LOED for critical body residues in fish was interpreted to mean that there was very low risk of harmful PCB residues in demersal fish. For dolphin consumption of prey (fish), the low risk of exceeding the NOAEL and very low risk of exceeding the LOAEL were interpreted to mean that there was very low risk of harmful PCB exposure to dolphins. The low risk of exceeding the NOAEL and very low risk of exceeding the LOAEL for cormorants and gulls indicated that there was very low risk of harmful PCB exposure to avian consumers. Based on the low risk of exceeding the NOAEL and negligible risk of exceeding the LOAEL for shark consumption of prey (fish), it was concluded that there was negligible risk of harmful PCB exposure to sharks.

The probability of exceeding the TEQ benchmarks was used to assess the potential risk of exposure to dioxin-like congeners. The low risk of exceeding the NOAEL and LOAEL for dioxin effects to fish eggs was interpreted to mean that there was low risk of harmful TEQ exposure to fish eggs. For dolphin consumption of prey (fish), the medium risk of exceeding the NOAEL and very low risk of exceeding the LOAEL was interpreted to mean that there was low

risk of harmful TEQ exposure to dolphins. It was also concluded that there was negligible risk of harmful dioxin exposure to avian consumers because there was very low risk of exceeding the NOAEL and negligible risk of exceeding the LOAEL for herring gull and cormorant consumption of prey (fish).

The dietary benchmarks were very conservative because they are based on the assumption that 100% of the predator's diet comes from the reef and that a predator would live out its entire life span on the reef (i.e. predator is nonmigratory and remains at the reef long enough to reach a steady state with the exposure concentrations).

The broader implications of potential ecotoxicolgical risk from PCBs were evaluated by comparing the PCB exposure distributions for reference and target reef fish to SSDs derived for CBRs in fish tissues (NOED and LOED) and effects of TEQs on sac fry larvae of fresh water fish. The cumulative distribution for the reference and target fish showed very little overlap with the cumulative distribution function estimated for fish tissue NOEDs and LOEDs, which supported the conclusion of low risk of PCB exposure to secondary consumers (demersal fish) at the target reef. There was very low risk of exceeding the SSD for sac-fry NOAEL that also supported the conclusion that there was low risk of PCB exposure to secondary consumers (demersal fish) at the target reef.

1.11. Uncertainty

The major sources of uncertainty in the risk assessment are from errors in assumptions, errors made during measurement activities, errors that occurred during analyses, and the natural variability in the components of the ecosystem that were studied. The sources of uncertainty in the ecorisk screening assessment included the implicit assumptions used to formulate the conceptual model, the uncertainty in interpreting critical values and benchmark concentrations, the complexities associated with multiple contaminant stressors, and the uncertainties arising from the lack of data and toxicological information on key components of the assessment endpoints used in the screening-level risk assessment. There was also uncertainty due to sampling methods, bias arising from the sites selected for monitoring, and bias from the species sampled. Due to the conservative assumptions and estimates used in the screening analysis, it is very unlikely that potential risks were underestimated.

1.12. Conclusions

An initial screening-level ecorisk assessment and an advanced ecorisk screening analysis for PCBs was conducted on data from artificial reefs located off the coast of South Carolina to assess the potential risk of contaminants that could be released from sunken Navy vessels. The conclusions were based on evidence of potential ecological harm, evidence of exceeding reference and background levels, and the degree to which data were available to support the assessment. The initial screening level assessment found that the risk of sediment exposure was negligible to low for most chemicals except for Cd, Cu, and Ni. The data reliability for the sediment screening was good, but there were no site-specific data from the ex-VERMILION site, so there was a medium level of confidence in the conclusions. Tissue residue data from the SCDNR study (Martore et al. 1998) showed that exposure to PCBs, Pb, and Cd in tissues of fish and PCBs and Pb in invertebrates were higher in samples from Navy ship reefs than reference reefs. The data from fish tissue residues suggested negligible risk of exposure to all assessment

endpoints except for primary producers and consumers, which had a medium risk of exposure due to elevated levels of Cr, Pb and Cd measured in the two fish samples from the ex-VERMILION reef. Risk of exposure inferred from data on invertebrate tissue residues (Martore et al. 1998) indicated negligible risk to all receptors except for low risk to plankton due to elevated Pb levels in invertebrates sampled from the ex-VERMILION reef. There was low confidence in the conclusions because the data available were limited to a single study with only two fish samples and nine invertebrate samples from the target reefs.

Based on the results of PCB analysis of the supplemental fish samples from the ex-VERMILION (target reef, n = 51) and natural hard bottom reef (reference reef, n= 62) there was negligible risk of exposure to secondary consumers (demersal fish) and low risk to primary producers and consumers (plankton and zooplankton), avian consumers (herring gulls and cormorants), and tertiary consumers (dolphins and sharks). There was high confidence of negligible to low risk of exposure to PCBs because the supplemental fish sampling produced high quality PCB data for the assessment. The advanced screening analysis for PCBs supported the conclusions that there was very low risk of PCB exposure to secondary consumers (demersal fish) and low risk of PCB exposure to tertiary consumers (dolphins and sharks) and avian consumers (herring gulls and cormorants) at the target reef.

Results from the empirical leaching studies and hypothetical steady state model were used to evaluate the consequences of removing materials from the ship to reduce PCB loading. For the average loading scenario, the greatest reduction in potential PCB release would be gained by removing bulkhead insulation. Removing relatively small quantities of bulkhead insulation would greatly reduce the amount of PCBs leached and further reduce the potential risk of exposure to PCBs. Future ships to be reefed will be cleaned in conformance with the "Best Management Practices for Preparing Vessels for Use as Artificial Reefs" (U.S. EPA and MARAD 2004). The risk management decisions to remove solid materials containing PCBs with high leaching rates would be based on the potential risk predicted by the Prospective Risk Assessment Model (PRAM, Goodrich 2004) following the process being developed for risk-based disposal of ex-Navy vessels.

The screening-level ecorisk assessment supports a process that will enable risk management decisions to be made regarding beneficial use of decommissioned Navy vessels for reef building projects. This report provides a framework and evaluates the potential ecotoxicological risks associated with sinking ex-Navy ships to create artificial reefs.

Photo 4. The ex-VERMILION being towed to its final resting place. (Photo by SCDNR)

2. Introduction and Purpose

The purpose of this report is to document the technical approach, identify the data and information sources, and present the findings of a screening-level ecorisk assessment for using former Navy vessels to construct artificial reefs. The problem formulation, conceptual model, and exposure pathways for the risk assessment are presented and the methodology, benchmarks, decision criteria, and findings from screening-level ecorisk assessment are described. In July of 1999, the REEFEX Technical Working Group was formed to assess the scientific and technical issues of using former Navy warships to construct artificial reefs. The REEFEX Technical Working Group consists of representatives from the U.S. EPA, the U.S. Navy, the South Carolina Department of Natural Resources, Florida Department of Environmental Protection, Florida Fish and Wildlife Commission, Florida Department of Health, and Escambia County, FL. This document has been revised to address all the comments received from the REEFEX Working Group on the draft ecorisk screening work plan (Appendix 1.A), and earlier drafts of this report (Appendix 1.B, Appendix 1.C, Appendix 1.D).

2.1. Objectives

The objective of this ecorisk assessment was to assess the potential toxicological risk of contaminants that may be released from ex-Navy vessels during or after sinking to create an artificial reef. Since data were available on ex-Navy ships and other artificial and natural reefs located off the Coast of South Carolina (Martore et al. 1998), a retrospective risk assessment was conducted to determine if there was any evidence of increased toxicological risk to reef-associated organisms that lived, fed, or foraged on existing artificial reefs composed of ex-Navy ships (Figure 1). The risk assessment does not address the ecological consequences of creating the reef itself, it is focused on characterizing potential toxicological risks of contaminants that may of been released from the ship.

A screening-level ecorisk assessment was conducted to develop a common understanding within the REEFEX Working Group regarding the decision criteria that must be satisfied to conclude a finding of no unreasonable risk. The screening-level ecorisk assessment will support a process that will enable risk management decisions to be made by the EPA and Navy regarding beneficial use of decommissioned Navy vessels for reef building projects. This assessment addresses the following risk management question:

- *Is it likely that the sinking of former Navy vessels containing PCBs in solid materials will pose an unacceptable risk to the environment?*

2.2. Approach

As defined by the U.S. EPA (1998c) screening-level risk assessments "are simplified assessments that can be conducted with limited data by assuming values for parameters for which data are lacking" (U.S. EPA 1998c). Consequently it is necessary to reduce the chance of underestimating risk by assuming conservatively-biased values for parameters for which data are inconclusive or lacking. This results in a conservatively biased estimate of risk, which can be used to eliminate the need to conduct a more detailed risk assessment if the conservative

screening evaluation results in "a defensible conclusion that no ecological risk exists" (U.S. EPA 1998c). Screening level risk assessments are recommended as an important step in developing a defensible approach for evaluating ecological risks (U.S. EPA 1992, 1998d). Based on the outcome of the screening level assessment, the risk assessment approach can be refined and focused on critical aspects of risk. In this report the initial screening analysis was followed by an advanced screening analysis to further address ecorisks from PCBs.

The limitations of the data from the SCDNR study (Martore et. al. 1998) were discussed among the REEFEX Working Group members and it was agreed that additional data collection would be needed to support the risk assessment[2]. For example, data were not sufficient to evaluate whether there were differences among groups of biological species collected. It was not possible to use the SCDNR data alone to establish the delta (incremental risk from ex-Navy vessels), quantify excess risk, and develop a statement of the ecological risk from sinking EX-Navy vessels. Therefore, based on the recommendations of the REEFEX Working Group[3] a supplemental fish-sampling plan was developed (NEHC 2000) to collect three species of fish commonly caught by sports fishers from an artificial reef constructed from a sunken Navy vessel (Target Reef) and a natural hard bottom reef (Reference Reef). The supplemental fish sampling plan specified that the samples would be analyzed for 30 individual congeners, 10 homologs, and total PCB using proper analytical methods (low detection limits, high resolution) and with proper data quality objectives (NEHC 2000, 2001).

School of fish near the ex-VERMILLON artificial reef (Photo by SCDNR).

[2] REEFEX Technical Working Group minutes of 7 July 1999.
[3] REEFEX Technical Working Group minutes of 9 DEC 1999

3. Background

Inactive U.S. Navy vessels would make excellent artificial reefs in U.S. coastal waters if preliminary data suggesting that they pose no threat to human health or the environment from PCB contamination can be confirmed. The U.S. EPA has stated that building reefs with ex-Navy vessels would be regulated as a PCB Bulk Product Waste under 40 CFR 761.62(c) Risk-based disposal approval[4]. Under the Toxic Substance Control Act (TSCA), a finding of no unreasonable risk of injury to human health and the environment must be made before EPA could allow disposal of PCB-contaminated material with concentrations ≥ 50 ppm. The amount of PCB-containing materials that can be left on a vessel used in reef building will be dependent on the potential risk to human health and the environment, the cost of cleanup, and cleanup thresholds that would be acceptable to regulatory agencies and the concerned public.

Banned from manufacturing and distribution since 1978, polychlorinated biphenyls (PCBs) are highly bioaccumulative and EPA has documented their toxic effects on human health and the environment (U.S. EPA 1998a). Recent evidence suggests that some PCBs have dioxin-like properties; the carcinogenic effects of PCBs on humans were reviewed and documented in a peer review workshop report on PCBs (U.S. EPA 1996b). Since 1996, a joint Navy and EPA Technical Working Group (SINKEX Working Group) has been working together as a team to gather data and perform technical analyses to address concerns about the potential release of PCBs from ships used in weapons training scenarios and subsequently sunk in deep ocean waters (SINKEX). In addition, a study of the potential human heath risk to active duty crew and shipyard workers exposed to solid materials containing PCBs in the performance of repair and decommissioning activities (Larcom et al. 1996) showed that the level of risk for occupational health was acceptable.

Discussions concerning the sinking of former Navy vessels for the purpose of reef-building (REEFEX) were initially discussed within the SINKEX Working Group. A decision was made in the summer of 1999 to establish a separate REEFEX Working Group for the purpose of providing a joint Navy/EPA forum to discuss similar issues relating to SINKEX but with the knowledge that the proposed area of REEFEX study would be very different from the SINKEX locations. Specifically, REEFEX locations are highly dynamic shallow coastal areas,

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

with more direct contamination from coastal sources and more opportunity for human health food chain effects than from deep ocean SINKEX operations.

The REEFEX Working Group has reviewed data from several studies that were specifically conducted to evaluate PCB levels and potential releases from former Navy vessels:

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

Regarding the deliberate sinking of Navy vessels containing PCB bulk product wastes, EPA representatives in the SINKEX Working Group indicated that the sinking may release PCBs into the aquatic environment and the impacts of such releases on human health and the environment should be addressed and documented through the use of a risk assessment (John Smith, EPA, 3/17/99[5]). The ability to approve risk-based disposal for bulk product waste (40 CFR 761.62(c)) was authorized by the rule published in June 29, 1998 (63 FR 35384). Cables, felt materials, sealant adhesives, paint, etc. onboard of Navy vessels, if they contain more than 50 parts per millions (ppm) of PCBs, are defined as PCB bulk-product wastes according to EPA. Risk assessment is a reasonable tool for deciding whether a request for approval of disposal should be granted.[6]

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

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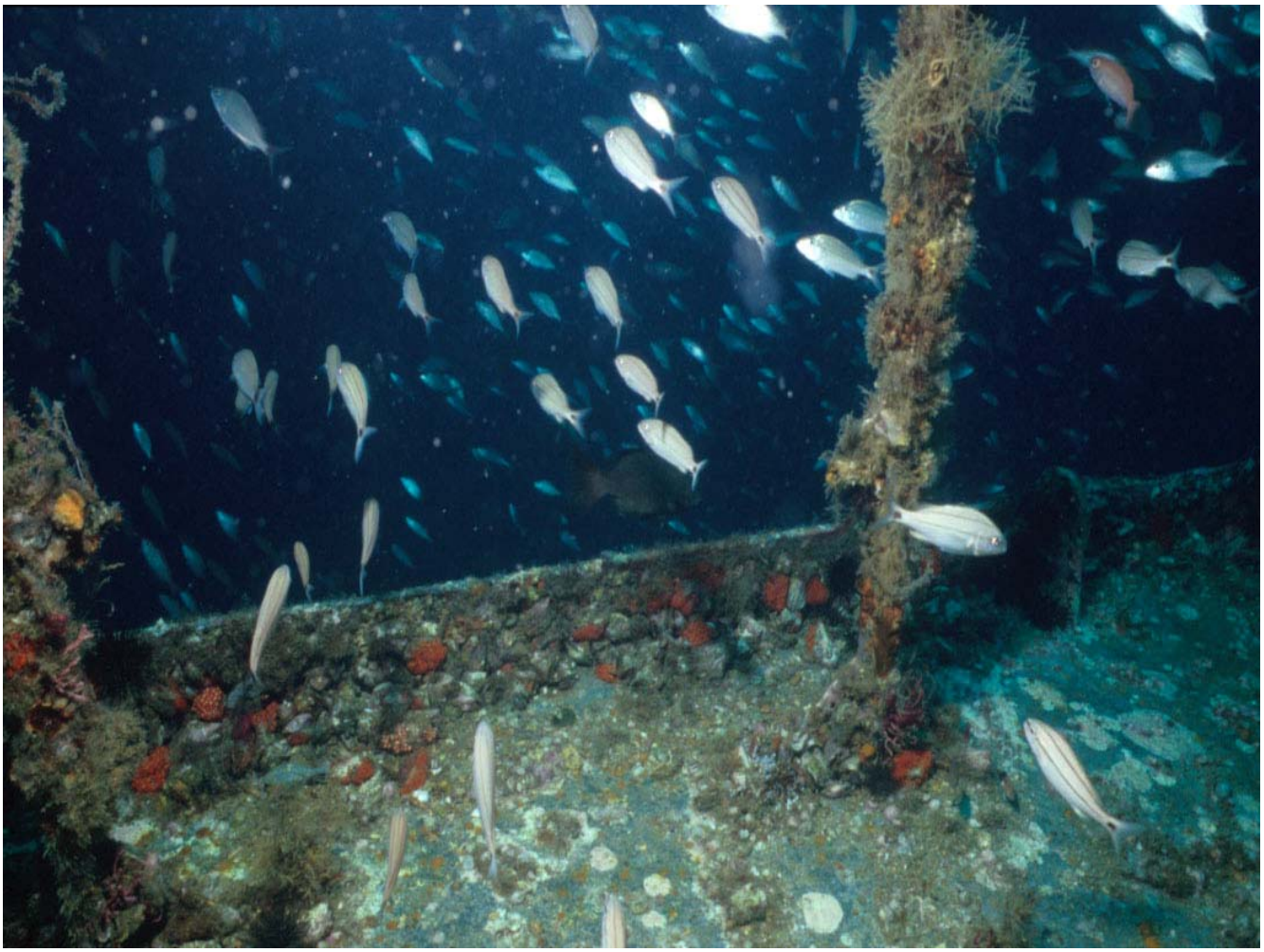
[5] SINKEX Technical Working Group (TWG) minutes of 17 March 1999.
[6] REEFEX TWG meeting minutes of 9 December 1999.

Various standards and guidelines exist for reefing activities (Stone 1985), Canada has developed cleanup guidelines and standards for vessel disposal (Environment Canada 2001a, b), and environmentally-based best management practices for preparing vessels to be sunk as artifical reefs is under development in the United States (U.S. EPA and MARAD 2004). However a process is needed to assess the potential toxicological risk of creating artificial reefs with ex-warships to satisfy the risk-based disposal rule (40 CFR 761.62(c)) for PCBs.

By determining the potential ecological and human health risks, better decisions can be made to effectively manage the risks associated with creating reefs from ex-warships.



Demersal fish and reef invertebrates on the ex-VERMILION artificial reef (Photo by SCDNR).

4. Problem Formulation

4.1. Study Area

The study area is located in coastal shelf waters of the Southeastern U.S. and encompasses the stations previously sampled by SCDNR (Figure 2A, 2B). Sandy, non-hard bottom is the predominant bottom type off the coast of South Carolina. Other bottom types are hard bottom (reefs) with low relief (<0.5 m), medium relief (0.5 – 2.0 m), or high relief (>2 m) and artificial reefs (Van Dolah et al. 1994). Many species of fish tend to congregate in the hard bottom areas, but they are also highly mobile and can move around within and out of the study area. Regional groupings were developed that consisted of one or more of the desired habitats (Figure 2A). The coastal and shelf waters of South Carolina comprise a very dynamic ecosystem characterized by storm and river runoff, along-shelf and cross-shelf currents, eddies, and major fronts (hurricanes). Because of the dynamic and heterogeneous nature of the study area it is necessary to develop a regional approach to control for spatial variability (Figure 2B). A regional approach provides a broader scientific basis for drawing conclusions than can be obtained from studying a single site and reference location (Seaman and Jensen 2000).

The following types of reefs were evaluated:

(i) Navy Vessel Reef. Artificial reefs constructed from former Navy vessels. Of primary interest were the former Navy warships the ex-VERMILION Reef and EX-BETSY ROSS Reef, which were suspected to contain PCB-laden solid materials when they were sunk (Martore et al. 1998). It is not known how much solid material containing PCBs were on either vessel. However, a sample of cable insulation containing PCB compounds (7.33 ppm) was collected by divers from the ex-VERMILION (Martore et al. 1998).

(ii) Other Artificial Reefs. Artificial reefs managed by the SCDNR Artificial Reef Program that were constructed of materials other than former Navy vessels.

(iii) Natural reef. Representative of naturally occurring hard bottom communities

(iv) Background. Data on contaminant levels measured in nonreef areas used to determine if contaminants are present independent of reef areas. In this study, "background" refers to areas that are not directly related to reef habitat, and can be most likely characterized as sandy soft bottom substrate (Van Dolah et al. 1994).

Although the ideal situation would be to identify reference artificial reefs with no known sources of PCBs, it may be possible that other types of artificial reefs are composed of materials that also contain PCBs.[7] In the case that the Other Artificial Reefs have their own sources of PCB, then the analysis would show whether there are differences between Navy Vessel Reefs and reefs composed of materials other than former Navy vessels. Based on the data available in

[7] REEFEX TWG meeting minutes of 9 December 1999.

the SCDNR report (Martore et al. 1998), the Other Artificial Reefs are composed of the following (Figure 2):

the ex-COMANCHE a Coast Guard Cutter

the Edisto offshore reef consisting of a civilian barge

an Army liquid tanker (Y-73) and

an Army tug, Army landing craft, and Army tanks (Eagle's Nest)

4.1.1. Artificial Reef Creation

In the late 1980s the South Carolina Department of Natural Resources (SCDNR) created artificial reefs consisting of sunken ex-U.S. Navy and Army ship hulls. The reefs were constructed as part of SCDNR's Marine Artificial Reef Program (Bell 2001, SCDNR 2002). One such reef was created about 30 miles off the coast of South Carolinia in 110 ft of water by sinking the ex-VERMILION (amphibious cargo ship LKA 107) (Appendix 3). The ex-Vermilion was obtained by the State of South Carolina in 1987 from the U.S. Maritime Administration's (MARAD) inactive reserve fleet in the James River near Ft. Eustis, Virginia. The 460 foot-long (139 m) ship was towed to Wilmington, North Carolina where it was cleaned, stripped and prepared for its new role as reef material by a private marine contractor and ship breaker. The goal of the artificial reef program was to enhance recreational fishing opportunities by developing carefully designed, permitted, and monitored artificial reefs (SCDNR 1987).

The vessel was prepared to acceptable standards for artificial reef construction activity in the U.S. at that time (Stone, 1985). A letter application to the Department of Transportation from SCDNR documented the procedures used to prepare the ship (SCDNR 1987, Appendix 3.D). All commonly encountered potential shipboard pollutants such as fuels, oils, solid or liquid chemicals, liquid PCBs (electrical transformers and switchboards) and floatable materials such as plastics or wood were removed and properly disposed of by the contractor. To facilitate use of the ship in 110 feet of water and minimize its risk as a possible hazard to navigation, the overall height of the vessel was reduced to no greater than 55 feet (17 m) above the keel. All structure above the O-1 level was removed. Large holes were cut in the sides of the ship and between watertight bulkheads. Removing or welding internal doors and hatches open further breached internal watertight integrity. After final inspection by U.S. Coast Guard Marine Safety Office Wilmington, the vessel was towed to its final destination and sunk by the use of explosive charges set by U.S. Navy Explosive Ordnance Disposal personnel (EOD Mobile Unit Six). The ex-VERMILION sank quickly, and settled in an upright position on barren flat sand bottom 110 feet (33 m) deep, approximately 32 miles southeast of the port of Georgetown, SC.

Between 1973 and 1992 forty-six naval vessels were sunk to create artificial reefs as part of the Maritime Administration's (MARAD) Fish Reef Program (MARAD 2004). Most of these ships were sunk along the coast of Texas, Mississippi, Alabama, and Florida in the Gulf of Mexico and Florida, South Carolina, North Carolina, and Virginia in the Atlantic Ocean (Figure 1). When the VERMILION and other similar ships were prepared for sinking during that time, SCDNR was not aware that solid materials containing PCBs were present onboard the vessel. Therefore, no effort was made to remove specific materials for this reason. When all materials

above the O-1 level (superstructure) were removed, some materials that likely contained PCBs were also removed. No effort was made to remove gaskets, cable runs, or other solid materials that may have contained PCBs in other parts of the ship. In the case where hatches or watertight doors were removed, they were often just thrown inside the ship, unless they were deemed to be of value to the contractor, then they were retained for scrap (some gaskets were left behind, others were removed).

4.2. Data Sources

Persistent environmental pollutants, like PCBs and heavy metals, are capable of causing ecological effects and health hazards if present at high enough concentrations. If hazardous contaminants were present on vessels that were sunk to establish artificial reefs, these chemicals could migrate into the surrounding environment. Depending on conditions at the sites and given sufficient time (10-15 yrs) it is possible that harmful levels of chemicals could be reached in media (water, sediment, or tissue) at the site. Direct observations and studies can determine whether or not chemicals from the sunken ships could reach harmful levels. The evidence of risk and environmental harm from sinking ships to create shallow water artificial reefs (~100 ft depth) was evaluated using data from a study of vessels sunken off the coast of South Carolina in the late 1980s (Martore et al. 1998) and supplemental fish sampling conducted at an ex-Navy ship reef (ex-VERMILION Reef) and a reference reef during May-July 2000 (NEHC 2000, 2001, 2002). In addition, sediment data from the study of the ex-AGERHOLM (destroyer DD 826) (SINKEX, Gauthier et al. 2005) and data developed from laboratory leaching experiments on solid materials containing PCBs that could possibly be on ex-Navy warships (LEACHRATE, George et al. 2005) were also used to assess exposure from ex-Navy warships. Regional background data to characterize environmental conditions in the absence of natural and artificial reefs were obtained from the Carolinian Province Environmental Monitoring Program (EMAP see Section 5.2 Determination of Background Levels). These data along with information available in the scientific literature were used to develop the screening-level ecorisk assessment.

4.2.1. South Carolina Department of Natural Resources Study

The South Carolina Department of Natural Resources (SCDNR) (Martore et al. 1998) conducted a field study of artificial reefs composed of sunken military vessels. The study investigated contamination levels associated with artificial reefs and natural reefs off of the coast of South Carolina (Figure 2, Martore et al. 1998). In the study, resident fish and invertebrates were collected from artificial reefs and from naturally occurring "hard bottom" reef sites. Two of the artificial reefs were composed of ex-Navy vessels — the ex-VERMILION (amphibious cargo ship LKA 107, ex-VERMILION Reef) and the ex-BETSY ROSS (cargo ship, AK-91, BETSY ROSS Reef). The other artificial reefs sampled included an ex-Army tanker (Y-73 Reef), an ex-Army landing craft and an ex-Army tug boat (Eagle's Nest Reef), a Coast Guard Cutter (Comanche Reef), and a civilian barge (Edisto Reef) (Figure 2, Martore et al. 1998). The objective was to determine the levels of PCBs and heavy metals present and to assess whether contaminant levels indicated any environmental or human health concerns. Tissues were analyzed for total PCBs, Cr, Cd, Pb, Cu, Ni, and Mn. The types of organisms sampled included various types of fish, bivalves, gastropods, a crustacean, an echinoderm, and sponges (Table 1). The tissue data from this study were used for the ecorisk screening analysis (Appendix 2).

4.2.2. Supplemental Fish Sampling

Based on the recommendations of the REEFEX Technical Working Group,[8] supplemental fish sampling was conducted during May – July 2000 (NEHC 2000, 2001). Subsequently, the working group agreed that additional fish samples were needed because there were only two samples of fish collected from an ex-Navy ship reef in the SCDNR study reported in Martore et al. 1998 (Table 1). Therefore, three species of fish commonly caught by sports fishers (vermilion snapper (VS) – *Rhomboplites aurorubens*, white grunt (WG) – *Haemulon plumierii*, and black sea bass (BSB) – *Centropristis striata*) were collected from the ex-VERMILION Reef (Target Reef) and a natural hard bottom reef (Reference Reef) (NEHC 2000, 2001, 2002). The Target Reef was an artificial reef constructed in 1987 by the SCDNR Artificial Reef Program by sinking an ex-amphibious cargo ship ex-VERMILION (LKA 107) in about 100 ft of water about 27.5 nm from the coast of South Carolina (Appendix 3). The Vermilion Reef is about 140 m long and provides high relief up to about 17 m. The reference reef was a relatively small area (45 m long) of naturally occurring hard bottom or "live bottom," located at a depth of about 100 ft on a low to moderate relief (extending to 2.4 m), intermittent rocky outcropping. The reference reef was located approximately 3.9 nautical miles west of the Vermilion Reef (Appendix 3)

Using fish traps, hook-and-line, and spear fishing, the supplemental fish were collected by the SCDNR at the reference and target sites between May 1 and June 15, 2004 (NEHC 2004). Specimens were measured for length and weight, sexed, and aged using total length to otolith relationships developed by SCDNR. Livers were excised and weighed and the fillets with skin-on were removed for chemical analysis. Two rounds of chemical analysis were performed. The first round consisted of 15 vermilion snapper and white grunt samples collected from each reef (target and reference). The frozen samples were shipped to AXYS Analytical Services, Ltd. (AXYS), Sidney, British Columbia, Canada, where they were homogenized using ultra clean procedures, extracted and analyzed for PCBs using high resolution, gas chromatography mass spectroscopy, selective ion monitoring (GC/MS SIM) according to EPA Method 1668A (U.S. EPA 1999a). The method provided quantitative data for congeners, including coplanar dioxin-like PCBs (Table 2) at the sub-part-per-billion detection level. AXYS was able to achieve the data quality objectives of the study (see "Data Validation Report," Appendix D-1 of NEHC 2001). In addition, splits of frozen sample homogenate from AXYS were sent to Arthur D. Little (ADL), Cambridge, MA for PCB analysis using low resolution GC/MS SIM (ADL 1999).[9] The split samples were analyzed to provide an interlaboratory calibration between the methods used for SINKEX (Gauthier et al. 2002) and EPA Method 1668A used for REEFEX.

The results from round one reported by AXYS indicated significantly lower lipid content and PCB concentrations in white grunt samples from the reference reef than from the target reef (NEHC 2001). Although QA/QC problems were not found during the data validation, analytical error could not be ruled out because all the white grunt samples from the reference reef were processed in the same analytical batch. Therefore for round two, both laboratories using their

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[8] REEFEX Technical Working Group minutes of 9 DEC 1999

[9] Two samples of each species (vermilion snapper and white grunt) from each reef (target and reference reefs) were split with ADL.

respective methods analyzed the remaining archived samples for white grunt, vermilion snapper, and black sea bass.[10] The results of the second round of analysis strongly supported the findings of the first round and verified that analytical error did not cause the differences detected in the first round (NEHC 2001). Furthermore, very good agreement between the results reported by both labs for the samples and certified reference materials (Johnston et al. 2001) indicated that both methods produced high quality data. Consequently, the data from Method 1668A reported by AXYS were used for both the human health risk assessment (NEHC 2001) and ecorisk screening assessment (see Appendix 4.B).

Data Analysis

Data from the supplemental fish and chemical analysis of the fillets (with skin-on) were evaluated to determine statistical differences between the fish collected from the target and reference reefs. The data were tested to determine whether they conformed to a normal distribution[11] and a one-way analysis of variance (ANOVA, Analytical Software 1996) was conducted to test the null hypothesis that there was no difference between sites for total length (mm), total weight (g), liver weight (g), age (yr), dry weight (%), wet weight of lipids (%), the ratio of liver weight to body weight (hepatosomatic index – HSI), Total PCB (ng/g dry), Total PCB per unit lipid (ng/g lipid), Log (Total PCB ng/g), and Log (Total PCB ng/g lipid). The null hypothesis was rejected if the p-value from the ANOVA was <0.05.

The concentration of PCB in whole body fish tissue was estimated using data obtained from the analysis of the fillets (see Appendix 4.C). The fillets were homogenized with "skin on" so that any lipoidal material between the fillet and skin was included in the analytical sample. The whole body tissue concentration was estimated by assuming that the total fillet weight of the fish was twice the weight of the fillet analyzed (each laboratory analyzed a separate fillet) and that the whole body weight of the fish was composed of the fillets, liver, and other tissue (viscera, skin, bones, etc.). The analysis further assumed that the PCB concentration in the fish was proportional to lipid, that the fraction of lipid in the liver was 55%, that there was 20% more lipid in other tissues compared to lipids in fillets, the dry weight of livers had 65% more solids than the fillets, and the other tissues had the same dry to weight ratio as the fillets (see Appendix 4.C for the details of Estimating PCB concentrations in whole body fish tissues)

Correlation and regression analysis of the supplemental fish data was conducted to evaluate the relationships between body weight, age, liver weight, %lipid content, tPCB concentrations, and HSI. Bivariate regressions with whole fish body weight, lipid content and HSI as the dependent variables were conducted for all fish, each species (VS, WG, and BSB), and each species-site group (target and reference, seeTable 3). The regression coefficient (r^2) and regression equation ($y = mx + b$) were reported for each regression equation with a slope

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[10] "On July 9, 2001 all of the archived fish fillet samples stored under custody at the URS-Franklin, TN office were split and shipped to … AXYS and ADL. Each sample was given a randomly selected field identification number … [and] the samples were independently homogenized and analyzed using different analytical methods" (NEHC 2001).

[11] The Lin-Mudhokar test for normality (Analytical Software 1996) was performed on the raw and $\log_{10}$-transformed raw data. The null hypothesis – The data are normally distributed – was rejected if the p-value was < 0.05.

significantly different than zero ($p \leq 0.05$). A step-wise multivariate regression of all fish data was also performed to identify the variables, including "dummy variables" for site, species, and sex, that contributed to explaining the variance in HSI (Table 3). Because total weight and liver weight were used to calculate HSI, they were not included in the stepwise multiple regression.

4.2.3. SINKEX Sediment Data

Since no sediment data were available from the South Carolina study area, the potential sediment contamination resulting from a sunken vessel was evaluated with data from the deep-water SINKEX study of ex-AGERHOLM (destroyer DD 826). Sunken during a military weapons test in 1982, the ex-AGERHOLM sits on the bottom, largely intact, at a depth of 2,750 ft (838 m) about 120 miles (193 km) off the coast of San Diego, CA (Gauthier et al. 2002). Chemical contamination levels were measured in sediments surrounding the vessel (Inner Ring, about 10±6 ft [3±2 m] from the hulk) and at reference locations about 0.6 miles (1 km) away (Outer Ring). Since the ex-AGERHOLM is located in a relatively isolated deep ocean environment with very low currents (Gauthier et al. 2005), contaminant levels in close proximity to the ship that are elevated above background levels, may be representative of contaminant levels that could be released from sunken vessels used for artificial reefs. The contaminants measured to assess releases from the EX-AGERHOLM were PCBs (26 congeners and 8 Aroclors), PAHs (41 parent and alkylated/methylated compounds), Ag, Cd, Cr, Cu, Hg, Ni, Pb, and Zn (Table 2).

4.2.4. Leach Rate Study Data

A study was conducted to determine the leaching rates of selected shipboard solid materials containing PCBs under shallow water conditions (George et al. 2005). The leaching tests were performed on intact solids that contained known amounts of PCBs. The materials tested and percent PCB in the solids (in parenthesis) were felt gaskets (23.00%), electric cabling (0.12%), paint (0.04%), rubber (0.16%), foam insulation (0.89%), and bulkhead insulation (0.04%) (George et al. 2005). The leaching rates of Aroclor 1254 and 1268 were also measured. The leaching rate of Aroclor 1254 (George et al. 2005) was used as an analogue for PCBs contained within residual oils & greases remaining on the ship following purging of fuel tanks and reservoirs (JJMA 1999).

Data from the leach rate study (George et al. 2005) were used to estimate the instantaneous steady state concentration of total PCBs in a well-mixed volume of water around a sunken ship (Figure 4). This is similar to the approach used to estimate PCB concentrations associated with the potential releases from the ex-SPIEGEL GROVE (Phillips and Casey 2001) and in the prospective risk assessment model (PRAM, NEHC 2000b, 2001b, NEHC 2004a, b).

If $m(t)$ is the mass of the PCB in the volume of water at time t, the rate of change will be $m'(t)$. If the PCB is being added at the rate of $a(t)$ and being removed at the rate of $r(t)$, the rate of change is:

$$dm/dt = m'(t) = \text{rate of addition} - \text{rate of removal} \quad [1]$$

$$m'(t) = a(t) - r(t) \quad [2]$$

At steady state, the rate of the PCB addition *a(t)* is a constant obtained from the experimental leach rate curve for each solid laden with PCBs (George and In 2002a, George and In 2002b). Also *r(t)* depends on the concentration, *c(t)*, of the mixture and flow rate out at time *t*. If *o(t)* is the flow rate out then,

$$r(t) = c(t)o(t) \quad [3]$$

But since we are assuming steady state the flow rate out is constant, the rate will be equal to the concentration times the outfall rate.

$$r = co \quad [4]$$

So, the concentration depends on the mass of the PCB in the volume of surrounding water at time *t*.

$$c(t) = m(t)/V(t) \quad [5]$$

For an instantaneous time, assuming the concentration is at steady state, *a(t)* and *r(t)* are constant, so the equation above becomes

$$c = m/V \quad [6]$$

The differential equation describing this problem is

$$m'(t) = a(t) - m(t)o(t)/V(t) \quad [7]$$

The model parameters were estimated as follows. The volume of water that contains the ship (*V*) was determined from the dimensions of the ex-VERMILION: length 139.95 m (459 ft 2 in), beam 19.20 m (63 ft), and height 16.76 m (55 ft)[12] as 45,052,457 liters (45,052.5 m^3). The average current velocity was obtained from the South Atlantic Bight Synoptic Offshore Observational Network (SABSOON), which is a real-time oceanographic observational network located on the southeastern continental shelf of the U.S. (Skidaway Institute of Oceanography 2002). Current data from Station M2 of the SABSOON network were used to estimate bottom currents at the ex-VERMILION reef. Located about 60 miles offshore of Savannah, GA at 31.533^o N -80.233^o W, Station M2 records bottom currents at about the same depth (28 m, 91 ft) and location on the continental shelf as the ex-VERMILION reef. The long-term average current velocity observed for bottom currents at Station M2 was 0.25 m/s for *u* (current in the "x" direction) and 0.25 m/s for *v* (current in the "y" direction), resulting in an average velocity (**v**) of 0.35 m/s (30,240 m/day, 0.68 knots/hr) (Skidaway Institute of Oceanography 2002).

Since, the flow rate $Q = \mathbf{v}A$ [8]

[12] Before she was sunk the VERMILION was cut down to the 01 level, leaving her at a height of 55 ft.

with the area (A) being the height of the reef times beam, then the exchange rate was calculated as:

$$i = o = Q/V \quad [9]$$

Empirical estimates of PCB leaching rates were developed for felt gaskets, electric cable, paint, rubber, foam insulation, oils and greases, and bulkhead insulation (George and In 2002a, George and In 2002b). Based on information available about the types of materials and PCB concentrations estimated to be present on the ex-AGERHOLM (JJMA 1998), low, average and high PCB loading scenarios were developed to simulate the leaching of PCBs from ex-VERMILION and estimate the instantaneous steady state concentration of total PCB around the ship. Because the ex-VERMILION is about 3 times larger in volume than the ex-AGERHOLM, the estimated mass of solid materials containing PCBs was multiplied by the ratio of the volume ratio of the two ships $V_{VERMILION} : V_{AGERHOLM}$.[13] The estimated concentrations were compared to the PCB water benchmarks and multiplied by bioconcentration factors to project the resulting PCB concentration in fish and shellfish. See leach rate computations for REEFEX study for the estimates of water column PCB concentrations using the leach rate data (Appendix 8 LEACHRATE Computations for the REEFEX Study).

4.3. Conceptual Model and Exposure Pathways

The potential exposure pathways and assessment endpoints evaluated are shown in Figure 3. Contaminants can enter the system from releases from the sunken vessel and inputs from coastal waters. Because the sunken vessels are not isolated from coastal contamination sources, contamination levels present at the sunken ship reef could be from other sources besides the sunken vessel itself. Chemicals of potential concern (COPC), such as PCBs, might have been released from the sunken vessels during or after the process of sinking. The released chemicals are expected to be present in various media, i.e., water, sediment, and biota, through transport, uptake and bioaccumulation (ingestion of prey). Depending on the nature of the contamination, these media may pose a risk to valued and relevant ecological resources and humans if the exposure pathway is complete. Exposure to contaminants present in the water column could occur to marine organisms through contact and uptake (e.g. gill tissues) and to higher-level predators by ingestion of contaminated prey and incidental contact. If depositional sediments are present, contaminants could accumulate from sorption and settling and cause exposure to benthic invertebrates. Another route of exposure is from direct contact with the surface of the ship.

Reef building increases the biomass per unit area because the pre-existing habitat (sandy bottom continental shelf) does not provide favorable substrates or habitat for high-density population of reef-dwelling marine species (Bell 2001). The sunken vessel provides habitat for reef-dwelling organisms, as well as additional resources to the existing fauna. From an ecological perspective, the valued resources or ecological receptors to protect are the species that might be affected by the sunken vessel and their relationships with other valued species in the

[13] This assumes that there is 3.3 times more of each type of PCB-laden solids on the larger ex-VERMILION than on the ex-AGERHOLM.

local or regional marine ecology. Species that could be impacted by exposure from contaminants include marine species that have migrated to the artificial reef or transient marine species that visit the reef.

4.4. Contaminants of Potential Concern

The Contaminants of Potential Concern (COPCs) are chemicals known to be present on sunken vessels. The chemicals that are present on sunken vessels at sufficient concentration (JJMA 1999) to be of potential concern to ecological receptors include:

- PCBs reported as total PCB (tPCB). PCBs are a mixture of compounds that consist of ten homolog groups (mono- through deca-biphenyl) and 209 different PCB congeners. PCBs were originally marketed as Aroclor mixtures. (See EPA Region V web site for PCB Species Identification, Barney 2001)

- Heavy Metals (Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn)

Other chemicals could also be released from sunken ships. These include fuel oils, hydraulic fluids, and greases; ordnance materials, and antifouling bottom paint. Because any ship used for artificial reef building must be clean of hazardous materials per Coast Guard Regulations before it can be sunk (Bell 2001, Stone 1985), any significant quantities of fuel oils, other hydrocarbon compounds, and ordnance would have been removed prior to sinking. However, trace quantities of hydrocarbon compounds could remain to leach from the sunken hulk and polycyclic aromatic hydrocarbons (PAHs) were evaluated for the ecorisk screening, to the extent possible, as COPCs from sunken ships. Bottom paints could also be a source of contamination from leaching of biocides from the hull (e.g. copper or organotin). Since only a few Navy vessels were painted with organotin-containing bottom paints (Champ and Wade 1996), organotin compounds were not considered a COPC associated with Navy ships used for artificial reefs.

4.5. Assessment Endpoints and Receptor Species

An assessment endpoint is defined to encompass a component of the ecosystem that may be impacted by the stressors of concern, has high ecological and/or societal value, and represents a component of the ecosystem that can be protected (Suter 1993). Generally considered to symbolize valued environmental conditions or processes, assessment endpoints usually cannot be directly quantified (Suter 1993, U.S. EPA 1992). Instead, data on exposure levels and information that relates the exposure to the ability to cause effects to the assessment endpoint are needed to perform the risk assessment (U.S. EPA 1998d). For the ecological system under consideration, primary exposure and indirect exposure through bioaccumulation in the food chain can occur to the reef community and reef consumers (Figure 3). The assessment endpoints were developed to assess the potential effects to survival, growth, and reproduction to primary producers (phytoplankton and encrusting algae), primary consumers (zooplankton, epifauna, infauna, and grazing fish), secondary consumers (grunt, snapper, sea bass, lobster, crab, and sea turtle), tertiary consumers (dolphin, reef shark, and barracuda), and avian consumers (cormorant and herring gull, Figure 3). Representative species were used to relate exposure levels to

potential effects to the assessment endpoint. Considerations for selection of receptor species for the ecorisk screening included the availability of data and toxicological information. Additional criteria, such as the importance of the receptor to the ecology, its sensitivity to COPCs, its link in the food web, and its aesthetic and/or commercial importance as a natural resource were also considered.

To assess ecological effects to the assessment endpoints receptor species were selected to evaluate contaminant exposure to species that comprise the reef community. The receptor species used in this risk assessment were selected to be representative of species found at the reef that would be sensitive to contaminant exposure and for which exposure and effects data would be available or could be inferred. Because this risk assessment was primarily concerned with evaluating toxicological risks associated with exposure to contaminants (especially PCBs migrating through the food chain), the primary ecological effects to the assessment endpoints to be evaluated were survival, reproduction, and individual growth and development. Evaluating ecological effects to other valued ecological entities, such as species diversity, primary productivity, or aquatic populations was possible only to the extent that the benchmarks (see Section 5) were also protective of those attributes. This risk assessment only evaluates the potential effects of contaminant exposure and does not address the presence and physical structure of the artificial reef, which greatly influences the ecological processes present at site.

Based on existing toxicological data, receptor species were selected that would most likely be sensitive to PCBs and other REEFEX-related COPCs. Toxicological data were reviewed to identify available toxicological benchmarks that could be used to interpret whether exposure concentrations to the receptor species could be harmful. To the extent possible, receptor species were selected that were representative of mammals, birds, reptiles, fishes, and invertebrates that utilize reef habitats. In many cases, toxicological data were not available for reef organisms and the susceptibility of the receptor species to the COPCs had to inferred or extrapolated from species used in toxicological tests and studies (mainly freshwater and estuarine species). As is appropriate for screening level assessments, conservative assumptions and uncertainty factors (UFs) were used to help assure that that the assessment did not underestimate potential risk.

4.5.1. Reef Community

The reef community is the community of organisms that live and associate with the reef. The community is composed of many fish, invertebrates, and plants. Many reef organisms spend most of their life on the reef, others may migrate over vast distances between reefs, and others may be larval or juvenile life stages of bottom dwelling organisms that will eventually settle out of the water column onto the reef before reaching maturity. Exposure to the reef community occurs from water-borne contaminants and/or contaminated sediment, which may accumulate on the reef, and to contaminants that accumulate in the food chain (Figure 3). Based on the life history and feeding behavior of different classes of reef organisms, there will be different exposure scenarios for demersal fishes, epibenthic and benthic invertebrates, and primary producers and zooplankton associated with the reef.

PRIMARY PRODUCERS

If light can penetrate to the depth of the reef, phytoplankton, benthic diatoms, encrusting algae, and other marine plants will be present on the reef. The phytoplankton in the water column around the reef and encrusting algae growing on the reef form the basis of the reef food chain. The primary producers can be exposed to contaminants in the water column and to contaminants that may come into contact with roots and holdfasts of marine macro flora, if present. Water column benchmarks are based on water quality criteria, which have been developed to be protective of aquatic species including phytoplankton and encrusting algae. Although data on contaminant concentrations in plants associated with artificial reefs was not available, contaminant concentrations estimated for water column exposures were used to assess ecological risk to primary producers of the reef (i.e. water column benchmarks are protective of both plants and animals).

PRIMARY CONSUMERS

Primary consumers on the reef include zooplankton, epifauna, infauna, and grazing fish. Zooplankton, the tiny crustaceans, mollusks, and other larval vertebrates and invertebrates that feed on phytoplankton and detritus comprise a key link in the reef food chain. Primary consumers also include other water column grazers such as pelagic and midwater bait fishes that feed primarily on phytoplankton. Zooplankton and other grazers can be exposed to contaminants in the water column, suspended sediments, and bedded sediments. The reef community includes a wide diversity of benthic and epibenthic invertebrates that live on, below, and above the reef. If sedimentary deposits are present, benthic invertebrates that live by burrowing and feeding in the sediment and foraging along the bottom would colonize the sediment. Benthic organisms are directly exposed to any contaminants that become attached to particles and are deposited in the sediment. Epibenthic invertebrates live on the surface of the bottom and on rocks, ledges, and artificial substrates sitting on the bottom. Many epibenthic invertebrates are sessile organisms, which are attached to hard surfaces for the majority of their life span. Epibenthic organisms are exposed to contaminants present in the water column, contaminants present on the surface of the substrates to which they are attached, and contaminants accumulating in the food chain. The primary consumers will also accumulate contaminants present in their food. Water column benchmarks are based on water quality criteria, which have been developed to be protective of aquatic species.

Data for reef invertebrates were used to evaluate ecological effects to primary consumers. The contaminant data on invertebrates (Table 1) was used to evaluate potential risk to the benthic and epibenthic invertebrates. Example receptor species include shovelnose lobster (*Scyllarides nodifer*), sea cucumber (Holothuroidea), the benthic infauna community, Atlantic winged oyster (*Pteria colymbus*), and the common slipper shell (*Crepidula fornicata*) (Table 1).

SECONDARY CONSUMERS

Secondary consumers include carnivorous fish and invertebrates such as grunt, snapper, sea bass, toadfish, lobster, and crabs that live on or near the bottom and are closely associated with the reef. Secondary consumers also include organisms such as sea turtles that may be

attracted to the reef to forage on the primary consumers present on the reef. Secondary consumers are exposed to contaminants present in the water column, associated with the sediment, and concentrated in prey.

Data for carnivorous fish, especially those that are long time residents of the reef, were evaluated to assess ecological effects of contamination to secondary consumers. The contaminant data on demersal fish (Table 1) and supplemental fish data (Appendix 4.B) were used to evaluate potential risk to the secondary consumers. Example receptors species for demersal fishes include back sea bass (*Centropristis striatia*), vermilion snapper (*Rhomboplites aurorubens*), white grunt (*Haemulon plumieri*), gag grouper (*Mycteroperca microlepis*), and leopard toadfish (*Opsanus pardus*) (Table 1).

Potential effects to sea turtles that may forage on the reef were also evaluated by assessing dietary exposure of sea turtles consumption of invertebrates (Table 1) present on the reef. Sea turtles such as loggerheads (*Caretta caretta*) may frequent reef habitats to take advantage of the relative abundance of food. Listed as a threatened species in U.S waters and an endangered species worldwide, loggerheads feed on a wide variety of invertebrates by using their powerful jaws to crush the shells of molluscs, barnacles, and crabs (Bolten and Witherington 2003, Turtle Trax 2004).

TERTIARY CONSUMERS

Tertiary consumers are the organisms that primarily feed on the secondary consumers present on the reef. The tertiary consumers are the top of the food chain; they are exposed to contaminants in the water and the sediment as well as contaminants that may be accumulating in the food chain. The top level predators at the reef include reef residents such as groupers, eels, and octopi as well as other predators such as sharks, barracuda, and marine mammals that may be attracted to feed on the abundance of food present at the reef. Some marine mammals that may frequent reef habitats include dolphins, seals, and possibly whales. Since whales migrate over vast distances of the ocean and manatees are mostly associated with shallow coastal waters, it is not very likely that these species would be commonly found in the reef areas. The worst-case exposure to a marine mammal would be from dolphins that could be attracted to the reef area by the abundance of food. Marine mammals (dolphin) can consume demersal fish and free-living invertebrates and incur incidental exposure to water- and sediment-borne contaminants.

The contaminant concentrations in prey items for fish and invertebrates (Table 1) and supplemental fish data (Appendix 4.B) were used to assess the potential dietary exposure to top predators for shark (sandbar shark, *Carcharhinus plumbeus*), barracuda (great barracuda, *Sphyraena barracuda*) and dolphin (bottle nosed dolphin, *Tursiops truncates*).

4.5.2. AVIAN CONSUMERS

Avian consumers (cormorants and herring gulls) may also be attracted by the abundance of food to feed and forage on the reef. While most avian predators would consume primary

consumers (pelagic and bait fishes) some avian predators may consume secondary consumers such as demersal fish, midwater fish, and some invertebrates. Avian predators are exposed to contaminants in the food chain, and they may be exposed to water-borne contaminants while foraging. The contaminant concentrations in fish and invertebrate prey items (Table 1) and supplemental fish data (Appendix 4.B) were used to assess the potential exposure to avian receptors. The receptor species for avian piscivore was the double-crested cormorant (*Phalacrocorax auritus*) and the receptor species for avian omnivore was the herring gull (*Larus argentatus*).

4.6. Working Hypotheses

To provide a framework for analyzing and interpreting the results of the screening level risk assessment, working hypotheses were developed. The hypotheses represent the knowledge base available for interpreting whether ecological risks are present. If measured, estimated or modeled data are available, the hypotheses can be tested and inferences about risk can be developed. If appropriate data are not available, and approximations cannot be reliably estimated, then "data gaps" are defined that should be addressed by follow-on field studies or laboratory investigations. The following are a set of working hypotheses that were used, to the extent possible, as the basis for inferring risk to ecological receptors:

1. If contaminants from sunken ships are affecting survival, growth and reproduction of reef organisms:
   There would be higher exposure levels in sediments, water, and biota around sunken ships than reference areas

2. If contaminants from sunken ships are accumulating in the food chain:
   There would be higher levels of contaminants in prey from the vicinity of sunken ships than reference areas.

Additionally, appropriate reference data sets were needed to make comparisons to data obtained from reefs made with sunken Navy ships so that the differences can be quantified and the degree of incremental risk, if present, can be determined. The reference areas were evaluated, to the extent possible, to quantify the degree of background risk to ecological receptors. The three types of reference and the hypotheses tested were:

1. Reference - Other Artificial Reefs
   Within the region there is no difference in indicators of exposure and toxicity between artificial reefs constructed of sunken ex-Navy ships and other types of artificial reefs.
   But what if toxicological effects are apparent at both artificial reefs?

2. Reference - Natural Reef
   Within the region there is no difference in indicators of exposure and toxicity between artificial reefs constructed of sunken ex-Navy ships and other natural reefs
   But what if reefs are not representative of background/ regional contamination because fish from contaminated areas tend to congregate in reef areas? This could occur

because reefs may attract fish from other areas, such has coastal areas, which could have higher sources of contaminants.

3. Reference - Regional Background

Within the region there is no difference in indicators of exposure and toxicity between artificial reefs constructed of sunken ex-Navy ships and other non-reef areas (true regional background).

Gag Grouper (*Mycteroperca microlepis*) foraging on the ex-VERMILION reef (Photo by SCDNR).

5. Screening Methodology

The screening procedure consisted of the following steps:

1. Benchmarks of ecological effects for exposure to water, sediment, and dietary uptake were identified for the assessment endpoints and receptor species evaluated and regional background concentrations were determined.

2. Based on available data, estimates of contaminant concentrations in exposure media (water, sediment, diet) were developed for: (i) Navy vessel reefs, (ii) other artificial reefs, (iii) natural reefs, and (iv) regional background.

3. Estimates of exposure associated with Navy Vessel Reefs were compared to estimates of exposure associated with (ii) Other Artificial Reefs, (iii) Natural Reefs, and (iv) Regional Background and compared to the appropriate ecological effects benchmarks.

4. If ecological effect benchmarks were exceeded, ecological hazard quotients (HQ) and ecological hazard indices (HI) were calculated for each assessment endpoint and complete exposure pathway.

5. Sources of uncertainty were documented and discussed and gaps in data and information were identified.

5.1. Selection of Benchmarks

Benchmarks were selected to evaluate potential effects to a broad range of reef-dwelling organisms. Benchmark concentrations for water (W_B), sediment (S_B), and tissue residues of fish (T_{Fish}) and invertebrates (T_{Invert}) were selected. The tissue benchmarks were for the bioaccumulation critical value (B_{CV}), tissue screening value (TSV), critical body residues (CBR) corresponding to the no observed effect dose (NOED) and the lowest observed effect dose (LOED) for a fish or invertebrate species. Benchmarks of ecological effects to assess dietary exposure to representative secondary and tertiary consumers and avian consumers were also developed. Dietary benchmarks for fish as prey were developed for herring gulls (D_{Gull}), cormorants ($D_{Cormoant}$), dolphins ($D_{Dolphin}$), and sharks and barracuda (D_{Shark}). Dietary benchmarks for invertebrates as prey were also developed for herring gulls (D_{Gull}), sea turtles (D_{Turtle}) and dolphins ($D_{Dolphin}$) (Table 4)[14].

[14] In the event that additional data are obtained, Table 4 provides benchmarks for COPCs for which exposure data were not available.

Following the initial screening, conducted using the most conservative benchmarks (Table 4), a more advanced screening analysis of PCB exposure was conducted. The advance screening involved evaluating individual PCB conger concentrations, using less conservative assumptions for specific benchmarks, evaluating potential effects from dioxin-like coplanar PCBs, and using the distribution of PCB levels measured in the available data set to calculate the probability of exceeding benchmarks and cumulative effects distributions (see Section 5.4).

5.1.1. Water Exposure

Benchmarks for water exposure were set to saltwater ambient water quality criteria, which have been developed to be protective of 95% of the species tested (or more precisely, of the genera tested) (U.S. EPA 1991, 1994). Water benchmarks (W_B, Table 4) were set to national water quality criteria (WQC) for saltwater continuous (chronic) concentrations (U.S. EPA 1998b, 1999b, summarized in Buchman 1999). The benchmarks selected based on national WQC were less than or equal to the water quality standards promulgated by the State of South Carolina (South Carolina 2001). Water benchmarks for metals were based on total recoverable metal using the recommended dissolved to total metal conversion factor (U.S. EPA 1999b). No direct measurements of water chemistry concentrations are available for the screening. Therefore water exposure was evaluated by comparing tissue residues to the bioaccumulation critical value (B_{CV}, see below, Johnston 1999, Johnston, Munns, and Nacci, 2001) and estimating water exposure levels from studies of the leaching rate of PCBs from solid materials (Appendix 8 LEACHRATE Computations for the REEFEX Study, George et al. 2005).

The water exposure benchmarks were used to evaluate potential ecological effects to primary producers (phytoplankton and encrusting algae), primary consumers (zooplankton and grazers), as well as other components of the reef community (fish and invertebrates). Water quality criteria, the basis of the water exposure benchmarks, were developed to be protective of both short-term (acute) and long-term (chronic) exposure. The criterion continuous concentration (CCC – chronic) "is an estimate of the highest concentration of a material in the water column to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect" and the criterion maximum concentration (CMC – acute) "is an estimate of the highest concentration of a material in the water column to which an aquatic community can be exposed briefly without resulting in an unacceptable effect" (U.S. EPA 1995). The water quality criterion for PCBs is defined as total PCBs (tPCB), which "is the sum of all homolog, all isomer, all congener, or all Aroclor analyses" (U.S. EPA 2002). The chronic benchmark for PCBs (0.03 ug/L) was assumed to be protective of direct exposure to PCBs for aquatic plants and animals present at the reef. The Great Lakes Water Quality Initiative criteria for protection of wildlife (GLWQI-Wildlife), which takes into account bioaccumulation in fish for wildlife exposure, has recommended the criteria for tPCB of 0.074 ug/L (Tier I[15]) and 0.14 ug/L (U.S. EPA 1995). It was assumed that the water benchmarks were applicable and appropriate for protection of the reef community.

[15] Tier I refers to the initial screening level concentration recommended by the Great Lakes Water Quality Initiative.

5.1.2. Sediment Exposure

The benchmarks for sediment (S_B, Table 4) correspond to the sediment ecotox thresholds recommended for ecological risk assessments (U.S. EPA 1996a, Buchman 1999). The Effects Range Low (ERL) and Effects Range Median (ERM), defined by Long et al. (1995), were developed from studies where chemical concentrations in the sediment and ecological effects were measured or modeled. The "no effects range" is defined for chemical concentrations below the ERL, the "possible effects range" is defined for chemical concentrations between the ERL and ERM, and the "probable effects range" is defined for chemical concentrations above the ERM (Long et al. 1995).

The sediment benchmarks were used to evaluate COPC exposure to primary producers (benthic diatoms, encrusting algae), primary consumers (benthic infauna and epifauna) and other components of the reef community that would come into contact with sediments associated with the reef (free swimming fish and invertebrates). The sediment benchmarks for PCBs were based on tPCB exposure characterized by the sum of the measured congeners (sumPCB) converted to tPCB using empirical relationships[16] (NOAA 1991, Long and Morgan 1990). It was assumed that the sediment benchmarks were applicable and appropriate for protection of the reef community.

5.1.3. Tissue Exposure

Tissue residue benchmarks were based on bioaccumulation critical values (B_{CV}), tissue screening values (TSV), critical body residues, and dietary uptake benchmarks. These benchmarks (Table 4) are chemical residue thresholds at or below which adverse toxicological effects would not be expected. The benchmarks were used to screen the data on tissue concentrations (Appendix 2 and 4).

Tissue Screening Values (TSV)

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

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

developed using conservative assumptions about contaminant uptake and potential effect and were calculated as (Table 5):

$$TSV = WQC \frac{\mu g}{L} \times BCF_a \frac{L}{kg(wet)} \times \frac{1\ g\ wet}{dw\ g\ dry} \times 0.001 \frac{kg}{g} \quad (\mu g/g \text{ dry weight}) \qquad [10]$$

Where

BCF_a = bioconcentration factor for aquatic organisms (L/kg wet weight) normalized to the average (3%) lipid content[17] of aquatic organisms (URS 1996)

dw = Dry weight:wet weight ratio for fish or invertebrates

WQC = was selected as the lowest value reported for marine or fresh water quality criteria (μg/L) that was in effect at the time the TSVs were calculated (URS 1996)

Many of the TSVs are considerably lower than the tissue residue concentration that would cause an effect (URS 1996). Chemical residue levels below the TSV are assumed to pose little or no risk to aquatic biota (Shepard 1995, URS 1996, Dyer et al. 2000).

Bioaccumulation Critical Values (B_{CV})

Bioaccumulation critical values (B_{CV}) were based on empirical relationships between chemical exposure and organism uptake and accumulation (Table 6). Similar in concept to the TSV, the B_{CV} was calculated using the most recent salt water quality criteria (U.S. EPA 1998b, Buchman 1999) and bioconcentration factors applicable to marine fish and invertebrates. The B_{CV} was defined as the tissue concentration that would occur if water exposure levels equaled the chronic or lowest available water benchmark (W_B):

$$B_{CV} = W_B \frac{\mu g}{L} \times BCF_M \frac{L}{kg(wet)} \times \frac{1\ g\ wet}{dw\ g\ dry} \times 0.001 \frac{kg}{g} \quad (\mu g/g \text{ dry weight}) \qquad [11]$$

where W_B = Most recent salt water chronic criteria (EPA 1998, Buchman 1999, see Table 4)

BCF_M = bioconcentration factor for marine organisms (L/kg wet weight), see Table 6

dw = mass fraction of dry to wet tissue g dry/g wet weight

and dw = 0.25 for fish (75% moisture)

dw = 0.2 for shellfish and other invertebrates (80% moisture)

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

For marine invertebrates, the BCFs for Cd, Cr, Cu, Hg, Ni, Pb and Zn were obtained from fitted values reported in Thomann et al. (1995) and the BCFs for PAHs were obtained from Pruell et al. (1986) (Table 6). The metal BCFs used for fish tissue were obtained from URS 1996, and the fish tissue BCFs for PAHs and tPCB were estimated from Mackay (1982, cited in Petersen and Kristensen 1998):

$$\log(BCF_{ww}) = -1.32 + \log(Kow) \quad [12]$$

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

The B_{CV} for total PCB (tPCB) accumulation in fish and invertebrate tissue was calculated using a BCF weighted by the fraction of tPCB (f_{tPCB}) present in each homolog group measured in a subset of four samples of vermilion snapper collected during the supplemental fish sampling study (Figure 5, Table 7). The BCF was calculated as:

$$BCF_{tPCB} = \Sigma f_{tPCBi} \times BCF_i \times 0.64 \text{ (L/kg wet weight)} \quad [13]$$

Where i is the index for each homolog group mono through deca (Table 7) and 0.64 is a lipid-normalizing factor used to normalize the lipid content of vermilion snapper (4.7%) to 3%. EPA uses 3% as the average lipid content of aquatic organisms to determine the water quality criteria value for PCBs (U.S. EPA 1980, URS 1996, Table 7).

Critical Body Residues

Critical body residues (CBR) are defined as the threshold concentration of a contaminant in the tissue of an organism above which adverse effects could occur (McCarty et al. 1992, Pabst 1999). Generally, the effect occurs as a result of narcosis (noncancer effects) and can result in death (mortality), or a reduction in fecundity, reproduction, or growth (chronic effects). Data from the US Army Corps of Engineers Environmental Residue-Effects Database (ERED 2002, see el.erdc.usace.army.mil/el/ered) were used to develop benchmarks for critical body residues. The database was searched for effects on reproduction, growth and development, mortality and survival. Results that were based on adult exposure, whole body concentration, and ingestion or absorption were used, if available (Figure 6, Appendix 5). Benchmarks were selected for highest no observed effect dose (NOED) and lowest observed effect dose (LOED) for the receptor species of interest (i.e. fish and invertebrates, Table 1).[18] If the highest NOED was greater than the lowest LOED, then a NOED was selected that was lower than the lowest LOED (Table 4, Table 8, Table 9). The NOED and LOED benchmarks for fish and invertebrates were derived by multiplying the value obtained from ERED by an uncertainty factor (UF), if applicable, and the dry:wet ratio (dw) to convert to dry weight for fish and invertebrates (Table 8, Table 9, Appendix 5).

$$NOED = NOED_{ERED} \times UF \times dw \quad [14]$$

$$LOED = LOED_{ERED} \times UF \times dw \quad [15]$$

[18] NOED and LOED are used to be consistent with the ERED nomenclature, which defined "dose" as the whole body burden concentration. Values selected from the database were the no observed adverse effects (NOED) and lowest observed adverse effect (LOED).

If a NOED or LOED was not available for the contaminant-receptor being evaluated, UFs were used to make other endpoints comparable to the NOED or LOED (Table 8). In the absence of a NOED, laboratory derived LOEDs were converted into a NOED by reducing the LOED by up to a factor of 10, depending on how severe the effect was (U.S. EPA 1995, Sample et el. 1996). If only data on an effective dose (ED_x.) were available for a COPC, then the ED_x was reduced by up to a factor of 10, depending on how severe the effect was, to obtain the LOED (Table 9). For example, the lowest toxicity endpoint obtained from ERED for Cu in whole fish tissue was 6.4 µg/g, which caused 100% mortality in non-metallothionein induced rainbow trout (*Oncorhynchus mykiss*, Dixon and Sprague 1981). This value was then multiplied by an UF of 0.5 to obtain the LOED benchmark of 3.2 µg/g, and an UF of 0.05 to obtain the NOED benchmark of 0.32 µg/g. For Cr, the lowest endpoint reported for whole fish tissue was an ED_{50} of 3.48 µg/g for rainbow trout (*Oncorhynchus mykiss*, Buhler et al. 1974) so the LOED of 1.75 µg/g was obtained by applying an UF of 0.5. The lowest endpoint for Cr invertebrate residues was an ED_{10} of 7.2 µg/g for stonefly (*Clioperla clio*, Poulton et al. 1989), which was multiplied by an UF of 0.75 to obtain the LOED benchmark of 5.4 µg/g and an UF of 0.1 to obtain the NOED benchmark of 0.72 µg/g. For Ni, the lowest invertebrate endpoint reported in ERED was an ED50 of 283 µg/g in clams (*Cerastoderma edule*, Wilson 1983) and UFs of 0.5 and 0.05 were applied to obtain the invertebrate LOED (141.5 µg/g) and NOED (14.5 µg/g), respectively. A UF of 0.5 was used to convert the LC_{50} of 203.5 µg/g reported for Pb in copepods (*Calanus hyperboreus*, Ritterhoff and Zauke 1997) to obtain the LOED of 101.8 (Table 8, Table 9, Appendix 5).

Food Chain Benchmarks

The potential for bioaccumulative contaminants to affect higher trophic levels was evaluated by assessing contaminant concentrations in tissues of representative prey. The exposure to an upper trophic level predator (bird of prey, dolphin etc.) is related to the exposure from eating prey species (clam, fish, worm, etc.) that have bioaccumulated contaminants from exposure pathways present within the reef community (Figure 3).

For cormorant, herring gull, and dolphin the food chain benchmarks were set to correspond to the dose that is equivalent to the no observed adverse effect level (NOAEL) for the receptor species. If available, Toxicity Reference Values (TRVs) were used to determine potential adverse exposure to predators. No applicable TRVs are currently available for reptiles (Chris Salice, U.S. EPA, personal communication) so the lowest mammalian or avian TRV for each COPC was assumed to be protective of sea turtles after converting to account for body weight and intake rate of sea turtles. This approach assumes that benchmarks protective of avian and mammalian species would also be protective of reptiles (see Great Lakes Water Quality Initiative Methodology for the Development of Wildlife Criteria, U.S. EPA 1995, CFR 40 part 132). For shark and barracuda the food chain benchmark was based on the dietary dose that corresponded to the concentration in the diet that would result in the NOED or LOED concentration obtained from ERED (Table 8, Table 9). When a NOEAL or NOED is used to calculate the TRV, the TRV represents a chemical concentration below which significant effects to the receptor are not anticipated. When the LOEAL or LOED is used to calculate the TRV, the TRV represents a chemical concentration above which ecological effects to the receptor could occur.

Water exposure was not evaluated for birds, mammals, and sea turtles. None of these species have gills, which is the main route of contamination from water exposure for marine fish and invertebrates. For birds, incidental contact with the water would occur when foraging at the reef (diving and swimming), but it was assumed that this exposure would not be significant. Although dolphins and sea turtles could also be attracted to forage at the reef for long periods, they are not considered to be reef residents and it was assumed that uptake of contaminants from the water would be negligible and could be ignored. Water exposure for the reef shark and barracuda was evaluated by assuming that potentially harmful tissue concentrations (NOED, LOED) could arise by accumulating contaminants from water and food.

The TRVs for the omnivorous herring gull (*Larus argentatus*) and piscivorous double-crested cormorant (*Phalacrocorax auritus*) were used to develop benchmarks for dietary exposure from the consumption of prey tissues (fish and invertebrates, see Table 1). Dietary benchmarks for avian consumers were developed using the highest dose that caused no observed adverse effects (NOAEL, microgram of chemical per gram of bird's body weight per day in wet weight) to the most sensitive taxonomically similar bird species, primarily, mallard duck (*Anas platyrhynchos*) (Table 10, Table 11, Sample et al. 1996). The TRV for exposure to PCBs was based on toxicological studies on ring-necked pheasants (*Phasianus colchicus*, Table 10, Table 11, Sample et al. 1996). Introduced into North America from Asia, ring-necked pheasants consume a wide variety of plants (seeds and grains) and animals including insects (grasshoppers, crickets, and ants are the primary food for young chicks) and occasionally small snakes and rodents (USFS 2004). Although ring-necked pheasants have a very different diet that seabirds, they are about the same size (1 kg) and have the about the same dietary needs (Sample et al. 1996) as herring gulls (body weight of 1.1 g and a dietary intake of 264 g/d, U.S. EPA 1995) and cormorants (body weight 1.9 g and a dietary intake of 475 g/d, Environment Canada 2004c). Herring gulls are opportunistic feeders and will consume virtually any available food (U.S. EPA 1995) while double-crested cormorants feed almost exclusively on fish (Environment Canada 2004c). The avain benchmarks assumed that the COPCs would have similar toxic effects and mode of action in herring gull and cormorant as was observed in the test species, after converting the dose for body weight and ingestion rate (see below).

The mink (*Mustela vison*) was selected as the most similar mammalian test species to dolphins. Minks are voracious carnivores, a large component of a mink's diet consists of fish (Sample et al. 1996), and mink are more similar to dolphins than other mammalian species for which toxicology data are available, such as laboratory rats, white-footed mice, and oldfield mice (Sample et al. 1996). Additionally, mink are more sensitive to PCBs than laboratory rats or white-footed mice (Sample et al. 1996).

Depending on the availability of food, bottlenose dolphins (*Tursiops truncatus*) will eat a wide variety of food including tarpon, sailfish, sharks, speckled trout, pike, rays, mullet, and catfish. They are also known to eat anchovies, menhaden, minnows, shrimp, eel and other free-swimming invertebrates. The average dolphin will consume 18-36 kg of fish each day (Davis and Schmidl 1997). The most common feeding behaviors is foraging; bottlenose dolphins are also known to chase prey into very shallow water where they can capture the trapped fish by lunging onto mud banks and shoals (Davis and Schmidl 1997). Adult bottlenose dolphins average 2.5-3 m (8-10 ft.) and weigh between 136-295 kg (300-650 lb.), with males being slightly larger than females (Seaworld 2000).

Experimentally derived toxicity values for mammals (minks - $NOAEL_{mink}$) were converted to effects levels for dolphins ($EL_{Dolphin}$) by scaling the dose to the ratio of body weight of the test species to the body weight of the receptor species using an empirical relationship (Equation [16], Sample et al. 1996). Sample et al. (1996) reported that scaling factors, such as used for mammals, are not appropriate for avian species because an analysis of existing data showed that the scaling factor which ranged from 0.63 to 1.55 with a mean of 1.15, was not significantly different than 1. This assumes that toxicity effects to birds of prey receptor species would be similar to the species tested (ring-necked pheasant for PCB) after adjusting for differences in food consumption rate and body weight of the receptor species. Therefore, based on the similarity of toxicity values reported among avian species, the NOAELs reported for the test species ($NOAEL_T$) were assumed to be equivalent to the NOAEL for herring gulls and cormorants (Equation [17], Sample et al. 1996).

Mammalian

$$EL_{Dolphin} = NOAEL_{mink}\left(\frac{bw_{mink}}{bw_{dolphin}}\right)^{1/4} \quad [16]$$

Avian

$$EL_{Gull} = EL_{Cormorant} = NOAEL_T \quad [17]$$

The dietary consumption benchmarks (D) of prey tissues for herring gull (D_{Gull}, Table 10), cormorant ($D_{Cormorant}$, Table 11), and dolphin ($D_{Dolphin}$, Table 12) were determined by the following relationships:

D = TRV/*F* µg/g (wet weight) [18]

where TRV = ($EL_T \times UF$) [19]

and EL = Effect Level for receptor species (e.g. No Observed Adverse Effects Level – NOAEL)

UF = uncertainty factor

F = dietary uptake factor (g/g body weight/day)

F = *aRdL* [20]

a = assimilation efficiency = 0.9

R = food ingestion rate (g/g body weight/day)

R = *f*/*bw* g/g body weight/day (Sample et al. 1996) [21]

f = Food consumption rate:
herring gull = 264 g/d for herring gulls (U.S. EPA 1995, CFR40 part132).
cormorant = 475 g/d (Environment Canada 2004c).
dolphin = 27,000 g/day (Davis and Schmidl 1997)

bw = herring gull body weight = 1,100 g (U.S. EPA 1995, CFR40 part132)
cormorant body weight = 1,900 g (Environment Canada 2004c)
dolphin body weight = 215,000 g (Seaworld 2000)

d = fraction of diet = 1.0

L = fraction of life span = 1.0

In the absence of published NOAELs, the lowest observed adverse effect level (LOAEL) can be used to estimate the NOAEL. To make LOAELs comparable to NOAELs, uncertainty factors (UF) were applied to benchmark concentrations (U.S. EPA 1993). Generally, an

uncertainty factor (UF) of 0.1 is used to convert the lowest observed adverse effect level (LOAEL) to a NOAEL, and an UF of 0.01 is used to convert a lethal dose to 50% of the population (LD_{50}) to a NOAEL (U.S. EPA 1993).

Listed as a threatened species in the Southeastern US (NOAA 2004), mature loggerhead sea turtles (*Caretta caretta*) weigh about 113 kg (Bolten and Witherington 2003, Turtle Trax 2004) and can consume about 3% of their body weight per feeding (Seaworld, Ask Shamu, personal communication). Captive loggerhead turtles generally feed about three times a week, but some loggerheads (especially rescued animals) feed every day (Seaworld, Ask Shamu, personal communication). Assuming that loggerheads in the wild will feed about five times a week (especially if food is plentiful at a reef), the daily intake rate was estimated as 1450 g/day. Due to the lack of toxicity data on reptiles, the lowest TRVs obtained for cormorant or dolphin for each COPC was assumed to be protective of sea turtles. The benchmark was obtained by using the same scaling factors used for mammals (Equation [16]) and avians (Equation [17]) and substituting the body weight and ingestion rate of loggerhead turtles into Equation [20]. The dietary benchmarks for loggerhead sea turtle (D_{Turtle}) were set to lowest value obtained between TRVs based on avian or mammalian literature toxicity reference values (Table 13).

The top predators on the reef are sharks and barracudas that would be drawn to the abundance of food at the reef. Long-lived and carnivorous, sharks only consume about 1-10% percent of their total body weight per week (Seaworld 2004b, Pauley 1989). Sharks don't require as much energy as birds and mammals because they are cold-blooded and very efficient swimmers (Seaworld 2004b). A common large, up to 2.4 m (7.5 ft.), coastal shark in the waters of Southeastern US is the sandbar shark (*Carcharhinus plumbeus*). In the Florida east coast shark fishery between 1938 and 1950 sandbar sharks constituted about 50,000 of the 100,000 coastal sharks caught commercially (Jon Dodrill, Florida Fish and Wildlife, personal communication). A reef-associated predator, sandbar sharks feed primarily on boney fishes (>95%) but they will also consume other elasmobranches, cephalopods, and shrimps (Fishbase 2004a). Growing up to 45-90 kg (100 – 200 lbs) in weight (Knickle 2004), sandbar sharks occupy the upper trophic level of the reef food chain (Trophic Level 4.1 to 4.5, Fishbase 2004a). Another reef-associated top-level predator frequently observed foraging on artificial reefs is the great barracuda (*Sphyraena barracuda*) (Robert Turpin, Escambia County, FL, Marine Resources Division, personal communication). Smaller, 2 m (6.6 ft) total length and maximum weight 50.0 kg (110 lbs, Fishbase 2004b) but faster swimmers than sharks, barracuda probably require more energy needs (per unit body weight) than sharks. With their large mouths and very sharp teeth, barracuda feed on jacks, grunts, groupers, snappers, small tunas, mullets, killifishes, herrings, and anchovies, sometimes by chopping large fishes in half (FMNH 2004). An opportunistic predator, great barracuda feed throughout the water column and are located at a Trophic Level of 4.5 (Fishbase 2004b).

Toxicological benchmarks for PCBs in shark and barracuda were developed using the ratio of bioaccumulation factors (BAFs) between trophic level IV (TL-IV reef predator, e.g. shark) and Trophic Level III (TL-III reef forager, e.g. prey) obtained from PRAM 1.3a (Goodrich 2004). Defined as the "the ratio (in L/kg) of a substance's concentration in tissue of an aquatic organism to its concentration in the ambient water" (U.S. EPA 1995) BAFs are used to account for the trophic transfer of a contaminant in the food chain. The ratio between BAFs for TL-IV and TL-III gives the relative increase in contaminant concentrations between a shark and

its prey, assuming all the shark's dietary requirements came from TL-III. The ratio was calculated by:

$$Ratio_{BAF4:3} = wBAF4/wBAF3 \quad [22]$$

where

$$wBAF4 = \Sigma wBAF_i = \Sigma(f_{PCBi} \times BAF4_i) \quad [23]$$

$$wBAF3 = \Sigma wBAF_i = \Sigma(f_{PCBi} \times BAF4_i) \quad [24]$$

$BAF4_i$ = The TL-IV BAF calculated for homolog i (i=1, 10) in PRAM 1.3A (Goodrich 2004).

$BAF3_i$ = The TL-III BAF calculated for homolog i (i=1, 10) in PRAM 1.3A (Goodrich 2004).

f_{PCBi} = The fraction of PCB present as homolog i (i=1, 10) in fish tissue (see Table 7)

This formulation is weighted by the fraction of PCBs observed in fish tissue for each homolog group (Table 7) and assumes that the shark and its prey have the same relative distribution of PCBs in their tissues. The benchmark tissue concentrations for PCB using the above ratio, were calculated by setting the shark's tissue concentration to the critical body residue NOED and LOED, and solving for the allowable tissue concentration in the diet of a shark of barracuda (D_{Shark}, Table 14):

$$D_{Shark} = NOED/Ratio_{BAF4:3} \quad [25]$$

$$D_{Shark} = LOED/Ratio_{BAF4:3} \quad [26]$$

The benchmarks obtained for avian consumers (Table 10, Table 11) indicated that cormorants and gulls would have about the same sensitivity to contaminant exposure. The benchmarks for exposure to tPCB were 0.8 (ug/g wet weight) for the no effects level and 8.0 (ug/g wet weight) for the low effects level, reflecting the factor of ten difference assumed between the observed LOAEL and calculated NOAEL reported in Sample et al. (1996). The tPCB benchmark was based on a 17-week chronic exposure to technical grade Aroclor 1254 introduced by gel capsules mixed into the ring-necked pheasants' food. The test showed significantly reduced egg hatchability following exposure throughout a critical life stage (reproduction, Dahlgren et al. 1972 cited in Sample et al. 1996), and these effects were assumed to be applicable and appropriate for the protection of sea birds. The main difference between the gull and cormorant benchmark was that the invertebrate data could be evaluated using the benchmarks for herring gull, while the cormorant benchmarks were only applicable to the fish data. The herring gull benchmark was 2.4 times lower than the omnivore benchmark for black duck (*Anas rubripes*) used in an earlier version of this report (Johnston et al. 2003). Although herring gulls and black ducks are about the same size (1.1 – 1.2 kg), the herring gull feeding rate (264 g/day) is 2.4 times higher than black duck (125 g/day). The cormorant benchmark was 25% lower than the piscivore benchmark for osprey (*Pandion haliaetus*) used in the earlier version of this report (Johnston et al. 2003). This was due to the larger size (1.9 kg) and higher feeding rate (475 g/day) of cormorants compared to osprey (1.5 kg, 300 g/day).

In comparison to the cormorant prey benchmarks (Table 11), the dolphin prey benchmarks (Table 12) were higher for total Hg (2 ug/g wet weight for cormorant compared to 9.2 ug/g wet weight for dolphin) and lower by a factor of 7.7 for Cu (208 ug/g wet weight for cormorant compared to 27 ug/g wet weight for dolphin). The relative increased sensitivity of

mammalian species to PCBs was evident in the fact that the dolphin NOAEL benchmark (0.32 ug/g wet weight) was about 3 times lower than the cormorant NOAEL benchmark (0.8 ug/g wet weight) and the dolphin LOAEL benchmark (1.58 ug/g wet weight) was 5 times lower than the cormorant LOAEL benchmark (8 ug/g wet weight). The tPCB benchmarks for dolphins were based on a 4.5-month chronic study where mink were feed a diet mixed with varying concentrations of technical grade Aroclor 1254. The study found that prolonged exposure to PCBs in the mink's diet reduced the number of live kits born at the end of the reproductive cycle (Aulerich and Ringer 1977 cited in Sample et al. 1996). Enough treatment doses were tested to allow the NOAEL to be calculated rather than estimated as was done for the ring-necked pheasant study (Sample et al. 1996), which explains the reduced range between the NOAEL and LOAEL benchmarks for dolphins as compared to birds. The effects from PCBs observed in mink were assumed to be applicable and appropriate for the protection of dolphins. In a study of PCB risk to bottlenose dolphins (*Tursiops truncates*), Schwacke et al. (2002) justified the use of mink as surrogates for dolphins because mink are the most sensitive mammalian species for which PCB toxicity data are available and that mink have similar pharmokinetic pathways as dolphins (cetaceans), specifically, both have relatively lower levels of phenobarbital-type (PB-type) and 3-methylcholanthrene-type (MC-type) enzymes necessary for metabolizing PCBs than other birds or mammals. Additionally, it is very difficult to obtain toxicological data for a protected species such as dolphins (Schwacke et al. 2002).

The tPCB fish tissue NOAEL benchmark for bottle-nosed dolphin (0.32 ug/g wet weight) is similar to the wildlife protection value (WV_{Fish}) derived to be protective of piscivorous birds and mammals (U.S. EPA 1997). The WV_{Fish} is based on monitoring data compiled in the National Sediment Quality Survey; it is based on the sum of measured congeners (sumPCB, i.e. NOAA 18) and set to the lowest toxicity threshold calculated for kingfisher, herring gull, otter, mink or eagle (U.S. EPA 1997). The mammalian species are more sensitive to PCBs, so the WV_{Fish} value was set to the mammalian threshold. When the WV_{Fish} value of 0.16 ug/g wet weight sumPCB is expressed as tPCB using the empirical relationship[19] from the NOAA Status and Trends Program (NOAA 1991), the value of 0.352 ug/g wet weight is obtained, which is essentially the same as the dolphin benchmark.

Because applicable TRVs are currently not available for reptiles (Chris Salice, U.S. EPA, personal communication), the lowest mammalian or avian TRV for each COPC was assumed to be proctective of sea turtles after accounting for consumption rate and size of sea turtles. The sea turtle benchmarks for Ag, As, Cd, Cr, Ni, Pb, Zn, and PAHs were based on avian TRVs and the benchmarks for Cu, Hg, meHg, and tPCB were based on mammalian (mink) TRVs (Table 13c). The sea turtle benchmarks based on avian TRVs were about a factor of 12 higher than the cormorant benchmarks and the sea turtle benchmarks based on mammalian TRVs were almost 7 times higher than the dolphin benchmarks. The massive size of sea turtles compared to sea birds accounts for the higher avian-based benchmarks for turtles and the relatively low feeding rate of cold-blooded sea turtles compared to warm-blooded mammals accounts for the higher

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

mammalian-based benchmarks for turtles. It is assumed that warm-blooded birds and mammals are more sensitive to PCBs than sea turtles (and other reptiles), but, in fact, it is not known whether this is true or not (Table 13c).

The BAFs obtained from PRAM were based on the conceptualized food chain for the reef represented by phytoplankton and encrusting algae (TL-I), sessile filter feeder (TL-II), planktivore (TL-II), forager (TL-III), and predator (TL-IV) and that a steady state existed among PCB sources (PCB-containing materials) and PCBs in all the abiotic (sediment, pore water, water, suspended solids, dissolved organic carbon) and biological compartments in the model (Goodrich et al. 2003, Goodrich 2004). Assuming that the top trophic level predators (TL-IV shark/barracuda) feed 100% on fish (TL-III forager) the tissue concentrations of prey that would cause the critical body residue levels of shark/barracuda to exceed the NOED or LOED were calculated. The shark/barracuda NOED (0.88 ug/g dry) and LOED (1.06) were about 3 and 1.5 times higher than the dolphin prey NOAEL and LOAEL benchmarks, respectively. The shark/barracuda benchmarks assumed that the large voracious predators had the same sensitivity to PCBs as the sheephead minnow (Hansen et al. 1975) and lake trout (Mac and Seelye 1981) tested in the laboratory (Table 14).

5.2. Determination of Background Levels

For the purposes of screening for ecological risk, regional background data were used to assess the environmental conditions in the region that were not subjected to the influences of natural and artificial reefs. An important source of background data available for the ecorisk screening is data reported as part of the Environmental Monitoring and Assessment Program (EMAP) EMAP-Estuaries for the Carolinian Province (Hyland et al. 1998). Sponsored by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. EPA, EMAP for the Carolinian Province was conducted to assess the environmental condition of estuaries in the Carolinian Province (Cape Henry, VA – St. Lucie Inlet, FL). From July 5 – September 14, 1995, about 90 randomly located nearshore and estuarine stations were sampled throughout the province. The study provides data that can be used to evaluate contaminant trends in biota and develop an overall assessment of the environmental conditions in the region (Hyland et al. 1998). Although the EMAP program was focused on coastal areas and estuaries, which can have relatively high levels of pollutants, the sample program also included many pristine and unimpacted locations as well (Hyland et al. 1998). Data available for the Carolinian Province through the EMAP website were used in the screening analysis. Specifically, tissue residue data on fish (spot — *Leiostomus xanthurus* and croaker — *Micropogonias undulatus*), white shrimp *(Penaeus setiferus*), blue crab (*Callinectes sapidus*) and oyster (*Crassostrea virginica*) were used to estimate contaminant levels present in biota within the region. Samples of these tissues were analyzed for PCBs and heavy metals. These data were used to evaluate background/regional concentrations of PCBs and metals in fish and invertebrate tissues (Appendix 6).

In the EMAP program, 18 PCB congeners were quantified in the tissue and sediment samples (Wade et al. 1993). Total PCB (tPCB) was calculated as (T.L Wade, Geochemical and Environmental Research Group, Texas A&M University, personal communication[20]):

$$\text{tPCB} = 2.19 \times \text{sumPCB} + 2.19 \qquad [27]$$

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

5.3. Ecorisk Screening Analysis

The ecological effects benchmarks (Table 4) represent the thresholds, that if exceeded would raise "sufficient concern regarding adverse ecological effects" (U.S. EPA 1996a). The initial ecorisk screening consisted of two components: a graphical analysis and a hazard quotient analysis.

The graphical screening analysis for sediments was conducted with data from the SINKEX study of the ex-AGERHOLM (Gauthier et al. 2005). This was necessary because there were no sediment data available for the artificial reefs off the coast of South Carolina. While there are uncertainties associated with the data from the ex-AGERHOLM site, the ship is an artificial reef constructed of a former Navy vessel (albeit a deep ocean reef), which mostly likely contained the PCB-bearing solid materials of interest. The ex-AGERHOLM was sunk in a relatively isolated, deep ocean environment and the increase in sediment contamination near the ship (3 m, inner ring) was evaluated relative to reference data near the site (1 km, outer ring, Gauthier et al. 2005). Sediment data from inner ring was compared to the sediment benchmarks (Table 4) and to data obtained from the outer reference ring.

For the graphical analysis of tissue residue data, the data from the SCNDR study (Martore et al. 1998) and the supplemental fish data (Appendix 4.B) were grouped according to Navy Ship Reef, Other Artificial Reef, and Natural Reef (Table 1) and plotted on the same scale as the background data from the EMAP study (Hyland et al. 1998, Appendix 6). The graphical screening analysis for tissue residues included the appropriate tissue benchmarks for the tissue screening value (TSV), bioaccumulation critical value (B_{CV}), critical body residues corresponding to the no observed effect dose (NOED) and the lowest observed effect dose (LOED) for the receptor species, and the dietary consumption of tissue by herring gulls (D_{Gull}), cormorants ($D_{Cormorant}$), and dolphins ($D_{Dolphin}$) (Table 4). The chemicals that exceeded the most conservative benchmark for each exposure pathway in the food chain were identified as COCs from the screening level risk assessment.

Water chemistry data from the artificial reef sites were not available for the ecorisk screening. Therefore, data from the leach rate study (George et al. 2005) were used to model steady state PCB concentrations in the water surrounding the reef (Equation [6]) and screen the estimated levels against the water benchmarks for PCB (Table 4). See Appendix 8 for the estimates of water column PCB concentrations using the data from the LEACHRATE study.

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

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

$$HQ_{AVG} = C_{AVG} / B \quad [28]$$
$$HQ_{MAX} = C_{MAX} / B \quad [29]$$

Where C_{AVG}, C_{MAX} are the expected exposure concentration (average and maximum) calculated using available data, and B are the benchmarks or thresholds that when exceeded have been associated with causing ecological effects (i.e. values in Table 4). When HQ < 1 the chemical is below potentially harmful exposure levels and the HQ represents the fraction of harmful exposure. When HQ ≥ 1 the chemical is above potentially harmful exposure levels and the HQ represents the factor above harmful exposure.

When more than one chemical may impact a receptor, an ecological Hazard Index (HI) was calculated for each exposure pathway

$$HI_{AVG} = \sum HQ_{AVGi} \quad [30]$$
$$HI_{MAX} = \sum HQ_{MAXi} \quad [31]$$

Where i = 1 to n, the number of chemicals of potential concern for a particular pathway. Ecological hazard indices were calculated for water quality criteria benchmarks (TSV, B_{CV}), critical body residues (NOED and LOED) and for dietary exposure (food chain benchmarks) to evaluate the potential additive effect of exposure to many chemicals.

5.4. Advanced Screening Analysis for PCBs

Advanced screening for potential effects from PCBs was also conducted. The advance screening was warranted due to the importance of evaluating potential toxicological effects from PCBs that could be associated with ex-Navy ships used to create artificial reefs. Furthermore, the significantly higher than reference concentrations of PCBs detected in the supplemental fish collected from the ex-VERMILION reef (see Section 6.1.2) and the fact that some of these samples exceeded the initial screening benchmarks for PCBs (see Section 6.4) also indicated that the advanced screening would be beneficial to risk managers. The advanced screening consisted of evaluating the distributions of PCB congeners measured in the supplemental fish samples, analyzing the potential toxicity from dioxin-like coplanar congeners, and conducting a probabilistic analysis of PCB exposure. The probabilistic analysis included calculating the probability of exceeding benchmarks of PCB exposure, comparing the PCB exposure distribution observed in fish at the target reef to species sensitivity distributions (SSDs) of effects from residues of PCBs in fish, and calculating the probability of an effect from PCB residues to fish, given the probability of exposure from PCBs in fish residues.

5.4.1. PCB Congener Distributions

The distributions of individual congeners measured in vermilion snapper, white grunt, and black sea bass collected from the ex-VERMILION (Target) reef and natural hard bottom (Reference) reef were evaluated to determine if there were important differences in the pattern of congeners measured in samples from the two reefs. The distribution of congeners present in a

sample can be useful for fingerprinting sources of contamination and differentiating between background and unique sources of contamination. For example, the relative differences in the distributions of congeners in sediment has been used as a forensic tool to identify past and present sources of contamination, elucidate weathering and transformation of PCBs under environmental conditions, and ascertain levels of background and non site related sources of PCBs (Durell et al. 2005).

Data for individual congeners (Table 2) analyzed by AXYS Analytical Services, Ltd. (AXYS), Sidney, British Columbia, Canada, using EPA Method 1668A (U.S. EPA 1999a) in the supplemental fish tissue samples were used for this analysis (Appendix 4.E). Non-detected values were set equal to ½ of sample specific detection limit reported for each analyte (Appendix 4.E2). The raw and log-transformed data were evaluated to determine whether the samples conformed to a normal distribution using the Lin-Mudholkar test for normality (Appendix 4.E5). The mean, standard deviation, minimum, and maximum were calculated for each congener and homolog for all fish, vermilion snapper, white grunt, and black sea bass for site and reference and mean and standard deviation of homologs and congeners was plotted for each group to qualitatively compare the distributions of homologs and congeners. A quantitative analysis of congener distributions between reference and target reefs and species of fish was performed using an eigen-vector principal component procedure (Statistix 1996) to obtain multivariate principal components based on the correlation matrices calculated from the data sets grouped by site and species. The principal component loading factors were evaluated to determine if different sources or contributions of PCB congeners could be identified between reference and target fish.

5.4.2. Analysis of Dioxin-like Toxicity

Early toxicity studies on PCBs were conducted on technical Aroclors and effects were reported as a function of total PCB or total Aroclor concentrations. In the last decade, evidence has been mounting that specific congeners are more toxic than others, especially the dioxin-like coplanar PCBs – PCBs with zero or one chlorine atom in the ortho position (closest to the biphenyl double bond, see information on orientation Polychlorinated Biphenyls (PCB) Multimedia Training Tool) (Ahlborg et al. 1994, Van den Berg et al. 1998, Barney 2001). The concentrations of these dioxin-like coplanar PCB congeners are expressed as the equivalent concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), the most potent dioxin congener (Van den Berg et al. 1998), determined from the toxicity equivalent quotient (TEQ). The TEQ is calculated by summing the products of the concentrations of individual coplanar congeners [PCB_i] and their dioxin toxicity equivalency factors (TEF_i):

$$TEQ = \Sigma\, PCB_i \times TEF_i \qquad [32]$$

Where TEF_i expresses the potency of the PCB congener relative to TCDD (i.e., TCDD TEF=1). The World Health Organization (Van den Berg et al. 1998, EPA 1998) has established TEFs for fish, birds, and mammals that can be used in ecorisk assessments for the coplanar PCBs (Table 15, see TEF Table on U.S. EPA PCB web site).

Data from dioxin-like coplanar congeners were multiplied by the respective TEFs to calculate TEQs for fish eggs and to assess dietary exposure to birds and mammals. No data were

available for PCB081, and the concentrations of PCB156 and PCB157 were not reported (NR) for all samples. The concentration of 3,4,4',5-tetrachlorobiphenyl (PCB081e) was estimated using the concentration of 3,3',4,4'-tetrachlorobiphenyl (PCB077) and assuming that the concentration was proportional to the concentration reported for lake trout (Cook et al. 2003) and pre- and postmigrating sockeye salmon (deBruyn et al. 2004, Appendix A4F.1). The data for the NR concentrations of 2,3,3',4,4',5-hexachlorobiphenyl (PCB156e) and 2,3,3',4,4',5'-hexachlorobiphenyl (PCB157e) were estimated using ratios determined from the concentration of 2,3',4,4',5,5'-hexachlorobiphenyl (PCB167) obtained for each species and site from the supplemental fish samples (Appendix A4F.1).

$$PCB081e = R_{81:77} \times PCB077 \quad [33]$$

$$PCB156e = R_{156:167} \times PCB167 \quad [34]$$

$$PCB157e = R_{157:167} \times PCB167 \quad [35]$$

where

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

$R_{156:167}$ = Ratio of PCB156/PCB167 measured in supplemental fish samples

$R_{157:167}$ = Ratio of PCB157/PCB167 measured in supplemental fish samples

Risk to fish from exposure to dioxin-like coplanar PCBs was evaluated by estimating the TEQ concentration that could be passed from female fish to eggs. Eggs and sac fry larvae are the most susceptible life stage of fish to dioxin-like toxicity (deBruyn et al. 2004, Cook et al. 2003). Mortality to lake trout sac fry larvae has been reported at 30 pg TEQ/g egg (wet weight) and sublethal effects have been reported above 5 pg TEQ/g egg wet (Cook et al. 2003). Sockeye salmon eggs were found to be more sensitive with a no effect to egg mortality at 0.3 pg/g egg wet weight and low effect level of 3 pg/g egg lipid wet weight (deBruyn et al. 2004, see Table 8 and Table 9). The TEQ concentrations in eggs were estimated using the average egg to female transfer ratio for each coplanar congener (EF_{PCBi}) calculated from data for lake trout and pre- and postmigrating sockeye salmon eggs and females reported in Cook et al. (2003) and deBruyn et al. (2004). The egg TEQ was obtained by:

$$TEQ_EFFL = \Sigma\, TEGG_{PCBi} \text{ (pg TEQ/g egg lipid)} \quad [36]$$

$$TEQ_EFFw = (\Sigma\, TEGG_{PCBi}) \times f_LIPIDw \text{ (pg TEQ/g egg wet weight)} \quad [37]$$

$$TEQ_EFFx = (\Sigma\, TEGG_{PCBi}) \times (LIPIDW \times 0.01) \text{ (pg TEQ/g egg wet weight)} \quad [38]$$

where

$$TEGG_{PCBi} = (TECF_{PCBi} / (LIPIDW \times 0.01))(EF_{PCBi}) \quad [39]$$

$$TECF_{PCBi} = [PCBi] \times TEF_{PCBi(Fish)} \quad [40]$$

f_LIPIDw = Mass fraction of lipid in female fillet (muscle) tissue (g lipid/g wet)

LIPIDW = % lipid in female fillet (muscle) tissue (g lipid/g wet)

$$EF_{PCBi} = \frac{[PCBi] \text{ pg/ g lipid egg tissue}}{[PCBi] \text{ pg/ g lipid female muscle tissue}} \quad [41]$$

(see Appendix 4.F.1)

[PCBi] = Concentration of coplanar congener i measured in sample

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

The whole body TEQ concentration for fish was also calculated using the whole body to fillet conversion factor calculated for each sample (ConvFac, see Appendix 4C.2):

$$FTEQ_W = (\Sigma TECF_{PCBi}) \times ConvFac \quad \text{(pg TEQ/g whole body wet weight)} \quad [42]$$

$$FTEQ_L = FTEQ_W/(LIPIDW \times 0.01) \quad \text{(pg TEQ/g lipid weight)} \quad [43]$$

The TEQs for dietary exposure were calculated to assess the risk of dioxin-like exposure to fish eating birds and mammals (see Table 10, Table 11, and Table 12).

$$TECB_{PCBi} = [PCBi] \times TEF_{PCBi(Bird)} \quad [44]$$

$[PCBi]$ = Whole body concentration of coplanar congener i measured in sample

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

$$BTEQ_W = (\Sigma TECB_{PCBi}) \times ConvFac \quad \text{(pg TEQ/g whole body wet weight)} \quad [45]$$

$$BTEQ_L = BTEQ_W/(LIPIDW \times 0.01) \quad \text{(pg TEQ/g lipid weight)} \quad [46]$$

and

$$TECM_{PCBi} = [PCBi] \times TEF_{PCBi(Mammal)} \quad [47]$$

$[PCBi]$ = Whole body concentration of coplanar congener i measured in sample

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

$$MTEQ_W = (\Sigma TECM_{PCBi}) \times ConvFac \quad \text{(pg TEQ/g whole body wet weight)} \quad [48]$$

$$MTEQ_L = MTEQ_W/(LIPIDW \times 0.01) \quad \text{(pg TEQ/g lipid weight)} \quad [49]$$

The average and standard deviation of the fish, fish egg, bird, and mammal TEQs were calculated for reference and target sites and compared to fish egg (Table 8 and Table 9), avian (Table 10 and Table 11), and mammalian (Table 12) TEQ benchmarks.

5.4.3. Probability of Exceeding Effects Levels for PCBs

Benchmarks of ecological effects were used in the initial screening to identify contaminants that could have the potential to cause ecological effects (e.g. Contaminants of Concern). The objective of the probabilistic analysis was to calculate the probability that harmful exposures would occur to better quantify the magnitude of ecorisk indicated by the available data (Johnston et al. 2001). This information is useful to risk managers because it adds quantitative rigor to the ecorisk analysis beyond the simple, exceeds benchmark analysis, provided by the initial screening alone. However, the probabilistic analysis is limited by the data available, and the conclusions drawn from the probabilistic analysis must factor in the assumptions and uncertainties associated with the ecological effects benchmarks. Because available data were limited for most of the COPCs, the probabilistic analysis was only conducted for PCBs measured in the supplemental fish samples.

The mean (μ) and standard deviation (σ) of the logarithm-transformed ($base_{10}$) raw data were used to estimate the exposure distributions for PCBs measured in all fish grouped by target (n = 51) and reference reefs (n = 62). There was a much better fit to lognormal than normal distributions in the data (See Appendix 4E.5). Furthermore, the tendency of pollutants to conform to lognormal distributions (Gilbert 1987) and the conservative estimate of exposure associated with lognormal distributions supported the assumption that the exposure distributions were lognormal.

By combining all the data from vermilion snapper, white grunt, and black sea bass together, the resulting exposure distribution represents the range of exposures, based on the available data, expected for all secondary consumers (demersal fish) associated with the reef. The exposure distribution calculated from the reference fish was assumed to represent the exposure that would be present in the absence of a ship and the difference between the target and reference distributions was interpreted to represent the incremental increase in exposure attributed to the target reef, or simply, risk.

Ecological risk can be defined as the probability of an effect P(Effect) given the probability of exposure P(Exp) or the probability $P(C_z)$ of exceeding a benchmark (Johnston et al. 2001):

$$P(Effect|Exp) = P(Effect \cap Exp)/P(Exp),\ P(Exp) \neq 0 \qquad [50]$$

The probability of exceeding an effects benchmark was obtained by determining the critical z-score (C_z) for each benchmark with the mean and standard deviation of the Target and Reference distribution and then calculating the resulting probability from the Standard Normal Distribution:

$$C_z = (B - \mu)/\sigma \qquad [51]$$

$$P(C_z) = \text{probability of exceeding } C_z \text{ of the Standard Normal Distribution} \qquad [52]$$

where

B = benchmark concentration of ecological effects
μ = mean of Target or Reference populations (lognormal)
σ = standard deviation of Target or Reference population (lognormal)

The incremental increase in risk (RISK) was obtained by subtracting the probability for the reference reef from the probability for the target reef.

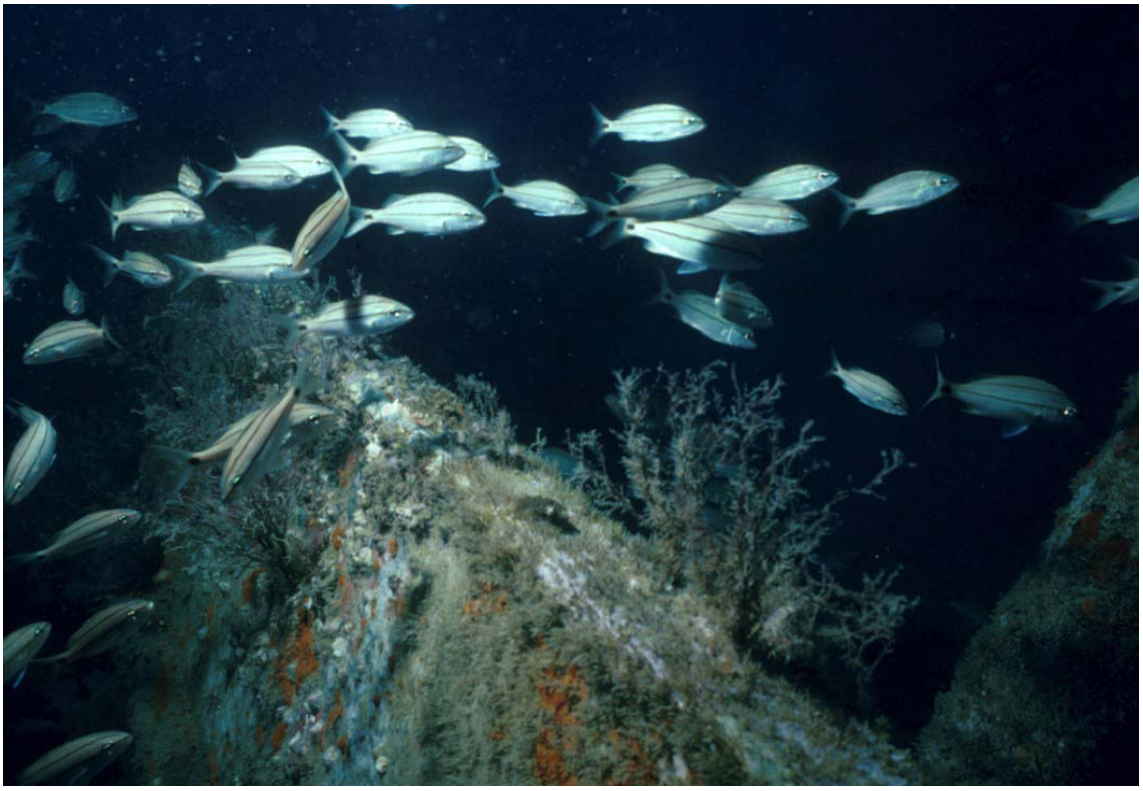
$$RISK = P(C_z)_{Target} - P(C_z)_{Reference};\ P(C_z)_{Target} > P(C_z)_{Reference} \qquad [53]$$

Where $P(C_z)_{Target}$ is the probability of exceeding a benchmark calculated for the target population and $P(C_z)_{Reference}$ is the probability of exceeding a benchmark calculated for the reference population. The probability density function (Sokal and Rohlf 1995) was used to plot the exposure distributions.

5.4.4. Probability of Exceeding Species Sensitivity Distribution for Effects of PCB Tissue Residues on Fish

The ecorisk benchmarks are based on a single (conservative) species effects level and do not necessarily reflect the wide range of species diversity and sensitivity to PCBs present in the ecosystem. One-way of addressing the broader implications of potential ecotoxicolgical risk from PCBs is to compare the PCB exposure distribution to species sensitivity distributions (SSD). Derived from toxicity data, SSDs are cumulative distribution functions, that describe the proportion of a class of organisms (in this case, fish) that are expected to be affected by a given level of exposure to a contaminant (Posthuma et al 2001, Maltby et al. 2005). Data from the ERED database on effects of PCBs to fish (both fresh and saltwater species) were used to calculate SSDs for PCB residues in fish (tPCB). The ERED data for effects to growth, mortality, reproduction, or survival from PCB residues in juvenile or adult fish (See Appendix 5.A ERED

Search Results for PCB) were used to calculate the cumulative probability distributions for No Effect (NOED) and Low Effect (LOED) assuming that the toxicity data conformed to a lognormal distribution. An SSD was also calculated for dioxin exposure in fish eggs to assess ecotoxicological risk from dioxin-like coplanar congeners. Assuming that the toxicity data reported in Gatehouse (2004) conformed to a lognormal distribution, an SSD for "No Effect" (NOAEL) to sac fry growth, development, and survival from exposure to dioxin TEQ in fish eggs was calculated to compare to the distribution of TEQ concentrations estimated for eggs from the supplemental fish data. The degree of incremental risk from the target reef was calculated by the overlap between the exposure distribution for the target reef and the SSD minus the overlap between the exposure distribution for the reference reef and the SSD.



Tomtate grunts (*Haemulon aurolineatum*) photographed on the ex-Vermilion reef (Photo by SCDNR).

5.5. Evaluation Criteria

The following evaluation criteria were used to evaluate the results of the screening level ecorisk assessment. The conclusions were based on evidence of potential ecological harm, evidence of exceeding background levels, and the degree to which data were available to support the assessment. An agreement within the REEFEX Working Group was developed for the evaluation criteria used for the initial ecorisk screening analysis.[21] The evaluation criteria were developed for sediment and tissue screening. For sediment screening, evaluation criteria were based on comparison to sediment benchmarks, comparison to reference sediment concentrations, and data reliability. For tissue screening, evaluation criteria were based on tissue residue and dietary benchmarks, comparison to reference conditions, comparison to background data, and data reliability. The media, data sources, exposure pathways, benchmarks, endpoints, receptors, and chemicals evaluated in the screening ecorisk assessment are summarized in Table 16.

5.5.1. Water Screening Criteria

Water exposure was evaluated using tPCB concentration modeled from the leachrate study (see Appendix 8) to assess potential risks to the reef community; water exposure to primary producers, primary consumers, secondary consumers, and tertiary consumers (Table 16, Figure 3). The benchmarks used for the screening were chronic and acute water quality criteria for water exposure (Table 4). The BCFs for PCB accumulation in fish and shellfish (Table 6) were also used to estimate the projected tissue concentration for fish and invertebrates exposed to the modeled water concentrations. The following evaluation criteria were used:

Comparison to Water Quality Criteria	
Outcome	**Interpretation**
Max modeled PCB concentration < Chronic WQC and Max projected PCB tissue concentration < TSV	Very unlikely exposure is harmful
Average projected PCB tissue concentration < TSV	Unlikely exposure is harmful
Average modeled PCB concentration > Chronic WQC	Moderate likelihood that exposure may be harmful
Max modeled PCB concentration > Acute WQC	Likely that exposure may be harmful
Average modeled PCB concentration > Acute WQC	Very likely that exposure may be harmful

[21] An agreement on the evaluation criteria for the initial screening was developed during the REEFEX Working Group Meeting of December 13, 2000.

5.5.2. Sediment Screening Criteria

Sediment data from the SINKEX study (Gauthier et al. 2002) were used to evaluate potential sediment effects from sediment contamination from PCBs, heavy metals, and PAHs to the components of the reef community that can come into direct contact with sediments. These include benthic diatoms and encrusting algae (primary producers), infauna and epifauna (primary consumers), and demersal fishes (secondary consumers) that regularly come into direct contact with the seabed while feeding and foraging (Table 16, Figure 3). It was assumed that tertiary consumers would only rarely come into direct contact with sediments therefore this pathway was ignored. For sediment screening the possible outcomes and interpretations for comparison of sediment data to sediment benchmarks and reference conditions were adopted by the REEFEX Technical Working Group.

Comparison to Sediment Benchmarks	
Outcome	**Interpretation**
All data < ERL	Very unlikely exposure is harmful
Average of data < ERL	Unlikely exposure is harmful
Average of data > ERL and Max of data < ERM	Moderate likelihood that exposure may be harmful
Max of Data > ERM	Likely that exposure may be harmful
Average of Data > ERM	Very likely that exposure may be harmful
Comparison to Reference	
Outcome	**Interpretation**
all data < reference	Less than reference
most data < reference	Similar to reference
most data > reference	Higher than reference

5.5.3. Tissue Residue Criteria

Data from Martore et al. (1998) and the supplemental fish sampling were used to evaluate contaminant exposure through the food chain (Table 16, Figure 3). Potential effects to primary producers and consumers (phytoplankton and zooplankton) were evaluated for PCB, Cd, Cr, Cu, Ni, and Pb using the TSV and B_{CV} benchmarks. Critical body residues (CBR) in primary consumers (reef invertebrates) and secondary consumers (demersal fish) were evaluated using the NOED and LOED benchmarks. Dietary exposure to avian omnivores (herring gull), avian piscivores (cormorant), secondary consumers (sea turtle), and tertiary consumers (dolphin and shark) were evaluated using NOAELs and LOAELs developed for those species. The data were also compared to reference and background conditions. The evaluation criteria adopted by the REEFEX Technical Working Group were:

Potential Effects to Primary Producers and Consumers (plankton – phytoplankton and zooplankton)	
Outcome	**Interpretation**
All data < TSV[22]	Very unlikely exposure is harmful
Average of data < TSV	Unlikely exposure is harmful
Average of data > TSV	Moderate likelihood that exposure may be harmful
Some data > Bcv	Likely that exposure may be harmful
Average of data > Bcv	Very Likely that exposure may be harmful
Potential Effects from CBR in Primary and Secondary Consumers (reef invertebrates and demersal fishes)	
Outcome	**Interpretation**
All data < NOED	Very unlikely exposure is harmful
Average of data < NOED	Unlikely exposure is harmful
Average of data > NOED and Max of data < LOED	Moderate likelihood that exposure may be harmful
Max of Data > LOED	Likely that exposure may be harmful
Average of Data > LOED	Very likely that exposure may be harmful
Potential Effects from Dietary Exposure to Secondary, Tertiary, and Avian Consumers (sea turtles, herring gulls, cormorants, dolphins, and sharks)	
All data < NOAEL	Very unlikely exposure is harmful
Average of data < NOAEL	Unlikely exposure is harmful
Average of data > NOAEL and Max of data < LOAEL	Moderate likelihood that exposure may be harmful
Max of Data > LOAEL	Likely that exposure may be harmful
Average of Data > LOAEL	Very likely that exposure may be harmful
Comparison to Reference	
Outcome	**Interpretation**
All data < reference	Less than reference
most data within range	Similar to reference
most data > reference	Higher than reference
Comparison to Background	
Outcome	**Interpretation**
All data < background	Less than background
most data within range	Similar to background
most data > background	Higher than background

5.5.4. Hazard Index Evaluation

The Hazard Index (HI) was calculated for the following pathways: (i) bioaccumulation in reef organisms (HI_{Bcv}), (ii) critical body burdens for demersal fish ($HI_{FishLOED}$) and reef invertebrates ($HI_{InvertLOED}$), and (iii) dietary exposure to dolphins ($HI_{Dolphin}$), cormorants

[22] For all chemicals screened the TSV was the most conservative benchmark (TSV < B_{CV}), except for Cu in fish tissue. For Cu residues in fish, the B_{CV} was used as the most conservative benchmark.

($HI_{Cormorant}$), herring gulls (HI_{Gull}), and sea turtles (HI_{Turtle}). The HI was calculated for the average (Equation [30]) and maximum (Equation [31]) tissue residue concentrations. The HIs were calculated using the data for fish and invertebrate tissue residues for both the Navy Vessel Reef and Natural Reef groups.

Since the denominators of the bioaccumulation HQs (TSV and B_{CV}) are based on chronic water quality criteria (Table 4), they are similar lines of evidence and the resulting hazard index (HI_{Bcv}) was used to evaluate water column exposure of multiple chemicals to reef organisms. Water quality criteria were developed to be protective of 95% of the species tested including plants, invertebrates, and fish, therefore the HI_{Bcv} provides an indication, based on observed tissue concentrations, as to what extent exposures may reach or exceed levels in the water column that could be potentially harmful to reef organisms. The bioaccumulation hazard index was evaluated as follows:

Benchmark	Outcome	Interpretation
TSV	$HI_{max} < 1$	Very unlikely exposure is harmful to the most sensitive reef organisms
B_{CV}	$HI_{avg} < 1$	Unlikely exposure is harmful to the most sensitive reef organisms
B_{CV}	$1 > HI_{avg} < 10$	Moderate likelihood exposure is harmful to the most sensitive reef organisms
B_{CV}	$HI_{avg} > 10$	Likely exposure is harmful to the most sensitive reef organisms
B_{CV}	$HI_{avg} >> 10$	Very likely exposure is harmful to the most sensitive reef organisms

The critical body burden HI ($HI_{FishLOED}$ and $HI_{InvertLOED}$) was based on the NOED and LOED benchmarks for demersal fish and reef invertebrates. The NOED represents the tissue residue below which effects will probably not occur and the LOED represents the tissue residue above which effects to fish and invertebrates may occur. Therefore, the HI represents the critical body burden for multiple contaminants. The critical body burden HI was evaluated as follows:

Benchmark	Outcome	Interpretation
NOED	HImax < 1	Very unlikely exposure is harmful to reef fish or invertebrates
LOED	HIavg < 1	Unlikely exposure is harmful to reef fish or invertebrates
LOED	1 > HIavg < 10	Moderate likelihood exposure is harmful to reef fish or invertebrates
LOED	HIavg > 10	Likely exposure is harmful to reef fish or invertebrates
LOED	HIavg >> 10	Very likely exposure is harmful to reef fish or invertebrates

The dietary exposure hazard indices ($HI_{Dolphin}$, $HI_{Cormorant}$, HI_{Gull}, and HI_{Turtle}) are based on NOAELs for multiple contaminants. The NOAEL is the concentration in the diet of a predator below which effects will probably not occur. When the dietary HI exceeds one, it means that the total exposure to all chemicals in the diet is higher than the combined NOAEL for all the chemicals present, assuming that the chemicals evaluated have the same mode of action (e.g. narcosis) in the target organism. The dietary hazard indices were evaluated for a diet of 100% fish for herring gulls, cormorants, and dolphins. A diet of 100% invertebrates was evaluated for dolphins, herring gulls, and sea turtles.

Only limited data were available to calculate each HI. Since benchmarks for dolphins were only available for PCB and Cu, the dolphin HI only evaluated exposure to those two chemicals. The data set from SCDNR provided data for PCBs, Cd, Cr, Cu, Ni, and Pb so the hazard indices do no take into account other contaminants that may be present in the environment. Dietary benchmarks for sharks were only available for PCBs. Obviously, the more chemicals that are used in the HI calculation the greater the chance of exceeding an HI of 1 or more. Because the hazard indices were calculated from both target and reference data, the hazard index provides a relative measure of total exposure at both sites. The dietary hazard indices were evaluated as follows.

Benchmark	Outcome	Interpretation
$D_{Dolphin}$ $D_{Cormorant}$ D_{Gull} D_{Turtle}	$HI_{max} < 1$	Very unlikely exposure is harmful to dolphins Very unlikely exposure is harmful to cormorants Very unlikely exposure is harmful to herring gulls Very unlikely exposure is harmful to sea turtles
$D_{Dolphin}$ $D_{Cormorant}$ D_{Gull} D_{Turtle}	$HI_{avg} < 1$	Unlikely exposure is harmful to dolphins Unlikely exposure is harmful to cormorants Unlikely exposure is harmful to herring gulls Unlikely exposure is harmful to sea turtles
$D_{Dolphin}$ $D_{Cormorant}$ D_{Gull} D_{Turtle}	$1 > HI_{avg} < 10$	Moderate likelihood exposure is harmful to dolphins Moderate likelihood exposure is harmful to cormorants Moderate likelihood exposure is harmful to herring gulls Moderate likelihood exposure is harmful to sea turtles
$D_{Dolphin}$ $D_{Cormorant}$ D_{Gull} D_{Turtle}	$HI_{avg} > 10$	Likely exposure is harmful to dolphins Likely exposure is harmful to cormorants Likely exposure is harmful to herring gulls Likely exposure is harmful to sea turtles
$D_{Dolphin}$ $D_{Cormorant}$ D_{Gull} D_{Turtle}	$HI_{avg} >> 10$	Very likely exposure is harmful to dolphins Very likely exposure is harmful to cormorants Very likely exposure is harmful to herring gulls Very likely exposure is harmful to sea turtles

To evaluate the HIs relative to reference conditions, the HIs determined for the Navy Vessel Reef were compared to the HIs obtained for the Natural Reef. The range between HI_{AVG} and HI_{MAX} obtained for the Navy Vessel Reef were compared to the range obtained for the Natural Reef.

Outcome	Interpretation
HI Range is less that Reference	Exposure is lower than reference
HI Range is over lapped by Reference	Exposure is similar to reference
HI Range is higher than Reference	Exposure is higher than reference

5.5.5. Data Reliability

The degree to which data are sufficient to draw a conclusion was also evaluated. The reliability of the data was evaluated by how well the data met data quality objectives for the risk assessment. The data quality objectives include how well the data represented site conditions,

spatial differences, temporal or seasonal variations, and responses from the stressors (Menzie et al. 1996). Ideally the data should be quantitative rather than qualitative and the data should be based on standard and acceptable methodology (Johnston et al. 2002). Confidence reflects the certainty of the finding based on the available data and other sources of uncertainty. If no data are available, no conclusion is possible, but as data reliability increases the confidence in the conclusions also increases. Low confidence suggests that additional information could change the conclusion, while high confidence suggests the opposite (Johnston et al. 2002, Johnston 1999). The evaluation criteria were used to interpret the results of the screening analysis.

Status of Data	Interpretation	Confidence in Conclusion
No data available	Serious Data Gap	No conclusion possible
Data are available but they may be anecdotal, undependable, unverifiable, or highly ambiguous	Data Reliability Low	Low
Quantitative data are available but they maybe limited and or contradictory .	Data Reliability Passable	Low
Quantitative data are available that meet at least 2 data quality objectives	Data Reliability Good	Medium
Quantitative data are available that meet 4 or more data quality objectives	Data Reliability High	High

5.5.6. Probabilistic Evaluation

Criteria for evaluating the outcome of the probabilistic analysis were developed for the advanced screening analysis.[23] The incremental risk of exceeding a benchmark or an effects distribution was interpreted using a geometric progression (10^{-4}, 10^{-2}, 10^{-1}, $10^{-½}$, $10^{-¼}$, $10^{-1/8}$) to define the (arbitrary) cutoff values for interpreting the level of risk:

Cutoff Value	Risk	Interpretation
10^{-4}	<0.0001	Negligible Risk
10^{-2}	<0.0100 and ≥0.0001	Very Low Risk
10^{-1}	<0.1000 and ≥0.0100	Low Risk
$10^{-0.5}$	<0.3162 and ≥0.1000	Medium Risk
$10^{-0.25}$	<0.5623 and ≥0.3162	High Risk
$10^{-0.125}$	<0.7499 and ≥0.5623	Very High Risk
	>0.7499	Adverse Risk

[23] At this writing the REEFEX Working Group has not yet reviewed and concurred with the evaluation criteria for the probabilistic analysis.

The overall risk was determined by the combination of risk levels obtained for exceeding the conservative (e.g. NOAEL) and less conservative (e.g. LOAEL) benchmarks for each assessment endpoint evaluated. [24]

Risk of Exceeding Conservative Benchmark (NOAEL)	Risk of Exceeding Less Conservative Benchmark (LOAEL)	Overall Risk
Negligible	Negligible	Negligible
Very Low	Negligible	Negligible
Low	Negligible	Negligible
Medium	Negligible	Very Low
High	Negligible	Very Low
Very High	Negligible	Very Low
Very Low	Very Low	Very Low
Low	Very Low	Very Low
Medium	Very Low	Low
High	Very Low	Low
Very High	Very Low	Low
Low	Low	Low
Medium	Low	Low
High	Low	Low
Very High	Low	Medium
Medium	Medium	Medium
High	Medium	Medium
Very High	Medium	High
High	High	High
Very High	High	Very High
Very High	Very High	Very High

5.5.7. Decision Criteria

Decision criteria were adopted to evaluate the results of the ecorisk screening level assessment.[25] Possible outcomes were based on evidence of potential ecological harm, evidence of exceeding background levels, and the degree to which data were available to support the assessment (Table 17). The decision matrix was used to evaluate the results of the ecorisk screening level assessment for each assessment endpoint. The decision matrix was adopted by the REEFEX Working Group as a way of reaching a common understanding and to formalize professional judgment. After all the available data and information were evaluated and reviewed by the REEFEX Working Group, an agreement within the REEFEX Working Group was reached that formed the basis for the conclusions.

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[24] At this writing the REEFEX Working Group has not yet reviewed and concurred with the evaluation criteria for the overall risk evaluation.

[25] An agreement on the decision criteria was developed during the REEFEX Working Group Meeting of December 13, 2000

6. Results and Discussion

This section presents and discusses the results from the supplemental fish sampling, sediment screening, tissue screening, the use of the leach rate data to estimate PCB exposure levels, and the results of the advanced screening analysis for PCBs. The significance of the findings and specific sources of uncertainty are also discussed.

6.1. Supplemental Fish Data

Three species of fish commonly caught by sports fishers (vermilion snapper – *Rhomboplites aurorubens*, white grunt – *Haemulon plumieri*, and black seabass – *Centropristis striata*, Figure 7) were collected from an artificial reef constructed by sinking the ex-VERMILION Reef (target) and the Northern Area natural hard bottom reef (reference) (NEHC 2000, 2001). A total of 22 vermilion snapper, 20 white grunt, and 20 black sea bass from the reference reef and 20 vermilion snapper, 20 white grunt, and 11 black sea bass from the target reef were analyzed for 30 individual PCB congeners, 10 homologs, and total PCB (Table 2, Appendix 4 Data from Supplemental Fish Sampling). These species are important members of the reef community at both the reference and target reefs (Appendix 3) and they are the top three most-landed species caught by recreational fishing charter boats off the coast of South Carolina.[25] Because these fish feed relatively high on the food chain and are considered to be residents of the reef (Figure 7), they provide excellent data for evaluating upper level carnivorous fish present on the reefs. However, there is uncertainty about how long the fish were present on the reef before they were caught and how representative these species are of other demersal fishes at the reef (e.g. toadfish, eels, tomtates, etc.). The reefs sampled were heavily fished, as was evident by the presence of fresh fishing tackle abandoned on the reef and the extra effort required catching the desired number of specimens from each reef (NEHC 2001). Indeed, it is rare to find "old" fish on any of the reefs managed by SCDNR Artificial Reef Program.

6.1.1. Interlaboratory Comparison

Fish samples were split between AXYS and ADL to assure comparability between the analytical methods used for SINKEX and REEFEX. Two methods were used, AXYS performed high resolution GS/MS SIM (Method 1668A) and ADL performed low resolution GS/MS SIM (ADL SOP 2845). For each method, the samples were processed in the same manner for sample preparation, extraction, and fractionation, only the injection and quantification procedures differed.

Data from the first round of samples appeared anomalous because the lipid content and PCB concentrations in the white grunt samples collected from the reference reef were markedly lower than the target reef (Figure 8). Similar results were obtained for the homogenized samples

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[25] The most landed species from charter boats are black sea bass > vermilion snapper > white grunt. Marine Resources Division, SCDNR, unpublished data.

split between AXYS and ADL (triangles shown on Figure 8) and the results reported by AXYS meet all QA/QC requirements for data validation (NEHC 2001). But because the samples with the low lipid content and low PCB concentrations from the reference reef were all processed in the same analytical batch by AXYS and the homogenized split sample analyzed by ADL were also from the same batch, analytical error could not be completely ruled out.[26] Therefore, it was deemed necessary to have both laboratories analyze the remaining archived samples of all three species. The archived samples, which consisted of two fillets with skin intact for each fish, were randomized and one fillet from each sample was sent to AXYS and ADL for sample preparation and analytical analysis.

There was good correspondence between Total PCB measured by ADL and AXYS and good agreement in results obtained from the analysis of certified standard reference materials (SRMs) (Figure 9). The results of the second round of analysis strongly supported the findings of the first round and verified that analytical error did not cause the differences in lipid and PCB levels detected in the first round (Figure 10, NEHC 2001). Furthermore, very good agreement between the results reported by both labs for the samples and certified reference materials (Johnston et al. 2001) indicated that both methods produced high quality data.

The fish samples analyzed by ADL SOP 2845 and Method 1668A (AXYS) showed similar results for Total PCB but there were differences in sensitivity and abundance of individual congeners. For low concentration samples, the ADL method resulted in reporting limits for non-detected congeners that were significantly higher than the detected results, whereas for Method 1668A the Reporting Limits were much lower than the detected results (Figure 11). Therefore, the difference in the detected results between the two methods is likely to be the congeners that are present but not detectable by the ADL method or congeners that were coeluted by the 1668A Method (Johnston et al. 2001). This was only pertinent to the low concentration samples. For PCB concentrations greater than 400 ppb, the detected concentrations are much greater than the reporting limits for either method and one gets good agreement between the two sets of results (Figure 12). For PCB concentrations between 20-400 ppb the ADL method resulted in higher concentrations of Total PCB. Below 20 ppb, the 1668 method resulted in higher concentrations of Total PCB (Figure 9). Overall there was very good comparison between the two methods. Method 1668A had much lower detection limits, but there were some problems with coelutions in comparison to SRM values. The ADL method tended to overestimate PCB concentrations in samples with low PCBs (Johnston et al. 2001). Based on these results and the fact that Method 1668 data were available for more samples (n = 113) than for the ADL method (n = 61), the data from Method 1668A reported by AXYS was used for both the human health risk assessment (NEHC 2001) and ecorisk screening assessment (see Appendix 4.B).

6.1.2. Comparison between Reference and Target Reefs

The total length, total weight, liver weight, and age of white grunt, vermilion snapper, and black sea bass sampled at the reference and target reefs are shown in Figure 13. The percent

[26] For example, something that caused the loss of lipid during sample preparation would also cause the loss of PCBs.

dry weight, percent lipid weight, and the sex ratios of fish sampled are shown in Figure 14. The vermilion snapper collected from the target reef were significantly larger ($p < 0.0001$) in length and weight than the vermilion snapper from the reference reef (Table 18), but the length and weight of white grunt and black sea bass were not statistically different between the reefs (Table 19 and Table 20, respectively). The liver weights of all three species of fish were significantly larger in the specimens collected from the target reef than from the reference reef (Table 18, Table 19 and Table 20; Figure 13), and samples of white grunt and black sea bass from the target reef had significantly higher ($p < 0.0001$) percent lipid content than the white grunt and black sea bass collected from the reference reef (Figure 14). Because there were similar numbers of male and female specimens collected from both reefs (Figure 14) and the specimens were collected during the same time period from both locations, it is unlikely that the differences in liver weight and lipid content were caused by sex or spawning differences between the two populations. Higher lipid content in the white grunt and black sea bass caught at the target reef indicates physiological differences between the two populations, which could be caused by significant differences in the diets of the fish or availability of food on the two reefs. The lipid content data reported by AXYS and ADL were in good agreement and supports the conclusion that physical differences existed between the two populations of white grunt and black sea bass. This may indicate that there was more food available at the target reef than the reference reef. The differences in lipid content at the target and reference reef were similar to the differences reported between pre- and post-migrating sockeye salmon (*Oncorhynchus nerka*) where the postmigration fish had extremely depleted lipid levels, probably due to the lack of feeding during migration (deBuryn et al. 2004).

The mean total PCB (ng/g dry weight), total PCB per unit lipid (ng/g lipid dry weight), and the log transformed-total PCB per unit lipid (log(ng/g lipid dry weight) measured in fish samples from the reference and target reefs are shown in figures Figure 15, Figure 16, and Figure 17, respectively. Significantly ($p \leq 0.05$) higher concentrations of total PCB (ng/g dry weight) were measured in all three species of fish sampled from the target reef (Table 18 – Table 20). Most notable was the difference in the dry weight concentrations of total PCB measured in white grunt, which was, on average, more than 60 times higher in samples from the target reef than from the reference reef (Figure 15). Since PCBs have a greater affinity for lipids, some of the differences in PCB concentrations could be explained by the fact that fishes at the target reef had lipid levels that were about 4-fold and 10-fold higher for white grunt and black sea bass, respectively (Table 19 and Table 20).

When normalized to lipid content, the concentrations of tPCB per unit lipid in black sea bass were not statistically different between the target and reference reefs, but the target reef was significantly higher for white grunt and vermilion snapper (Figure 16). The ANOVA using the log-transformed lipid normalized data (log(tPCB ng/g lipid)) showed that the white grunt and vermilion snapper samples from the target reef were significantly higher and the black sea bass samples from the target reef were significantly lower than the samples from reference reef (Figure 17). Assuming that the data conformed to a lognormal distribution, the mean total PCB per unit lipid concentration in samples from the target reef were 15 times higher in white grunt, 60% higher in vermilion snapper, and 60% lower in black sea bass than samples from the reference site (Figure 18). This indicates that while higher lipid levels could explain some of the differences in PCB concentrations, there was significantly higher accumulation of PCBs at the target reef in two of the three species sampled.

The hepatosomatic index (HSI) is the ratio between liver weight:body weight expressed as a percentage of total body weight (UVM 2001). Increased liver weight in relation to body weight is a general indicator of liver structure and function. Elevated HSI in fish has been linked to pollution-related stress (Collier et al. 1998). The HSI can also be affected by diet and disease (Adams and McLean 1985 cited in UVM 2001) and the reproductive status of female fish undergoing gametogenesis (Cek et al. 2001). The HSI measured in fish from the target reef was significantly higher than fish from the reference reef for all three species (Figures 19, 20). On average, the HSI was twice as high in fish from the target reef. The greatest difference in HSI was measured in black sea bass, which was more than 3 times higher in samples from the target reef than the reference reef (Figure 20). The samples that had HSI > 2% were predominantly from the target reef (Table 21). The black sea bass with high HSI (> 2%) were mostly small, 4-yr old female fish, which also had relatively high lipid content. The vermilion snapper samples with high HSI were all females 4 or 5 years of age. There were eleven white grunt samples with high HSI, seven were female and five of the specimens were 9 years old or older. Values of HSI in English sole (*Pleuronectes vetulus)* and rock sole (*Pleuronectes bilineatus*) greater than 1.5 to 2 times higher than reference have been reported from contaminated sites in the Puget Sound[27] (Collier et al. 1998). Since most of the samples with high HSI were also older female fish, the elevated HSI may be due to increased fecundity and gametogenesis (Cek et al. 2001). Nevertheless, a highly significant difference in HSI is another indication of apparent physiological differences between the fish populations sampled at the two reefs.

6.1.3. Whole Body Tissue Residues

In order to compare the supplemental fish data to the tissue residue benchmarks the supplement fish data obtained from the fillets with the skin on were converted into whole body residues. When the fillets with skin on were prepared for chemical analysis, the skin was scored with a scalpel and the fillets were homogenized with a blender equipped with a titanium blade to produce a uniform homogenate for lipid and PCB analysis (Appendix 4C, Figure 4C-1, Estimating PCB concentrations in whole body fish tissues). Assuming that both fillets were about the same size (one fillet was analyzed by AXYS and the other was analyzed by ADL) the weight of the remaining soma (head, visera, internal organs, bones, etc) was calculated by:

$$O_{bw} = \text{WEIGHT} - 2(\text{F_WEIGHT}) - \text{L_WEIGHT (wet weight)} \quad [54]$$

where

O_{bw} = Other tissue wet weight (g)
WEIGHT = Wet weight of whole fish (g), measured when caught
F_WEIGHT = Fillet weight (g), measured when fish was dissected
L_WEIGHT = Liver weight (g), measured when fish was dissected

Recognizing that the PCBs present in the various tissues of the fish would most likely be present in proportion to the lipid content of the tissue, and further assuming that the fish liver was composed of 55% lipids (LL), that there was about 20% more lipid in the remaining soma (OL) than in the fillet, that the ratio between the dry:wet ratio of liver and fillets was 1.66 (LD),

[27] The average HSI in fish from the impacted site (Hylebos Waterway) was 2.0 and the average HSI from the reference site (Colvos Passage) was 1.4 (Collier et al. 1998).

and that the remaining soma had the same dry:weight (OW) ratio of the fillets, the whole body tissue PCB concentration could be calculated (Appendix 4C, Estimating PCB concentrations in whole body fish tissues). The mass of tPCB in each type of tissue (liver, fillet, and other) was obtained by multiplying the concentration of tPCB/g lipid measured in the sample by the amount of lipid in the tissue, the lipid and tissue dry:wet weight conversion factors, and the size of the tissue. By summing the mass of tPCB and dividing by the whole body weight of the fish the whole body concentration was obtained:

Mass of tPCB in liver:

$$mtPCB_{Liver}\ (ng) = C_{tPCBL}\frac{(ng\ tPCB)}{(g\ lipid\ dry)} \times LL\frac{(g\ lipid\ dry)}{(g\ liver\ dry)} \times LD\frac{(g\ liver\ dry)(g\ fillet\ wet)}{(g\ liver\ wet)(g\ fillet\ dry)} \times DW\frac{(g\ fillet\ dry)}{(g\ fillet\ wet)} \times LW\ (g\ liver\ wet) \quad [55]$$

Mass of tPCB in fillets:

$$mtPCB_{Fillet}\ (ng) = C_{tPCBL}\frac{(ng\ tPCB)}{(g\ lipid\ dry)} \times FL\frac{(g\ lipid\ dry)}{(g\ fillet\ dry)} \times DW\frac{(g\ fillet\ dry)}{(g\ fillet\ wet)} \times 2FW\ (g\ fillet\ wet) \quad [56]$$

Mass of tPCB in other tissue:

$$mtPCB_{Other}\ (ng) = C_{tPCBL}\frac{(ng\ tPCB)}{(g\ lipid\ dry)} \times FL\frac{(g\ lipid\ dry)}{(g\ fillet\ dry)} \times OL\frac{(g\ lipid\ dry)(g\ fillet\ dry)}{(g\ other\ dry)(g\ lipid\ dry)} \times OW\frac{(g\ other\ dry)(g\ fillet\ wet)}{(g\ other\ wet)(g\ fillet\ dry)} \times DW\frac{(g\ fillet\ dry)}{(g\ fillet\ wet)} \times (BW - LW - 2FW)\ (g\ other\ wet) \quad [57]$$

Whole body tissue concentration (dry weight):

$$tPCB_{WB}\ (ng/g) = \frac{mtPCB_{Liver}\ (ng) + mtPCB_{Fillet}\ (ng) + mtPCB_{Other}\ (ng)}{BW\ (g\ tissue\ wet)} \times \frac{(g\ tissue\ wet)}{WW(g\ tissue\ dry)} \quad [58]$$

where

C_{tPCBL} = Concentration of tPCB per unit lipid measured in sample (ng/g lipid)
LW = Wet weight of liver (g liver wet)
FW = Wet weight of fillet (g fillet wet)
BW = Wet weight of whole fish (g fish wet)

conversion factors:

LL = Fraction of liver that is lipid (g lipid dry/g liver dry)
LD = (Dry:Wet ratio of liver)/(Dry:Wet ratio of fillet)
DW = Dry:Wet ratio of fillet
FL = Fraction of fillet tat is lipid (g lipid/g fillet dry)
OL = Fraction of other tissue that is lipid expressed as a ratio (lipid other tissue)/(lipid fillet)
WW = Whole body dry:wet ratio

$$= ((LW/BW)LD + 2FW/BW + ((BW - LW - 2FW)/BW)OW)DW \quad [59]$$

A conversion factor (ConvFac) to convert fillet concentration to whole body concentration was also calculated. Expressed as a percentage, ConFac gives the relative difference in PCB concentrations in the whole body relative to the fillet. For comparison purposes, the lipid-based conversion factor (ConvFacL) was also calculated.

$$\text{ConvFac} = \text{tPCB}_{WB}/\text{tPCB}_{Fillet} \quad [60]$$

$$\text{ConvFacL} = (\text{tPCB}_{WB}/\text{lipid}_{WB})/(\text{tPCB}_{Fillet}/\text{lipid}_{Fillet}) \quad [61]$$

The calculated whole body tissue residues of tPCB were higher than the measured concentrations of tPCB in fillets (see Figure A4c-2 in Appendix 4C), but because the fillets were analyzed with "skin on," which would include the layer of fatty tissue between the skin and fillet, the increases were not drastic (Appendix 4.C.3 Whole Body Fish Data). There was an average increase in whole body tPCB concentrations of about 20% relative to fillets (ConvFac = 1.2 average for all fish, Appendix 4.C.3 Fillet and Whole Body tPCB, Figure A4c-2); the largest differences were observed in fish with low lipid levels and relatively low levels of PCBs (Figure A4c-3). The whole body tPCB concentrations estimated for the reference black sea bass and reference white grunt were about 50% and 25% higher than tPCB concentrations measured in fillets, respectively (Appendix 4.C.3 Fillet and Whole Body tPCB). These were the fishes with the lowest lipid levels.

The assumptions used in the whole-body calculations were reasonably conservative. The faction of lipids in liver (LL = 0.55 dry weight) was taken as the average lipid content measured in livers of winter flounder (*Pleuronectes americanus*) from Portsmouth Harbor and Gulf of Maine (0.32 dry weight MESO 2000) and sable fish (*Anoplopoma fimbria*, aka blackcod or butter fish) from deep waters off the coast of Southern California at the SINKEX study site (0.78 dry weight, Gauthier et al. 2003, Table A4c-1 and A4c-2). Sable fish are known for their high oily content (ASMI 2004) and winter flounder were assumed to represent typical coastal fishes, so this range probably brackets the likely values for LL. When LL was varied from 0.32 to 0.78, with all other parameters held constant, the whole body to fillet ratio varied from 1.14 to 1.28 (Table A4c-4).

The assumption that the other tissues had about 20% more lipids than fillets with skin on (OL = 1.2) was based on the consideration that the other tissues are composed of internal organs with relatively higher lipids (visera and gonads) as well tissues with low lipid content (head, tail, bones, etc). The average ratio of lipid in whole fish to fillets with skin on[28] of coho salmon (*Oncorhynchus kisutch*) and rainbow trout (*Oncorhynchus mykiss*) from the Great Lakes was 1.75 (range 0.73 – 4.42) and 1.70 (range 0.85 – 3.08), respectively (Amrhein et al. 1999). When the value of OL was set to 1.75 the average ConvFac increased by 14% to 1.38 over the base condition, the lipid ratio increased by 12%, but the lipid-based conversion factor (ConvFacL) only increased by 2% (Table A4c-4). The relatively higher solid density of liver tissue than other tissue was estimated using the ratio of liver dry weight to fillet dry weight in winter flounder (Table A4c-1) and it was assumed that the dry weight of the other tissue and fillet tissue were the

[28] Fillets were processed with skin on according to USFDA guidelines, J.F. Amrhein, WI Department of Natural Resources, personal communication).

same. These factors were necessary for unit conversion in the calculation but they had little effect on the outcome of the calculation (Table A4c-4).

The conversion factors (ConvFac) obtained for black sea bass, white grunt, and vermilion snapper (average ConvFac = 1.2) was in the range of whole body to fillet conversion factors of 1.0 (Jackson and Schindler 1996 cited in Amrhein 1999), 1.5 (Stow and Carpenter 1994 cited in Amrhein et al 1999), and 1.7 (Amrhein et al 1999) reported for coho salmon and 1.47 (Amrhein et al. 1999) reported for rainbow trout. The lipid-normalized tPCB conversion factor (ConvFacL) for black sea bass (0.74), white grunt (0.94), and vermilion snapper (0.84) were very similar to the lipid-normalized PCB reported by Amrhein et al. (1999) for coho salmon (0.98) and rainbow trout (0.85). Some of the differences between the tPCB whole body to fillet ratios reported by Amrhein et al. (1999) and the ratios calculated for the REEFEX fish may be due to the fact that Amrhein et al (1999) did not take into account the contribution of lipids and PCBs from liver tissue in their analysis (J.F. Amrhein, WI Dept. of Natural Resouces, personal communication). Liver size varied markedly in the REEFEX fish and while livers only accounted for 1-3% of the whole body mass (Figure 20) they contained about 5 – 25% of the tPCBs calculated to be present in the fish (Figure A4c-4).

Statistical Analysis of Whole Body tPCB residues

For the supplemental fish samples, there was a statistically significant correlation ($p \leq 0.05$) between HSI and tPCB measured in white grunt ($r=0.47$) and black sea bass samples ($r=0.63$) but not for vermilion snapper (Figure 19, Table 22, Appendix 4.D). For all fish data HSI was significantly correlated ($p \leq 0.05$) to log(tPCB) ($r = 0.57$), lipid content ($r = 0.54$) and total length ($r = 0.21$) (Table 22, Appendix 4.D.1). Liver weight was significantly ($p \leq 0.05$) correlated to age ($r = 0.67$), length ($r = 0.65$), PCB levels ($r = 0.64$), and lipid content ($r = 0.44$) (Table 22, Table A4d-1). There was a significant increase ($p<0.05$) in whole body Log(tPCB) as a function of body weight for the combined reefs for white grunt, vermilion snapper, and black sea bass with a regression coefficient (r^2) of 0.16, 0.29, and 0.32, respectively (Appendix 4.D, Table A4d-5, Figures A4d-5a, A4d-5b, and A4d-5c). For all fish from the combined reefs, Log(tPCB) increased in a linear fashion, indicating that bigger fish had higher concentrations of total PCBs than did smaller fish. The vermilion snapper from the target reef were significantly larger than the reference reef and they had significantly higher PCBs as well (Figure 13, Table 18). The white grunt and black sea bass from the target reef were also larger than the reference reef (Figure 13, Table 19 and Table 20) and the largest fishes with the highest PCB levels were caught from the target reef.

A linear regression between whole body Log(tPCB/Lipid) and HSI for all fish from the combined reefs showed a significant positive slope, but with a very low regression coefficient ($r^2=0.05$) (see Appendix 4.D Table A4d-5). For white grunt from the combined reefs the regression showed a significant positive slope, an r^2 of 0.29, and the relationship appeared to differ between the two reefs (see Appendix 4.D Figure A4d-9b). The opposite relationship was observed for black sea bass, which had a significant negative slope and an r^2 of 0.23 indicating that HSI decreased in black sea bass with higher PCB per unit lipid (see Appendix 4.D Figure A4d-9c). The relationship between whole body Log(tPCB/Lipid) and HSI was not significant for vermilion snapper, however there was a clear separation between reference and target reef

vermilion snapper, the vermilion snapper from the target reef had higher HSI than reference vermilion snapper for the same concentration of PCB per unit lipid (see Appendix 4.D Figure A4d-9a).

A significant positive regression ($p<0.05$) with an r^2 of 0.16 was obtained for all fish from both reefs between body weight and Log(tPCB/Lipid) (see Appendix 4.D Table A4d-5,). The regression of data for white grunt from both reefs showed a significant positive slope with an r^2 of 0.15 for increasing PCB levels in larger white grunt and the relationship appeared to differ between the two reefs (see Appendix 4.D Figure A4d-6b), such that for a given fish size, target reef white grunt generally had higher total PCB concentrations per gram of lipid than did reference white grunt. A significant positive slope ($p <0.05$) was also detected for vermilion snapper from the combined reefs (r^2=0.23) and target reef (r^2=0.22), which was probably due to the fact that smaller fish with less PCB were sampled from the reference reef (see Appendix 4.D Figure A4d-6a). The black sea bass data did not show the same trend, instead Log(tPCB/Lipid) levels in black sea bass were independent of body weight (see Appendix 4.D Figure A4d-6c).

The stepwise multivariate regression of all fish data for HSI resulted in the equation (Table 23):

$$HSI = 0.01214 + 0.0066(SITEVAR) + 0.01785(W_LPCB) - 0.10508(F_LPCBL) + 0.08696(W_LPCBL) + 0.00053(AGE) \quad [62]$$

Where:

HSI = Hepatosomatic Index
SITEVAR = Site (target = 2 or reference reef = 1)
W_LPCB = Whole body Log(tPCB)
F_LPCBL = Fillet Log(tPCB/lipid)
W_LPCBL = Whole Body Log(tPCB/lipid)
AGE = Age

The model assumed that the independent variables were equally weighted, including dummy variables for site, species, and sex. The result of stepwise multiple regressions indicated that SITEVAR was the most important variable for explaining the variance in HSI for all fish data combined (r^2 = 0.48). The stepwise regression also indicated that there was a positive relationship between HSI and whole body Log(tPCB), whole body Log(tPCB/lipid), and age and a negative relationship between HSI and fillet Log(tPCB/Lipid). While this analysis does not demonstrate a cause-and-effect relationship between PCB exposure and elevated HSI, it does suggest that PCB exposure may contribute to elevated HSI.

As discussed above, the differences in contaminant levels and physiology of the fish populations sampled at the reefs may be related to the differences in the availability of food and foraging behavior. The higher relief and greater size of the artificial reef (Appendix 3) may provide more habitat for development of epibenthic biomass comprising different links in food chain than is present on the natural reef. Since all specimens were collected at about the same time, it is unlikely that spawning could account for the differences measured. However, if fish from the reference reef were migratory while the fish from the target reef were nonmigratory, that could explain the large differences in lipid content in the reference and target white grunt and black sea bass. Other studies have shown significant depletion of lipid mass and a corresponding increase of PCB residues per unit lipid between pre- and post-migration sockeye

salmon (*Oncorhynchus nerka*, deBruyn et al. 2004). White grunt feed lower on the food chain than vermilion snapper and black sea bass (Figure 7) so it is reasonable to suspect that white grunt are feeding on prey that are in closer proximity to reef and spend more time on the reef than vermilion snapper and black sea bass. The largest fish collected were white grunts caught on the Vermilion Reef and these were the fish with the highest levels of PCBs (Appendix 4.B).

6.1.4. Summary from Supplemental Fish Data

There were physical and physiological differences between the fish from the reference and target reefs. Fish from the target reef had larger livers, higher HSI, and more lipids (fish from the reference reef had significantly less lipid content). On a dry weight basis, there were significantly higher PCB levels in black sea bass, vermilion snapper, and white grunt sampled from the target reef. On a lipid weight basis, the mean total PCB per unit lipid concentration in samples from the target reef were higher in white grunt and vermilion snapper, and lower in black sea bass than samples from the reference site. A significant positive regression was obtained for all fish from both reefs between body weight and log of lipid-normalized data. The regression of data for white grunt from both reefs showed a significant positive slope for increasing PCB levels in larger white grunt and the relationship appeared to differ between the two reefs, such that for a given fish size, target reef white grunt generally had higher total PCB concentrations per gram of lipid than did reference white grunt. A significant positive slope was also detected for vermilion snapper from the combined reefs and target reef, which was probably due to the fact that smaller fish with less PCB were sampled from the reference reef. The black sea bass data did not show the same trend, instead the log of the lipid-normalized PCB concentrations in black sea bass were independent of body weight.

6.2. Results of Leach Rate Study to Assess Water Column Risk

The results of the leachrate study (George et al. 2004, 2005) were used to estimate water column PCB concentrations using data from the leach rate study are shown in Appendix 8 LEACHRATE Computations for the REEFEX Study. Empirical estimates of PCB leaching rates were developed for felt gaskets, electric cable, paint, rubber, foam insulation, oils & greases, and bulkhead insulation (George and In 2002a, George and In 2002b, George et al. 2004, 2005). Based on information available about the types of materials and PCB concentrations estimated to be present on the ex-AGERHOLM (JJMA 1998), low, average and high PCB loading scenarios were developed to simulate the leaching of PCBs from the ex-VERMILION and estimate the instantaneous steady state concentration of total PCB around the ship. The estimated concentrations were compared to the PCB water benchmarks and multiplied by bioconcentration factors to project the resulting PCB concentration in fish and shellfish. The results showed that there was negligible risk of exceeding water column or tissue benchmarks for any of the loading scenarios evaluated (Appendix 8 LEACHRATE Computations for the REEFEX Study).

The results from the empirical leaching studies and hypothetical steady state model were used to evaluate the consequences of removing materials from the ship to reduce PCB loading (Table A8-1). In general, removing the materials with the highest leach rates would result in the greatest reduction in PCB loading per unit material removed. Based on the empirical upper bound of the leach rate obtained from the solids tested (George et al. 2004, 2005) removing 1 g

of pure Aroclor 1254 would reduce leaching by the same amount as removing 4 g of pure Aroclor 1268, 143 g of bulkhead insulation, 1.855 kg of foam insulation, 3.8 kg of felt gaskets, 5.3 kg of rubber products, 56.5 kg of paint, or 80 kg of electrical cable (Table A8-1). For the solid materials tested in the laboratory leaching experiments, the effect of decreasing PCB loading by reducing the amount of solid materials containing PCBs was evaluated using the steady state model. The steady state model takes into account both the quantity and concentration of PCBs in the materials estimated to be on the ship when it was sunk. Based on the average loading scenario, removing about 150 g of bulkhead insulation would result in about the same reduction in PCB loading as removing about 4 kg of felt gaskets, 30 kg of foam insulation, 200 kg of electrical cable, 300 kg of rubber products, or 500 kg of paint (Table A8-1).

Estimates of water and tissue concentrations based on steady state leaching showed that water exposure and tissue levels of PCB were very low (Appendix 8) which indicates negligible exposure from contact with water surrounding the reef. The leach rates reported by George et al. (2004) were applied to the mass of PCBs present on the ex-VERMILION to derive the release rate *a(t)* (Equation [2], Table A8-1). These leach rate values represent the maximum PCB release for PCB molecules present in the solid up to the weight fraction in the solid tested, and includes the effect of transport being inhibited by the solid matrix (stationary phase) in which the PCBs reside. This is why the rate is expressed as shipboard-solid-specific and normalized to the mass of shipboard solid tested, rather than to the mass of PCBs in the solid tested (Table A8-1).

The highest leach rate was for oils and greases, because the leaching rate of pure Aroclor 1254 was used as a proxy for PCBs in oils and greases. The leaching of PCBs from oils and greases was obtained by assuming that all the PCBs within oils and greases were present as Aroclor 1254 and that the Aroclor leached at the same rate as the pure Aroclor measured in the laboratory leaching experiment. This overestimates the leaching, because pure Aroclor 1254 probably has a higher leach rate than Aroclor 1254 dissolved in oils and greases. It represents the highest possible leaching, if PCBs were present in non-mobile, non-soluble, non-dispersing residual oils and greases. The lack of empirical data on PCB leaching in oils and greases was identified as a major source of uncertainty in the model.

The steady state model assumed that there is no loss of PCB from adsorption, degradation, bioaccumulation, or partitioning, but simply focused on the maximum "available" PCB released into the environment (all other loss terms are set to zero, Figure 4). This greatly simplifies the modeling exercise and allows the relative importance of leaching from the solid materials on the ship to be evaluated. More detailed model constructs are needed to evaluate PCB fate and potential bioaccumulation in the environment and the development of such models (Goodrich et al. 2003, Goodrich 2004, NEHC 2005) was beyond the scope of this screening level ecorisk assessment.

The mass of the solid materials containing PCBs on the ex-VERMILION was obtained by multiplying the estimates for the ex-AGERHOLM by a scale factor of 3.33 to account for greater size of the ex-VERMILION. This imparts uncertainty to the loading estimates, because there are fundamental differences in the materials present on a troop transport ship (noncombatant) versus a destroyer (combatant). Because the ex-VERMILION was a troop transport ship, there would be more berthing areas, ducts, vents, etc. on the ex-VERMILION (per unit volume) than the ex-AGERHOLM, therefore, scaling by volume may underestimate the

total amount of felt gaskets and other comfort materials like bulkhead insulation for a troop transport ship. Conversely, cabling and oils and greases may be overestimated because there are more electrical and power plant systems per unit volume on a destroyer.

6.3. Sediment Screening

No sediment data from the South Carolina study area were available for the assessment so sediment data from the deep-water SINKEX study were screened against the sediment benchmarks. The SINKEX study site was located about 120 mi off the coast of southern California in about 2750 ft of water (Figure 21). The results of the sediment screening are shown in figures Figure 22 to Figure 31. The graphs show sediment data from the SINKEX study (Gauthier et al. 2002, 2005) obtained near the hull of the ex-ARGERHOLM (INNER RING) and a reference location 1 km away from the hull (OUTER RING) (Figure 21). The data were compared to the ERL and ERM benchmarks. Data reliability for the sediment screening was good. Only one study was conducted at the SINKEX Site (Gauthier et al. 2002, 2005), but there were multiple sampling events (1998 and 1999), ten stations were sampled on the inner ring, eight stations were sampled on the outer ring, and all the data reported met the data quality objectives of the SINKEX study (Gauthier et al. 2002, 2005).

6.3.1. Graphical Screening of Sediment Data

Total PCB. The sediment screening for Total PCB is shown in Figure 22. Total PCB was estimated using the "Green Book"[29] protocol by summing 21 specific PCB congeners, with non-detected congeners given a value of zero (Gauthier et al. 2002, 2005). Although the total PCB measured in samples from the inner ring were slightly higher than the concentrations measured in samples from the outer ring, there was no statistical difference between the two sample populations, and the values from the inner ring were well below the ERL benchmark (Figure 22). This indicates that exposure was similar to reference and it is very unlikely sediment exposure to total PCB would be harmful.

PAHs. In the SINKEX study, 41 PAH compounds were measured including parent and alkyl- and methylated homologs. The sum of the 41 PAH compounds (Total PAH) measured in samples from the inner ring were very similar to the total PAHs measured in samples from the outer ring and the concentrations were more than an order of magnitude lower than the ERL threshold for Total PAH (Figure 23). Therefore is very unlikely that sediment exposure to PAHs would be harmful.

Silver. The concentrations of Ag measured in samples from the inner ring were significantly higher than samples from the outer ring, indicating Ag exposure was higher than

[29] The Army Corps of Engineers and EPA provided guidance for the determination of total PCBs in the publication "Evaluation of Dredge Material Proposed for Ocean Disposal, Testing Manual" commonly referred to as the Ocean Testing Manual or "Green Book" (U.S. EPA and USACE 1991).

reference. Most of the inner ring samples were below the ERL so it is unlikely that the exposure would be harmful (Figure 24).

Cadmium. Cadmium levels measured in samples from the inner were very enriched above background levels (Gauthier et al. 2002, 2003), most of the samples exceeded the ERL benchmark, but no sample exceeded the ERM (Figure 25). Therefore, Cd concentrations were higher than reference and there is a moderate likelihood that the exposure could be harmful.

Chromium. Chromium concentrations measured in samples from the inner ring were about the same as in samples from the outer ring, and there were no statistically significant differences between the two groups ($p = 0.29$). All except for one of the inner ring samples exceeded the ERL benchmark, but no sample exceeded the ERM (Figure 26). Based on the screening analysis, there is a moderate likelihood that Cr exposure could be harmful, but the Cr concentrations were similar to reference conditions.

Copper. Copper concentrations in samples from the inner ring were also very enriched above background levels (Gauthier et al. 2002, 2003) and the inner ring samples were significantly higher than the outer ring reference samples. Eight of ten samples from the inner ring exceeded the ERL benchmark, but no samples exceeded the ERM (Figure 27). Copper exposure at the sunken ship was greater than reference and there is a moderate likelihood that Cu exposure could be harmful.

Mercury. Mercury concentrations measured in samples from the inner ring were slightly higher than samples from the outer ring, but the difference was not statistically significant ($p = 0.09$). None of the samples from either ring exceeded the ERL benchmark (Figure 28). This suggests that the exposure levels are similar to reference and it is very unlikely Hg exposure from the inner ring is harmful.

Nickel The Ni concentrations measured in samples from the inner ring were statistically higher ($p = 0.003$) than the concentrations measured in samples from the outer ring. Six of the ten samples from the inner ring exceeded both the ERL and ERM benchmarks (Figure 29). The screening analysis suggests that Ni concentrations at the sunken ship site are higher than reference and because the ERM was exceeded it is very likely that the exposure may be harmful.[30]

Lead. The Pb concentrations measured in samples from the inner ring were not significantly different than the Pb concentrations measured in samples from the outer ring. Both the inner ring and outer ring concentrations were well below the ERL benchmark (Figure 30). Accordingly, Pb exposure at the sunken ship was similar to reference and it is very unlikely that Pb exposure may be harmful.

Zinc. Zinc concentrations were enriched above backgound concentrations (Gauthier et al. 2002, 2003) and the Zn concentrations measured in samples from the inner ring samples were

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[30] Because the ERM for Ni is overprotective (Long et al. 1995), the finding of adverse exposure from Ni may be overly conservative (see Section 6.3.2).

higher than the outer ring, although the difference was not statistically significantly ($p = 0.16$). Two of ten samples from the inner ring exceeded the ERL benchmark (Figure 31). Therefore, Zn exposure at the sunken ship was higher than reference but it is unlikely that Zn exposure is harmful.

Overall, Cd, Cu, Ni, Ag, and Zn were higher in samples from the inner ring. Samples from the inner ring for Cd, Cu, and Zn exceeded the ERL but were less than the ERM, Ag concentrations were below the ERL, and Ni concentrations exceeded both ERL and ERM benchmarks (Figure 32). The sunken vessel provides a large reservoir of metals that could be leached into the environment (JJMA 1998); relative to natural sediments, sediments from inner ring were enriched by about a factor of 4 and 5 for Cu and Ni, respectively (Gauthier et al. 2002, 2003). Based on data from the SINKEX study, very little accumulation of PCB in the sediments surrounding the site was evident. Assuming that solid materials containing PCBs were present on the ex-AGERHOLM (JJMA 1998), this suggests that PCBs were not readily released into the deep-water sediments at the site.

6.3.2. Uncertainty of Sediment Screening

There is uncertainty in using data from the SINKEX study to infer sediment exposure conditions that could occur at a shallow water artificial reef. The lower temperature and higher pressure at the deep ocean site results in lower leaching rates of materials containing PCBs (George and In 2002b) than would occur at much warmer and shallower water artificial reefs. On the other hand, the isolated environment at the deep-water site creates an essentially "closed" system for evaluating contaminant accumulation in the sediment than would occur at a shallow water reef with much higher velocity currents, open water exchange, and dissipation of contaminants released from the ship. Furthermore, there is also uncertainty about other sources of coastal pollution at the shallow water reef. From the point of view of sediment accumulation, the SINKEX site is more of a depositional environment (sedimentation rates of 0.03 – 0.07 cm/yr, Gauthier et al. 2002, 2003) than the reefs studied off the coast of South Carolina, which are subject to erosive forces like hurricanes and other sediment transport processes.

The ERL for a particular chemical represents the lower 10th percentile of observed toxicity effects of all chemicals when the chemical is present (Long and Morgan 1990). The ERM represents the median concentration of the chemical in samples that were toxic. The ERL represents the value at which toxicity may "begin to occur in the sensitive species" (Buchman 1999). Because there is a significant degree of correlation between individual chemicals in the studies conducted to determine the ERL and ERM benchmarks, there is uncertainty about the cause of toxicity and the confidence of individual ERL and ERM to predict toxicity for individual chemicals. There is a relatively weak relationship between toxicity and the benchmarks for Ni, Hg, and total PCB (Long et al. 1995) so the sediment benchmarks should be used with caution (Long and Morgan 1990). The benchmarks for Ni had the lowest incidence of effect (toxicity was generally over predicted, Long et al. 1995).

Biological tests conducted for the sediments from the ex-AGERHOLM (SINKEX, Gauthier et al. 2003) showed "no significant difference" between the Inner Ring (3 m from ship)

and Outer Ring (1 km from ship). Toxicity tests conducted for the SINKEX site included 10-day *Rhepoxynius* (Survival[31] and Reburial) and 28-day *Neanthes* (Survival and Growth[32]). Bioaccumulation tests (28-d) were also conducted for *Nephtys* and *Macoma*, which showed no significant difference in PCB bioaccumulation between the Inner Ring and Outer Ring (Gauthier et al. 2003).

Possibly the greatest difference between the shallow and deep reefs is the food chains present at the sites. The relative lack of epibenthic organisms present on the ex-AGERHOLM compared to the dense growth present on the ex-VERMILION, could be attributed to the lack of primary producers and epibenthic larvae for recruitment at the deep water site, which are abundantly plentiful in shallow, coastal waters (Figure 33). Another source of uncertainty is that the SINKEX study consisted of only a single vessel, so it is unknown how representative the ex-AGERHOLM is of other ex-warships. At the very least, the SINKEX sediment data provide an indication of the relative magnitude and types of chemicals that could be released into the surrounding environment from a "typical" ex-Navy warship that could be used for reef construction.

6.3.3. Conclusions from Sediment Screening

Figure 32 presents a summary of the potential risk of exposure from the sediment pathway. The risk of exposure was negligible for PCB, PAH, Cr, Hg, Pb, and Zn; low for Ag; medium for Cd and Cu; and adverse for Ni. Because the sediment benchmarks for Ni are overprotective (Long et al. 1995), the finding of adverse exposure for Ni may be overly conservative. The data reliability for the sediment screening was good, but there was uncertainty associated with extrapolating sediment results from the ex-AGERHOLM site. This resulted in a medium level of confidence in the conclusions.

6.4. Tissue Screening

Tissue concentrations of PCBs and metals reported for fish and invertebrates in the SCDNR study (Martore et al. 1998, Appendix 2) and PCBs measured in vermilion snapper, white grunt, and black sea bass from the supplemental fish sampling (Appendix 4) were screened against the tissue residue benchmarks (Table 4) for bioaccumulation critical values (B_{CV}), tissue screening values (TSV), critical body residues, and dietary uptake benchmarks.

6.4.1. Graphical Screening of Tissue Residue Data

The results of the graphical screening of the tissue residue data are shown in figures Figure 34 to Figure 45. In each figure the fish or invertebrate residue data from the SCDNR study (Natural Reef, Other Artificial Reef, Navy Vessel Reef, Martore et al. 1998) are compared

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[31] 10% survival difference was statistically different, but did not meet Green Book species-specific requirements to show a 20% difference, based on inherent variability in response of this particular species.

[32] Large difference in Zero Time size of test organisms caused uncertainty in results, but worms from the Inner Ring grew faster, relative to control worms, than those of the Outer Ring.

to fish (spot and croaker) or invertebrate (blue crab or white shrimp) data from EMAP (Carolinian Province Background, Hyland et al. 1998) and to ecological effect benchmarks for fish tissue (see Table 4). Data from the SCDNR study that were reported below the limit of quantitation (LOQ) or detection limit (DL) were plotted as ½ the LOQ (LOQ/2) or DL (DL/2), respectively.

The data reliability for screening PCB concentrations in fish tissue was high. Two independent studies were conducted, the SCDNR study (Martore et al. 1998) and the supplemental fish sampling study (NEHC 2002). The SCDNR study sampled 9 separate reefs over a wide geographical area (Figure 2), and provided quantitative data on PCBs that met minimum QA/QC criteria for 12 species of fish (Martore et al. 1998). However, data from individual reefs were limited, and most of the reported data were below LOQ or DL limit of the analytical method. In the supplemental fish sampling study, three species of fish were sampled from two reefs with adequate replication, and PCB analysis was conducted using two separate analytical procedures by independent laboratories. Each laboratory met or exceeded all data quality objectives and very good comparability was achieved between both laboratories.

The data reliability for the screening of fish residue for metals and invertebrate data for PCBs and metals was passable. Quantitative data that met minimum QA/QC criteria were available (Martore et al. 1998), but they were only from a single study and the data were limited to 2 samples for fish and less than 10 invertebrate samples from the Navy vessel reef group.

PCB

Fish. Figure 34 presents the results of the screening analysis for PCB concentrations in fish tissue. For the plot of fish PCB concentrations, the supplemental fish data for vermilion snapper, white grunt, and black sea bass were included for the ex-VERMILION reef (Navy Vessel Reef) and northern area hard bottom natural reef (Natural Reef). The PCB data from the SCDNR study for Navy Vessel Reef, Other Artificial Reef, and Natural Reef were very similar to EMAP data reported for spot and croaker from the Carolinian Province. Concentrations of PCBs in spot ranged from 15 ng/g dry weight (ppb) to 141 ppb and PCBs in croaker ranged from 20 – 340 ppb. Most of the data reported from the SCDNR study were below the LOQ (<200 ppb) or ND (<20 ppb). Only four samples in the SCDNR data set had quantifiable levels of PCB. They were one black sea bass sample (1348 ppb) and one scamp (*Mycteroperca phenax*) sample (464 ppb) from the central area natural reef, and a leopard toadfish (*Opsanas pardus*) sample (716 ppb) and a black sea bass sample (408 ppb) from the Eagle's Nest Reef.

The data from the supplemental fish sampling of the natural reef were also similar to background data, except for white grunt samples. The total PCB concentrations in white grunt samples from the natural reef were lower than background (white grunt minimum concentration = 2.5 ppb). Data from the target were higher than reference and background, especially for white grunt, which were many times higher than data from the reference site (white grunt maximum concentration. = 5121 ppb). Seven white grunt samples from the Vermilion reef and one black sea bass sample from the central reference reef exceeded the dietary NOAEL benchmark for dolphins. For the target reef, five white grunt samples exceeded the TSV benchmark, 2 samples exceeded the dietary NOAEL for avian piscivores (gulls and cormorants) and sharks, and 87% of the samples did not exceed any of the benchmarks (44 of 51 samples).

Because PCB concentrations in fish from Navy Vessel Reefs were significantly higher than data for the reference reefs (see Table 18 – Table 20) and higher than background concentrations for the Carolinian Province, exposure to PCBs at the Navy Vessel Reef was higher than reference and background. All the data were below the NOED benchmark for fish tissue so it is very unlikely that the exposure would be harmful to demersal fish at the reef. Some samples exceeded the dietary benchmarks (HQmax > 1), but because most of the data were below the benchmarks (HQavg < 1) it is unlikely that the exposure would be harmful to dolphins, cormorants, gulls, and sharks (Table 24).

Invertebrates. Figure 35 presents the results of the screening analysis for PCB concentrations in invertebrate tissues. None of the samples exceeded any of the benchmarks, so it is very unlikely PCB exposure would be harmful to reef invertebrates and very unlikely that PCB exposure would be harmful in the diet of omnivores, sea turtles, and dolphins feeding on invertebrates at the reef. Based on the data available it appears that exposure was higher at Navy vessel reefs than natural reefs and background for the Carolinian Province (Table 25).

Cd

Fish. Figure 36 presents the results of the screening analysis for Cd concentrations in fish tissues. Fish tissue concentrations of Cd from the Navy Vessel Reef were higher than reference and background concentrations; therefore, Cd exposure was higher than reference and background. Half of the Cd data from the Navy Vessel Reef exceeded the TSV benchmarks (HQavg > 1) suggesting that there was a moderate likelihood that the exposure may be harmful to plankton. Neither sample exceeded the NOED nor LOED indicating it was very unlikely that the exposure would be harmful to fish. The Cd data did not exceeded dietary benchmarks for fish-eating predators, so it is very unlikely that Cd exposure in the diet of fish-eating birds would be harmful. With only two fish samples from the Navy vessel reef, confidence in these conclusions was very low (Table 24).

Invertebrate. Figure 37 presents the results of the screening analysis for Cd concentrations in invertebrate tissues. Concentrations of Cd in invertebrate tissues from the Navy vessel reefs were lower than the natural reefs but higher than background for the Carolinian Province, which indicates that exposure to Cd at Navy vessel reefs was similar to reference but higher than background. Most of the Cd data from all the reefs exceeded the TSV benchmark (HQavg > 1) indicating a moderate likelihood that exposure may be harmful to plankton. Two of eight samples from Navy vessel reefs exceeded the NOED benchmark, but none exceeded the LOED benchmark and none exceeded dietary benchmarks for herring gulls or sea turtles. Based on the data available, it is unlikely Cd exposure would be harmful to reef invertebrates and very unlikely Cd exposure would be harmful to herring gulls and sea turtles feeding on invertebrates from the reef (Table 25).

Cu

Fish. Figure 38 presents the results of the screening analysis for Cu concentrations in fish tissues. Copper concentrations in fish from the Navy vessel reef were within the range of the concentrations reported for natural reefs and background for the Carolinian Province, suggesting

the Cu exposure at the Navy vessel reef was similar to reference and background. There is a moderate likelihood that exposure to Cu may be harmful to demersal fish at the reef because all the data for the Navy vessel reef exceeded the NOED benchmark. There is uncertainty associated with this finding because the NOED was estimated from the LOED and may be overly conservative. No data exceeded the TSV or dietary benchmarks for dolphins, cormorants, and herring gulls, suggesting that it is very unlikely that copper exposure in the diet of predators feeding on fish from the reef would be harmful. With only two fish samples from the Navy vessel reef, confidence in these conclusions was very low (Table 24).

Invertebrate. Figure 39 presents the results of the screening analysis for Cu concentrations in invertebrate tissues. Copper concentrations in invertebrates from the Navy vessel reefs were within the range of the concentrations reported for natural reefs and background for the Carolinian Province, which shows that Cu exposure at the Navy vessel reefs was similar to reference and background conditions. Half of the data from Navy vessel reefs exceeded the TSV benchmark, however the average HQ was below the benchmark (HQavg < 1) indicating it was unlikely that Cu exposure was harmful. None of the samples from the Navy vessel reefs exceeded any of the other benchmarks. The available data suggests that it is unlikely that exposure would be harmful to invertebrates on the reef and very unlikely that dietary exposure would be harmful to dolphins, herring gulls, and sea turtles feeding on invertebrates from the reef (Table 25).

Cr

Fish. Figure 40 presents the results of the screening analysis for Cr concentrations in fish tissues. Chromium concentrations in fish from the Navy vessel reef were within the range of the concentrations reported for natural reefs and background for the Carolinian Province, which shows that Cr exposure at the Navy vessel reef was similar to reference and background conditions. One of the samples from Navy vessel reefs exceeded the TSV, NOED, LOED, and B_{CV} benchmarks, but neither samples from the Navy vessel reef exceeded the dietary benchmarks for herring gulls and cormorants. The available data suggests that it is likely that Cr exposure may be harmful to plankton and demersal fish on the reef, but it is very unlikely exposure is harmful in diet of predators feeding on fish from the reef. With only two fish samples from the Navy vessel reef, confidence in these conclusions was very low (Table 24).

Invertebrate. Figure 41 presents the results of the screening analysis for Cr concentrations in invertebrate tissues. The concentrations of Cr in samples of invertebrates from the Navy vessel reefs were similar to Cr in samples from the natural reefs and much lower than Cr reported in invertebrates for Carolinian Province. This means that Cr exposure at the Navy vessel reefs was similar to reference. Two of eight samples from the Navy vessel reefs exceeded the NOED (HQavg > 1) and TSV (HQavg > 1) benchmarks so there was moderate likelihood that the exposure could be harmful to reef invertebrates and plankton. No samples exceeded any of the other benchmarks. Based on the available data it is very unlikely that Cr exposure in the diet of predators feeding on invertebrates from the reef would be harmful (Table 25).

Ni

Fish. Figure 42 presents the results of the screening analysis for Ni concentrations in fish tissues. It is very unlikely that Ni exposure would be harmful because Ni was not detected in either of the samples analyzed from the Navy vessel reef. However, Ni was detected in some fish samples from the natural and other artificial reefs demonstrating that the analytical methods were capable of detecting Ni if the chemical was present in fish tissue. Based on the available data it is very unlikely that Ni exposure is harmful With only two fish samples from the Navy vessel reef, confidence in these conclusions was very low (Table 24).

Invertebrate. Figure 43 presents the results of screening Ni concentrations of invertebrate tissues. Nickel was also not detected in the samples analyzed from the Navy vessel reefs. However, Ni was detected in some invertebrate samples from the natural and other artificial reefs demonstrating that the analytical methods were capable of detecting Ni if the chemical was present in shellfish tissue. Therefore, it is very unlikely that Ni exposure would be harmful (Table 25).

Pb

Fish. Figure 44 presents the results of the screening analysis for Pb concentrations in fish tissues. Lead exposure at the Navy vessel reef was higher than background and reference conditions. Both samples from the Navy vessel reef were higher than the TSV and B_{CV} benchmarks, but the data were not higher than the NOED, LOED, or dietary benchmarks for piscivores and omnivores. This indicates that although Pb did not exceeded critical body residues in carnivorous fish, it is likely that Pb exposure may be toxic to primary producers and consumers (plankton) present at the reef. Since dietary benchmarks for piscivores and omnivores were not exceeded it is very unlikely that Pb exposure would be harmful to predators feeding on fish from the reef. With only two fish samples from the Navy vessel reef, confidence in these conclusions was very low (Table 24).

Invertebrates. Figure 45 presents the results of the screening analysis for Pb concentrations in invertebrate tissues. Lead concentrations in samples of invertebrates from the Navy vessel reefs were higher than reference and backgound levels, which indicated that Pb exposure was higher than reference at the Navy vessel reefs. Concentrations of Pb exceeded the TSV benchmark (HQavg > 1) suggesting that there was a moderate likelihood that exposure could be harmful to plankton. Because none of the samples from the Navy vessel reefs exceeded the NOED or dietary benchmarks it is unlikely that Pb exposure would be harmful to reef invertebrates and very unlikely that Pb exposure in the diet of reef predators foraging on invertebrates from the reef would be harmful (Table 25).

6.4.2. Hazard Quotients and Hazard Indices for Tissue Residue Data

Ecological hazard quotients (HQs) and hazard indices (HIs) were calculated for each complete exposure pathway. The average and maximum HQs obtained for the most conservative benchmarks for demersal fish and invertebrates are presented in figures Figure 46, Figure 47, respectively. Unless otherwise noted, the plots show the HQs for TSV and SCDNR data.

Generally, the TSV benchmark (Dyer et al. 2000, Shepard 1998) was the most conservative benchmark. Both the TSV and B_{CV} benchmarks are based on water quality criteria, and it was assumed that the HQs from the individual benchmarks for each contaminant were additive. The benchmarks for NOED and LOED were based on toxicological effects to fish and invertebrates, but the benchmarks were not always for the same species (or phyla) or for the same toxicological endpoint (Table 8, Table 9). The dietary doses were based on similar effects and were therefore assumed to be additive (Table 10, Table 11, and Table 12). The HI represents the potential for ecological effects to occur when an organism is exposed to all the contaminants in the pathway (Table 26A, 26B).

The range between the average and maximum hazard indices calculated for natural and Navy vessel reefs based on fish and invertebrate data are shown in Figure 48 and Figure 49, respectively. The figures show the relative difference between natural reefs and Navy ship reefs for the benchmarks evaluated. The HIs based on fish tissue calculated for the Navy ship reef exceeded the reference reef for only the TSV and B_{CV} benchmarks (Figure 48). The HIs based on invertebrate residues exceeded the reference reef for only the NOED benchmark (Figure 49).

The average and maximum PCB HQs calculated from the supplemental fish data indicated there was negligible risk of exposure from PCBs for demersal fish and low risk of exposure from PCBs for plankton, herring gulls, cormorants, sharks, and dolphins (Table 26C, Figure 50).

6.4.3. Uncertainty About Tissue Screening

The main sources of uncertainty for the tissue screening were the limited amount of data for screening, the uncertainty about the tissue benchmarks, the assumptions required to assess dietary exposure, and the applicability of reference and background data. There were no data available to screen tissue concentrations for PAHs, Ag, As, Hg, and Zn. Quantitative data were available for the screening but the data were only from a single study (except for the supplemental fish sampling for PCBs) and the data were limited to 2 samples for fish and less than 10 invertebrate samples from the Navy vessel reef group.

Many of the tissue residue benchmarks were derived from toxicity data on freshwater species because toxicity data on reef organisms is not widely available. The TSV represents a conservative initial screening value capable of eliminating chemicals that do not pose significant risks to aquatic biota. If a TSV is exceeded it does not necessarily mean that an observed tissue concentrations poses an adverse risk to biota, rather it indicates that the chemical requires a more detailed evaluation in later phases of the ecological risk assessment (Shepard 1995). Uncertainty factors were used to account for some of the uncertainty, but in many cases application of the uncertainty factors may make the conclusions overly conservative. The assumption that food chain receptors would consume 100% of their diet from the target reefs is very conservative. The dietary benchmarks are based on prey consumption and direct ingestion of surface water and sediment were not included. This was because data on sediment and surface water concentrations were not available. Exposure from incidental contact with sediment would be negligible for predators in the reef environment. Estimates of water concentrations based on steady state leaching showed that water exposure levels were very low which indicates negligible exposure from incidental contact with surface water at the reef (see Section 6.2). Additionally, hazard

quotients and hazard indices do not take into account biological availability and other site-specific factors. While exceeding an HQ=1 or HI=10 in the reference area has little to do with risk from the sunken ship, these metrics presumably reflect the background risk and the difference between the reference and target reefs is the incremental or potential increase in risk that could be attributed to the presence of a sunken ship. Due to the conservative estimates used in the screening analysis, it is very unlikely that potential risks were under estimated.

6.4.4. Conclusions about Tissue Screening of Data from Martore et al. (1998)

The risk of exposure inferred from data from fish and invertebrate tissue residues and low (L), medium (M), or high (H) confidence in conclusion is shown in Table 24 and Table 25 and summarized in Table 26. Risk of exposure inferred from data on fish and invertebrate tissue residues (Martore et al. 1998, Table 26A and B) are summarized below:

Bioaccumulation in Primary Producers and Consumer

The data from fish tissue residues indicated medium risk because there was a moderate likelihood that exposure was harmful and the HI range was higher than reference due to elevated levels of Pb and Cd measured in the two fish samples from the ex-VERMILION reef. The invertebrate tissue data suggested negligible risk because exposure was unlikely to be harmful and the HI range was less than background. Based on the limited data available it was determined that there was a moderate likelihood that exposure may be harmful to the most sensitive primary producers and consumers at the reef.

Critical Body Residues in Secondary Consumer (Demersal Fish, Reef Invertebrates)

The data from fish tissue residues indicated negligible risk of exposure to demersal fish because while there was a moderate likelihood that exposure would be harmful to fish the exposure range was similar to reference and background conditions and could not be attributed to incremental risk from the target reefs. The invertebrate tissue data showed negligible risk of exposure to invertebrates because exposure levels were very unlikely to be harmful and the exposure levels were similar to reference and background conditions. Based on the limited data available it was concluded that there was negligible risk to demersal fish and reef invertebrates.

Dietary Exposure to Secondary Consumer (Sea Turtle)

The invertebrate tissue data indicated negligible risk to sea turtles because it was very unlikely that exposure was harmful to sea turtles and that the exposure level was similar to reference and background conditions. Based on the limited data available it was concluded that there was negligible risk to sea turtles.

Dietary Exposure to Tertiary Consumers (Dolphin, Shark)

The data from fish and invertebrate tissue residues indicated negligible risk to dolphins and sharks because it was very unlikely that exposure levels were harmful and that exposure

levels were similar to reference and background conditions. Based on the limited data available it was concluded that there was negligible risk to dolphins and reef sharks.

Dietary Exposure to Avian Consumers (Herring Gull, Double-Crested Cormorant)

The data from fish and invertebrate tissue residues indicated negligible risk to herring gulls and cormorants because it was very unlikely that exposure levels were harmful and that exposure levels were similar to reference and background conditions. Based on the limited data available it was concluded that there was negligible risk to herring gulls and cormorants.

6.4.5. Conclusions about Tissue Screening of Data from Supplemental Fish Sampling

There was high confidence in the conclusions derived from the supplemental fish sampling because it was a site-specific study that collected three species of fish from the target and reference reefs, with a high degree of replication, using high resolution methods capable of quantify homologous and congeners at very low detection limits that were verified by two independent laboratories. The risks of exposure inferred from data from the supplemental fish sampling for PCBs (Table 26C) are summarized below:

Bioaccumulation in Primary Producers and Consumer

The tPCB data from the supplemental sampling indicated low risk to primary producers and consumers because it was unlikely that exposure to tPCB was harmful but the exposure levels were significantly higher at the target reef than the reference reef. Because the supplemental fish sampling provided high quality site-specific data for the risk analysis there was high confidence of low risk of exposure to PCBs to primary producers and consumers.

Critical Body Residues in Secondary Consumer (Demersal Fish)

The tPCB data from the supplemental sampling indicated negligible risk of exposure to secondary consumers (demersal fish) because even though the exposure levels were significantly higher at the target reef than the reference reef it was very unlikely that exposure to tPCB was harmful. Because the supplemental fish sampling provided high quality site-specific data for the risk analysis there was high confidence of negligible risk of PCB exposure to demersal fish.

Dietary Exposure to Tertiary Consumers (Dolphin, Shark)

The tPCB data from the supplemental sampling indicated low risk of exposure to tertiary consumers (dolphins and sharks) because even though the exposure levels were significantly higher at the target reef than the reference reef it was unlikely that exposure to tPCB was harmful. Because the supplemental fish sampling provided high quality site-specific data for the risk analysis there was high confidence of low risk of PCB exposure to dolphins and reef sharks.

Dietary Exposure to Avian Consumers (Herring Gull, Double-Crested Cormorant)

The tPCB data from the supplemental sampling indicated low risk of exposure to avian consumers (herring gulls and cormorants) because even though the exposure levels were significantly higher at the target reef than the reference reef it was unlikely that exposure to tPCB was harmful. Because the supplemental fish sampling provided high quality site-specific data for the risk analysis there was high confidence of low risk of PCB exposure to herring gulls and cormorants.

6.5. Advanced Screening for Effects from PCBs

To further address the ecotoxicological risk of exposure to PCBs an advanced screening analysis for PCBs was conducted. The advanced screening consisted of evaluating the distributions of PCB congeners measured in the supplemental fish samples, analyzing the potential toxicity from dioxin-like coplanar congeners, and conducting a probabilistic analysis of PCB exposure. The probabilistic analysis included calculating the probability of exceeding benchmarks of PCB exposure, comparing the PCB exposure distribution observed in fish at the target reef to species sensitivity distributions (SSDs) of effects from residues of PCBs in fish, and calculating the probability of an effect from PCB residues to fish, given the probability of exposure from PCBs in fish residues.

6.5.1. PCB Congener Distributions

The raw data for PCB congeners and homologs measured in the supplemental fish samples are reported in Appendix 4E.2. (Note the variable names, description, and units of the variables used in the appendices are listed in Appendix 4E.1). A review and validation of the congener and homolog data performed for the human health risk assessment determined that the data met the data quality objectives for sensitivity, accuracy, precision, completeness, representativeness, and comparability (NEHC 2004a). The sample specific detection limits reported for individual congeners and homologs ranged from 0.01 – 3.6 pg/g (wet) and 0.02 – 1.9 pg/g (wet), respectively (Appendix 4E.3). Nondetected results were reported for 7% of HOMO_CL1, 9% of PCB077, 3% of PCB123, 58% of PCB126, 93% of PCB169, and 5% of PCB184 sample results (Appendix 4E.4). Nondected results were estimated as ½ of the sample specific detection limit.

The Lin-Mudholkar test for normality showed that the log-transformed data better conformed to a normal distribution than the untransformed data (Appendix 4.E5) and it was assumed that the data conformed to a lognormal distribution for subsequent analyses. Example histograms calculated for tPCB and PCB126 for all fish from both reefs, and HOMO_CL6 and PCB153 for all fish from the reference and target reefs shown in Figure A4E-1 illustrate the lognormal characteristics of the data set.

The mean, and standard deviation calculated for each congener and homolog for all fish, vermilion snapper, white grunt, and black sea bass for site and reference (Appendix 4E.6) were used to generate plots for each group to qualitatively compare the distributions of homologs and congeners (Appendix 4E.6). The plots for all fish data grouped by reference and target reef

showed similar distributions of homologs and congeners, but that the target fish had much higher levels and more variability than the reference fish (Figure A4E-2). The most abundant homolog in both groups was hexachlorobiphenyl (HOMO_CL6) followed by penta-, hepta-, and tetrachlorobiphenyl, which accounted for 43%, 25%, 17%, and 4% and 39%, 36%, 10%, and 9% of tPCB for reference and target fish, respectively (Figure A4E-3). The percentage of HOMO_CL5 and HOMO_CL4 was higher in the target reef while the percentage of HOMO_CL6 and HOMO_CL7 was higher in the reference fish. The most abundant congeners measured in both groups were PCB153, PCB138, PCB118, and PCB101 (Figure A4E-3). The percentage of more chlorinated compounds (PCB153, PCB180, and PCB187) were slightly higher in the reference fish and the less chlorinated congeners (PCB118, PCB101, PCB087, and PCB052) were slightly higher in target fish (Figure A4E-3).

Distributions of homologs and congers in the individual species were similar to the distribution found in all fish. Vermilion snapper samples from the target reef had concentrations about twice as high for homologs and congeners than the reference samples (Figure A4E-4) and lower chlorinated homologs and congeners were slightly higher in the target samples (Figure A4E-5). As expected, the homologs and congeners measured in white grunt samples from the target reef were much higher than the reference reef, but the pattern of congeners and homolog distributions were very similar in both groups (Figure A4E-6). The white grunt data had the most similar pattern of homologs and congeners of the three fish species evaluated with nearly the same percentage of homologs and congeners present at both sites (Figure A4E-7). The black sea bass from the target site had distinctly more lower-chlorinated congeners that the reference site (Figure A4E-8) which resulted in a higher proportion of penta- and tetra- homologs and congeners in the samples from the target reef (Figure A4E-9).

An eigen-vector principal component procedure (Statistix 1996) was conducted to further quantify the differences in the PCB congeners observed between reference and target fish. Multivariate principal components based on the correlation matrices were calculated from the data and principal component loading factors were obtained (Appendix A4E.7). The first four principal components (PC1, PC2, PC3, PC4) explained 86.7%, 7.5%, 2.4%, and 1.2% of the variance in the data, respectively (97.8% cumulative percent). The loading vectors were used to transform and project the raw data on to principal component space to evaluate any underlying patterns in the data (Figure A4E-10). The best separation of the data was obtained plotting PC3 vs. PC4 (Figure 52), which showed a tight cluster of points near the origin consisting of reference and target reef vermilion snapper and black sea bass samples surrounded by outlying white grunt and black sea bass samples from the target reef. Because none of the samples formed readily distinguishable groupings in the scatter plots of principal components it appeared that samples from the target and reference reef were exposed to similar patterns of congeners. The most discriminating feature of the PCA was the strong relationship between PC1 and PCB concentration (Figure 53). PC1 explained 86.7% of the variance and most of the variance was due to differences in concentration, which clearly separated the samples with the highest levels of tPCB or individual congeners (Figure 53).

6.5.2. Analysis of Dioxin-like Toxicity

Data from the dioxin-like coplanar congeners were multiplied by the respective TEFs to calculate TECs for fish and fish eggs (Appendix 4F.2) and dietary exposure to birds (Appendix 4F.4) and mammals (Appendix 4F.6). The TEQs calculated for fish tissue were similar between target and reference for black sea bass and vermilion snapper, but were much higher for white grunt from the target reef than from the reference reef (Table A4F-2 and Figure A4F-1). Based on maternal transfer from female to egg, the average TEQs calculated for white grunt fish eggs at the target reef exceeded the NOED (0.3 pg TEQ/g wet weight) and LOED (3 pg TEQ/g lipid) benchmarks for salmon egg mortality (Figure A4F-2). The largest component of the TEQ in fish tissues and fish eggs from the target reef was from congeners PCB081 and PCB126 which accounted for about 40% and 30% of the TEQ, respectively (Figure A4F-3). The lipid-based TECs calculated for dioxin-like coplanar PCBs in fish eggs had a different distribution of TECs than was obtained for the fish (Figure A4F-3). This is probably because of the differences in the egg:female transfer ratio and lipid levels in the females used to calculate the fish egg TECs.

The TEQ benchmarks for fish eggs were based on the most susceptible life stage of fish to dioxin-like toxicity (deBruyn et al. 2004, Cook et al. 2003) and provide a very conservative estimate of potential risks to reproductive effects to the reef fish. The TEQ concentrations in eggs were estimated using the average egg to female transfer ratio for each coplanar congener (EF_{PCBi}) calculated from data for lake trout and pre- and post-migration sockeye salmon eggs and females reported in Cook et al. (2003) and deBruyn et al. (2004, see Appendix 4F.2 Table A4f.1). The analysis assumed that there are similar processes and sensitivities between lake trout and sockeye salmon and the REEFEX fish. The egg:female transfer ratio (EF) is lipid normalized, so whole body concentration was assumed to be proportional to lipid (Appendix 4F.2). The EF is very sensitive to lipid concentrations, which were highly variable in the REEFEX fish, especially black sea base and white grunt. The concentrations of dioxin-like PCB congeners reported in lake trout females sampled from Lake Ontario in 1988 (Cook et al. 2003), that were used to calculate EF, were about 3-4 orders of magnitude higher than the dioxin-like congeners measured in the REEFEX fish. On the other hand, the concentrations of dioxin-like congeners in the REEFEX fish were very similar to the pre-migration sockeye salmon and slightly lower by about a factor of two to the post-migration sockeye salmon reported in deBruyn (2004). The TEQs calculated for eggs were based only on dioxin-like toxicity from PCBs and do not take into account any additional toxicity from the presence of dioxins and furans. The largest component of the TEQs reported in lake trout from Lake Ontario were from TCDD (60-85% of the TEQ, Cook et al. 2003) while the TEQ for the pre- and post-migration sockeye salmon was almost all from dioxin-like PCBs (>95%, deBruyn et al. 2004).

The TEQs calculated for dietary exposure to birds showed that the average TEQ calculated for white grunt from the target reef exceeded the Canadian Council of Ministers of the Environment (CCME) guideline concentration of 2.4 pg TEQ/g diet (wet, CCME 2003) from PCBs for protection of avian wildlife consumers (Figure A4F-4). However, the maximum TEQ for white grunt 42 pg/g (wet) did not exceed the site-specific cormorant or herring gull NOAEL TEQ of 62 and 65 pg/g, respectively (Table A4F-3). The largest component of the TEQ for bird consumption of fish tissues from the target reef was from congeners PCB077, PCB126, and PCB105 which accounted for about 40%, 30%, and 13% of the TEQ, respectively (Figure A4F-5).

The TEQs calculated for dietary exposure to dolphins showed that the average TEQ calculated for white grunt and black sea bass from the target reef exceeded the Canadian Council of Ministers of the Environment (CCME) guideline concentration of 0.79 pg TEQ/g diet (wet, CCME 2003) from PCBs for protection of mammalian wildlife consumers (Figure A4F-6). The average TEQ for white grunt exceeded the site-specific NOAEL for dolphin and the maximum TEQ for white grunt 48 pg/g (wet) also exceed the dolphin LOAEL TEQ of 18 pg/g (Table A4F-4). The largest component of the TEQ for dolphin consumption of fish tissues from the target reef was from congeners PCB118, PCB126, and PCB156 which accounted for about 32%, 24%, and 23% of the TEQ, respectively (Figure A4F-7).

The CCME guidelines were derived as very conservative benchmarks for the protection of wildlife species such as mink, otter, kingfisher, and eagle (CCME 2003) and were not scaled to the body size and consumption rate of marine mammals and birds that could forage on the reef. They are included in this report for comparison purposes only.

Because PCB126 was not detected in more than half of the samples (58%) there is uncertainty about the TEQ calculations. PCB126 is the most toxic dioxin-like PCB congener and has a TEF of 0.005 for fish and 0.1 for birds and mammals (van den Berg 1998, Table 15) so the concentrations of PCB126 have a large bearing on the total TEQ calculated for each sample. The nondetected (ND) values were assumed to be equal to the sample specific detection limit (ND = DL/2), and in many cases this resulted in estimated values of PCB126 that were higher than actually quantified concentrations. ND values of PCB126 were reported for samples from all three species of fish from both the target and reference reefs, including samples with some of the highest concentrations of total PCBs. This most likely occurred because the samples with high concentrations of tPCB required the analysis to be performed on diluted samples, which raised the sample specific detection limits for individual congeners including PCB126. To address the relative uncertainty associated with the ND values, the TEQs were also calculated after setting the ND results to zero (ND=0) and after setting the ND results to the detection limit (ND=DL). The TEQs calculated when ND was set to zero showed a reduction by a factor of 1.3 – 2.8 for the TEQs calculated for fish, reduction by a factor of 1.3 – 1.5 for dietary exposure to birds, and reduction by a factor of 1.2 – 1.9 for the TEQs calculated for dietary exposure to mammals (Appendix 4F.8). The TEQs calculated when ND was set to the DL showed an increase by a factor of 1.2 – 1.5 for the TEQs calculated for fish, increase by a factor of 1.3 for dietary exposure to birds, and an increase by a factor of 1.2 – 1.5 for the TEQs calculated for dietary exposure to mammals (Appendix 4F.9). This indicated that the DL/2 was a reasonable estimate of the ND values and did not overly bias the TEQ calculation as neither too high nor too low.

There is a wide range of sensitively to dioxins among fish, birds, and mammals (Gatehouse 2004). The benchmarks used in this analysis were based on data available for the most sensitive fish (salmonids), avian (order galliformes – chicken-like birds e.g. pheasant) and mammal (mink) for which toxicity data are available (Gatehouse 2004) and it was assumed that these benchmarks would not under estimate the potential risk to receptors on the reef. Additionally, the dietary benchmarks assumed that tertiary consumers dined exclusively on the reef throughout their whole life span with an assimilation efficiency of 90% (diet and life span, d = L = 1.0; a = 0.9 see Equation [20]). Reducing these parameters would increase the dietary benchmarks by the same factor.

6.5.3. Probability of Exceeding Effects Levels for PCBs

The probability that harmful exposures would occur was calculated to better quantify the magnitude of ecorisk indicated by the available data (Johnston et al. 2001). This information is useful to risk managers because it adds quantitative rigor to the ecorisk analysis beyond the simple, exceeds benchmark analysis provided by the initial screening alone. The probability of exceeding the benchmarks used in the initial screening for PCBs was calculated for the reference and target populations and the difference between target and reference (Equation [53]) was interpreted as the incremental risk of exceeding the benchmarks (Table 27, Figure 54). At this writing the criteria used to evaluate the results of the probabilistic analysis (see Section 5.5.6) have not yet been reviewed and agreed to by the REEFEX Technical Working Group.

The probability that fish from the reference reef would exceed a benchmark was P<0.000001 for all benchmarks, therefore the probability of exceeding a benchmark for the target reef was equal to the incremental risk (Equation [53]). The risk of target fish exceeding the dietary NOAEL for dolphin was low (RISK = 0.076) and there was very low risk (RISK = 0.006) that the dietary LOAEL for dolphins would be exceeded. There was low risk that the target fish would exceed the TSV benchmark (RISK = 0.0495) and very low risk (RISK = 0.00014) that the B_{CV} for PCBs would be exceeded. There was low risk of exceeding the dietary NOAELs for cormorants, gulls, and sharks and very low risk that the CBR for fish NOED (RISK = 0. 006) or LOED (RISK = 0.004) would be exceeded in fish at the target reef (Table 27B).

The risk calculation for dioxin-like PCBs to fish eggs showed that there was low risk of exceeding the sensitive rainbow trout benchmark for egg mortality NOAEL (RISK =0.093) and LOAEL (RISK = 0.084) at the target reef and very low risk (RISK <0.001) of exceeding the thresholds for effects to lake trout sac-fry larvae (Table 27C). For dioxin-like PCB exposure to avian receptors there was very low risk of exceeding site-specific benchmarks for herring gulls or cormorants (Table 27D and E). There was medium risk (RISK = 0.24) and low risk (RISK = 0.036) of exceeding the site-specific dietary NOAEL and LOAEL, respectively for dolphins at the target reef (Table 27F).

The risk of exceeding other benchmarks for effects to dolphins from exposure to tPCB (Table 27G) and dioxin-like congeners (Table 27H) and effects to fish eggs from exposure to dioxin-like congeners (Table 27I) were also evaluated. For the target reef fish, there was high risk of exceeding the very conservative NOAEL of 37 ng/g tPCB (dry weight), low risk for exceeding the lowest reported LOAEL of 1238 ng/g tPCB (dry weight), low risk of exceeding benchmarks greater than 1100 ng/g tPCB (dry weight), and negligible risk of exceeding benchmarks greater than 36000 ng/g tPCB (Table 27H). For dolphin dietary exposure to TEQ there was medium risk of exceeding the NOAEL and low risk of exceeding the LOAEL reported for exposure to weathered PCBs (references [20] and [23] in Table 27H). The concentrations of TEQ in fish eggs indicated very low risk of exceeding the lowest NOAEL for mortality to lake trout sac fry larvae and negligible risk of exceeding of exceeding the benchmarks for the other species (Table 27I).

The exposure distributions for the target and reference fish were also compared to the concentrations of the PCBs and TEQs measured in diets of harbor seals that were feed “clean” fish from the Atlantic Ocean and “contaminated” fish from the Baltic and Wadden Seas. The

seals feed contaminated fish exhibited immune suppression and other effects consistent with exposure to PCBs (Ross et al. 1994, Gatehouse 2004). The Atlantic Ocean fish had an average concentration of 123 ng/g tPCB (dry weight) and 3.56 pg/g TEQ (wet weight), the Wadden Sea fish had an average concentration of 737 ng/g tPCB (dry weigth), and the Baltic Sea fish's concentration was 35.4 pg/g TEQ (wet weight, Table 27G and H, see references [15], [16], [41], and [42]). The probabilistic analysis showed that 98% of the reference reef fish were below the average concentrations of tPCB and TEQs reported for the "clean" Atlantic Ocean fish and that 15% of the target reef fish exceeded the levels of tPCB reported for "contaminated" Wadden Sea fish and 1% of the target reef fish exceeded the levels of TEQ reported for "contaminated" Baltic Sea fish (Table 27G and H). This indicates that the reference reef fish were cleaner than the "clean" Atlantic Ocean fish and that 15% of the fish from the target reef exceeded the levels that have been associated with adverse effects from PCBs.

The probabilistic analysis quantified the potential level of risk to ecological receptors based on the benchmarks and available data (Table 28). The overall risk was determined from the combination of risk levels calculated for exceeding the conservative benchmark (i.e. TSV, NOED, and NOAEL) and the less conservative benchmark (i.e. B_{CV}, LOED, and LOAEL). The low risk of exceeding the TSV and very low risk of exceeding the B_{CV} was interpreted to mean that there was very low risk of potentially harmful PCB exposure to primary producers and consumers of the reef community. The very low risk of exceeding the NOED and LOED for critical body residues in fish was interpreted to mean that there was very low risk of harmful PCB residues in demersal fish. For dolphin consumption of prey (fish), the low risk of exceeding the NOAEL and very low risk of exceeding the LOAEL were interpreted to mean that there was very low risk of harmful PCB exposure to dolphins. The low risk of exceeding the NOAEL and very low risk of exceeding the LOAEL for cormorants and gulls indicated that there was very low risk of harmful PCB exposure to avian consumers. Based on the low risk of exceeding the NOAEL and negligible risk of exceeding the LOAEL for shark consumption of prey (fish), it was concluded that there was negligible risk of harmful PCB exposure to sharks.

The probability of exceeding the TEQ benchmarks was used to assess the potential risk of exposure to dioxin-like congeners. The low risk of exceeding the NOAEL and LOAEL for dioxin effects to fish eggs was interpreted to mean that there was low risk of harmful TEQ exposure to fish eggs. For dolphin consumption of prey (fish), the medium risk of exceeding the NOAEL and very low risk of exceeding the LOAEL was interpreted to mean that there was low risk of harmful TEQ exposure to dolphins. It was also concluded that there was negligible risk of harmful dioxin exposure to avian consumers because there was very low risk of exceeding the NOAEL and negligible risk of exceeding the LOAEL for herring gull and cormorant consumption of prey (fish).

The dietary benchmarks were very conservative because they are based on the assumption that 100% of the predator's diet comes from the reef and that a predator would live out its entire life span on the reef (i.e. predator is nonmigratory and remains at the reef long enough to reach a steady state with the exposure concentrations). Reducing these assumptions would reduce the amount of risk. For example, assuming that only 50% of a dolphin's diet came from the reef and that only half of the dolphin's life span was on the reef (i.e. dolphin is present on the reef long enough to obtain 50% of the steady exposure) the dietary benchmarks would be increased by a factor of four and the risk of exceeding the benchmarks would be reduced

considerably. In this case the risk of exceeding the dolphin NOAEL and LOAEL for tPCB would decrease from 0.076 to 0.008 and from 0.006 to 0.0003, respectively, and the risk of exceeding the dolphin NOAEL and LOAEL for TEQ would decrease from 0.24 to 0.044 and from 0.037 to 0.003, respectively.

6.5.4. Probability of Exceeding Species Sensitivity Distribution

The broader implications of potential ecotoxicolgical risk from PCBs was evaluated by comparing the PCB exposure distributions for reference and target reef fish to SSDs derived for CBRs in fish tissues (NOED and LOED) and effects of TEQs on sac fry larvae of fresh water fish. The cumulative distribution for the reference and target fish showed very little overlap with the cumulative distribution function estimated for fish tissue NOEDs and LOEDs (Figure 55). The NOED had a slightly better fit to the cumulative probability distribution than the LOED, but it appeared that the assumed lognormal distributions described the effects distributions reasonably well (Figure 55). The overlap between the upper tail of the target reef exposure distribution and the lower tail of the effects distributions are shown graphically in Figure 56 and Figure 57 for the NOED and LOED SSDs, respectively. There was low risk of exceeding an NOED (RISK = 0.047) and an LOED (RISK = 0.0392) for fish from the target reef. This supported the conclusion of low risk of PCB exposure to secondary consumers (demersal fish) at the target reef.

The cumulative distribution estimated for sac-fry larvae effects from TEQs showed a good fit to the data available for fresh water species (Figure 58, Gatehouse 2004). There was very low risk of exceeding the SSD for sac-fry NOAEL (RISK = 0.0003, Figure 59), which supported the conclusion that there was low risk of PCB exposure to secondary consumers (demersal fish) at the target reef. This analysis assumes that sac-fry larvae of reef fish are as susceptible to the effects of TEQ exposure as are the fresh water fish for which toxicity data are available. The SSD reflects the sensitivity of a whole group of species and the overlap with the target exposure reef was interpreted to represent the risk to all fish at the reef assuming that the exposure distribution was truly representative of the exposure to the reef fish population.

It was assumed that the exposure and effects distributions conformed to lognormal distributions. This is conservative because the lognormal distribution for exposure has a long tail on upper end that extends toward the lower tail of the effects distribution without the apparent threshold that is implied by a single point benchmark. The tail of the exposure distribution can be interpreted to represent the proportion of the population that is exposed to the highest concentrations of PCBs.

The underlying assumptions and uncertainties inherent in the exposure distributions and effects levels are still present and must be factored into the uncertainty of the analysis and confidence in conclusions. However, the probabilistic analysis provides a more quantitative evaluation of the existing data. This information is useful to risk managers because it quantifies the magnitude of risk and can be used to calculate the effect of an outlier in the data set or evaluate the risk levels in the light of newer data or better information on toxicity thresholds. The SSD supported the findings of the other components of the risk assessment, namely, that there was low risk of exposure to secondary consumers (demersal fish) at the target reef.

Interior of the ex-VERMILION artificial reef (Photo by SCDNR).

7. Literature Review

7.1. Decommissioned Ships as Artificial Reefs

Other than the ex-AGERHOLM (SINKEX) and the ex-VERMILION and ex-BETSY ROSS (this study) few studies have been conducted to evaluate PCB levels and potential releases from former Navy vessels. One exception is the study performed by the Environment Canada on former Canadian Navy destroyers that were sunk to create artificial reefs in British Columbia and San Diego, California. The study, conducted by the by the Ocean Disposal Division of Environment Canada, evaluated PCB contamination levels in the vicinity of an artificial reef created from the sinking of a former Canadian warship (ex- SASKATCHEWAN DDE 262 Destroyer Escort). The study was discussed during the June 28, 2000 REEFEX Technical Working Group Meeting. Prepared according to the clean-up standard for ocean disposal of vessels required by Environment Canada (Environment Canada 2001a, 2002b), the ex-SASKATCHEWAN was sunk at a depth of 100 ft in coastal waters off the coast of Vancouver Island, British Columbia (Lee 2000). Sediment, sea urchin, and free-swimming scallops were collected from within and around hulk. Environment Canada reviewed these data and concluded that: "based on our current knowledge … the decommissioned vessel appears to pose no risk to human health and minimal risk to the marine environment" (Lee 2000).

The data from the ex- SASKATCHEWAN were also evaluated by the California Coastal Commission during their review of the San Diego Oceans Foundation and City of San Diego's application to sink the ex-YUKON DDE 263 about 2 miles offshore of Mission Bay along the Coast of San Diego (California Coastal Commission 2000a). A special condition of the permit to sink the YUKON required that the results of sampling of the ex-SASQTCHEQUAN and ex-MACKENZIE DDE 261[33] showed that "… levels of PCBs [were] not higher than background levels" (California Coastal Commission 2000a). Upon reviewing the data from Environment Canada and meeting other provisions of the application, the request to sink the ex-YUKON was approved with conditions on April 12, 2000 (Application No. E-99-8). Provisions of the approval included that "… all PCBs are to be removed from the vessel, including those components which may have PCB concentrations less than 50 ppm" (California Coastal Commission 2000b). On July 14, 2000 the ex-YUKON was sunk off Mission Bay in 105 ft of water where it is now a popular dive site (San Diego Oceans Foundation 2002b).

The experience from the ex-YUKON and other reefs created from ex-warships shows that ex-warships can be successfully reused to create artificial reefs that provide ecological and socioeconomic benefits (Jones and Welsford 1997, Francis 2001, Phillips and Gamble 2001, San Diego Oceans Foundation 2002a, b). According to Environment Canada's clean-up standard for ocean disposal of vessels, any equipment or components suspected of containing PCBs must either be removed or certified that the "equipment or component does not contain PCBs" (Envi-

[33] The HMCS MACKENZIE was another Canadian destroyer sunk to create an artificial reef in British Columbia.

ronment Canada 2001b). However, Environment Canada's standard is not based on risk and the cost and practicability of removing everything irregardless of risk may preclude realizing the benefits of creating artificial reefs with ex-warships.

Currently, the San Diego Oceans Foundation has been caring out a volunteer monitoring program for the ex-YUKON (Barger 2003, SDOF 2004, Parnell 2005). In the ex-YUKON study volunteer divers are recording data on colonizing patterns and fish abundance on the reef. Data complied over the first four years after sinking shows that the ex-YUKON provides fish habitat that is being utilized by sheephead (*Semicossyphus pulcher*), baccacio (*Sebastes paucispinis*), blacksmith (*Chromis punctipinnis*), barred sand bass (*Paralabrax nebulifer*) and other fishes. However, there is concern that the attraction of these fish to the ex-YUKON may be leading to over exploitation by recreational fishers from private boats and commercial charter boats. Whether the ex-YUKON is enhancing natural populations of fish or increasing their exploitation is unknown because rigorous studies to address this issue have not been conducted (Parnell 2005).

A few studies have also evaluated contaminants released from other types of artificial reefs. Scrap tires are popular materials for artificial reefs because they are cheap, plentiful, durable, and have lots of void spaces. Hundreds of millions of tires are produced ever year (200 million/yr in the US, 37 million/yr in UK, Collins 1999). However, little is known about the environmental consequences of tire disposal in the marine environment. Laboratory leaching studies have shown that zinc and PAHs are released from tires. Collins (1999) studied experimental reefs constructed of scrap tires and concrete to compare colonization patterns and accumulation of metals and PAHs in organisms growing on the reef. Results one year after depolyment showed that Zn, Cu, Pb, and Cd were higher in hydroids (*Halecium* sp) and Cd was higher in bryzoans (*Bugula flabellata*) collected from tire reefs than those collected from concrete reefs. There were no differences in the colonization patterns on the tires and concrete except that the percent cover of bryzoans was four times higher on the tires than on concrete. Differences in community composition were greater among different reef shapes than surfaces (concrete or tire) suggesting that the orientation of reef is more important than its composition. Photos of the reef showed well-developed invertebrates present on both tires and concrete, although flexing of the tires may limit the build up of rigid fouling organisms. Laboratory leaching studies showed a decrease in the amount of chemicals released with exposure time, presumably because only a very thin surface layer of the tire is depleted. The leaching studies were conducted by shaking tire "crumbs" in seawater for 1-42 days, so there is much more surface area and probably no buildup of the slime layer than would be present on surfaces actually deployed in the sea (Collins 1999).

Contaminant releases from coal-fly ash have also been evaluated (Spanier 1999). Coal-fly ash is generated from the combustion of coal for energy production. Because 10-20% of coal mass remains as ash after burning, 8.6 million tonnes were produced in Israel between 1982-1998. There is concern that heavy metals could leach from large-scale disposal of coal fly ash. The study showed that fly ash increased the compressive strength of concrete by up to twice as much and the effect was enhanced with immersion time in the sea. The number of species that settled on the blocks and the biotic coverage did not vary significantly with differing proportions of fly-ash, from 0% to 80%. Furthermore, no temporal changes in trace metal composition were detected in selected biota sampled from the blocks (Spanier 1999).

A detailed review of data from studies of other sunken vessels and global ocean PCB concentrations reported in the literature was prepared for the SINKEX study. For more information the reader is referred to that review (Gauthier et al. 2002, 2005). In addition, a volume of Marine Technology Society Journal that addresses Underwater Pollution Threats to Our Nation's Marine Resources was recently published.

7.2. Considerations for the Development and Management of Artificial Reefs

There were striking differences between the natural and artificial reefs studied during this project (Figure 51). They are comprised of different substrates, natural hard bottom versus steel ship. They are located in about the same location and depth on the continental shelf, but they have different profiles – the ex-VERMILION artificial reef extends to 55 ft (17m) from the bottom while the natural reef has a very low profile of about 8 ft (2.4 m). The higher relief and greater size of the artificial reef (Appendix 3) may provide more habitat for development of epibenthic biomass comprising different links in food chain than is present on the natural reef.

The physical and ecological difference between natural and artificial reefs is a theme that pervades artificial reef. The question is one of whether artificial reefs are really beneficial — resulting in net increases in productivity (fisheries); or harmful — because artificial reefs actually attract fish from natural areas and make them more exploitable (easily accessible to fishermen) resulting in increased pressure and a decrease in the overall status of the resource. Complicating this question is the many different purposes of building artificial reefs. These range from “protection reefs” (reefs designed to discourage and disrupt bottom trawling) to mitigation reefs (reefs built to mitigate for loss of natural habitat) and fisheries enhancement reefs (reefs constructed specifically to enhance the harvesting of one or more species of fish or shellfish).

There are also many contrasts in the way reef science is evolving and how it is applied in different countries. Japan is, by far, more advanced than other countries, with a more refined conceptual approach (the seabed is just an extension of the landscape) and a clear focus on fisheries enhancement and increasing productivity (building reefs to create upwelling zones, farming the sea, etc.). The European focus tends to be more towards “protection reefs” (nature conservation and habitat protection — protecting seagrass beds in the Mediterranean Sea from bottom trawlers for example) and aquaculture (especially in France), while in the US reef building is almost exclusively focused on recreational fishing, diving, and mitigation for development projects. Is the creation of artificial reefs a euphemism for “dumping junk — like ships” (sic W. Seaman, University of Florida, personal communication) and disposal of unwanted debris (in the case of oil platforms in the North Sea and Southern California) or is it really enhancing the natural environment?

A central issue is the ability to scientifically evaluate the effects of artificial reefs (“trick or enhancement?” sic Prof. Giulio Relini, University of Genoa, personal communication). There appears to be no commonly accepted “standardized” approach. Virtually every investigator is going about it differently, and except for a few notable exceptions, there is no unifying framework for evaluating potential benefits or ecological harm.

Although building artificial reefs is a manipulation of the environment, there is no true experimental "control" that can be used for hypothesis testing. Usually "reference reefs" or "natural reefs" are used as "controls" for comparison purposes. This results in a definite inability to infer differences between "natural" and "artificial" because the reefs invariably differ in time, space, and key ecological conditions (very similar to the problem of trying to conduct environmental assessments between "impacted" and "nonimpacted" areas.) An exception is experiments where replicate reefs are constructed with different materials. In this case, the reef material itself is the experimental variable and inferences can be made relative to the different substrates. However, even in this case, the basis for determining whether the ecological system has been enhanced or not is generally lacking.

Ecological systems can be described by their structure (what they are composed of) and function (what they do). Most reef studies are aimed at quantifying the structure of the reef (counting and enumerating the species present) and very few attempts have been made to evaluate the reef's ecological function (recruitment, primary and secondary production, biogeochemical cycling of nutrients and energy, etc). This is similar to reporting that building "A" has 3 floors, 5 doors, 6 windows, etc. and building "B" has 8 floors, 4 doors, 16 windows, etc. but failing to discern that building "A" is a factory and building "B" is a hotel. Without methods capable of quantifying the structure and function of reef systems it will be very difficult to derive conclusions about how artificial reefs may benefit natural systems.

As stated above, artificial reefs are being constructed for many different purposes. It is possible that artificial reefs may accomplish one set of objectives (e.g. enhance SCUBA diving and recreational fishing) but may not be ecologically sound (leading to overexploitation) unless they are managed properly (no take and conservation areas). In some cases the reef may have conflicting or mutually exclusive objectives (mitigation for lost habitat, fisheries enhancement, and recreational fishing and diving). Evaluation criteria are needed to evaluate whether artificial reefs can meet design goals, whether they are functioning as desired, and if they are providing ecological benefits.

The multi-purpose nature of reefs results in an array of management alternatives that are not always identified. How to balance the conflicting goals of interest groups and users (stakeholders) and how to incorporate good science into management decisions is a daunting task for reef managers. Developing a plan for getting a reef in the water is only the beginning of the management process. Management goals and alternatives must be projected beyond simply deploying artificial reefs if a basis for long-term ecological enhancement is to be developed.

With respect to using former Navy vessels as artificial reefs, the beneficial reuse of deactivated ships for the construction of artificial reefs as an extremely cost-effective alternative to ship breaking (Hess et al. 2001, Hynes et al. 2004). For REEFEX, the question of whether contaminants from sunken vessels are effecting or bioaccumulating in the reef biota is overlaid on top of the other artificial reef issues discussed above. The efficacy of artificial reefs to enhance ecological productivity depends on the amount of new production provided by the artificial reef versus redistribution of production that would have been produced elsewhere (e.g. support individuals that would have survived equally well without the reef). An artificial reef either increases production or causes the redistribution of existing biomass. Two types of empirical studies can be conducted to evaluate the effect of the artificial reef (Osenberg 1999):

1) Patch reef study. A standard replicated experiment consisting of two treatments "natural reef" and "natural reef w/adjacent artificial reef". The experiment would be carried out over wide regional scales and types of reefs, where half of the reefs would receive an "artificial reef." The number of replicate reefs and the spatial area sampled limits the power of the approach.

2) An unreplicated assessment. A Before-After-Control-Impact-Paired-Series (BACIPS) such as is used for environmental impact assessments. In this type of study a natural "control" reef and a natural "impacted" reef are monitored before the "impact" (deployment of the artificial reef) and then a time series is developed for both reefs. The level of "impact" is ascertained by the difference in the delta between the "control" and "impacted" reefs. The power of this approach is limited by how well the reefs are characterized "before" and "after" the "impact" and how long of a time series is developed.

Biologically significant effects could be expected to be resolved with samples sizes of 10-25 patch reefs or 10-25 time periods (eg years, seasons) for the BACIPS approach, where about half of the patch reefs have artificial reefs ("treatments") and about half of the BACIPS time periods are before "impact" (Osenberg 1999).

The ex-VERMILION being sunk to establish an artificial reef off the coast of South Carolina (photo by SCDRN).

8. Uncertainty

As we know,
There are known knowns.
There are things we know we know.
We also know
There are known unknowns.
That is to say
We know there are some things
We do not know.
But there are also unknown unknowns,
The ones we don't know we don't know.

Donald H. Rumsfeld (2003)

The purpose of this section is to summarize the sources of uncertainty, identify procedures and precautions taken to reduce uncertainty to the extent possible, and discuss the ramifications of uncertainty in the conclusions drawn from the risk characterization. This section provides a concise summary of major sources of uncertainty identified during the risk assessment. Specific sources of uncertainty were discussed throughout the document and are, therefore, not repeated here.

8.1. Uncertainties About Assessing Toxicological Effects from Contaminants

The major sources of uncertainty in the risk assessment arise from errors in assumptions, errors made during measurement activities, errors that occurred during analyses, and the natural variability in the components of the ecosystem that were studied. The sources of uncertainty in the ecorisk screening assessment include:

- the assumptions that were implicit in the conceptual model used to formulate the screening-level assessment,
- the uncertainty in interpreting critical values and benchmark concentrations,
- the complexities associated with multiple contaminant stressors,
- complexities from the interaction among chemical, abiotic, and non-xenobiotic stressors, and
- the uncertainties arising from the lack of data and toxicological information on key components of the assessment endpoint used in the screening-level risk assessment.

8.2. Study Area

There is uncertainty about whether the area selected for this study is representative of conditions found at other artificial reef sites that were created by sinking decommissioned Navy vessels. The assessment was based largely on the data available from the study of the ex-VERMILION and a nearby reference reef. The study by Martore et al. 1989 and the supplemental fish sampling provided the only site-specific data for the risk analysis. Since only one site (the ex-VERMILION) was evaluated, it is impossible to determine whether the results are broadly applicable to other reefs (see Figure 1) or wildly anomalous due to factors not considered in the studies used for the risk assessment. However, similar findings were reported for the SINKEX study that showed higher levels of exposure at the ex-AGERHOLM site than reference locations but at levels below ecological effects thresholds (Gauthier et al. 2005). Additionally, the leach rate study provided empirical data on the upper bound of leaching from PCB-containing materials into the environment. The use of background data from the Carolinian Province and reference data from natural and other artificial reefs off the coast of South Carolina provided the basis for evaluating potential impacts.

8.3. Contaminant Source Terms for ex-VERMILION

No data were available on the types and amounts of PCBs and other contaminants that were on the ex-VERMILION when she was sunk. It was assumed that the contaminants, if present, were "typical" of contaminants left on ships prepared for sinking without any special precaution or attention paid to reducing potential risks from exposure to shipboard materials containing PCBs (see Appendix 8 for more detailed discussion on uncertainties associated with estimating source terms on the ex-VERMILION).

8.4. Applicability of Assessment endpoints

Based on existing toxicological data, receptor species for the reef community were selected that were taxonomically similar to species for which toxicity data were available (or could be inferred) and that would most likely be sensitive to PCBs and other REEFEX-related COPCs. Toxicological data were reviewed to identify available toxicological benchmarks that could be used to interpret whether exposure concentrations to the receptor species could be harmful. To the extent possible, receptor species were selected that were representative of mammals, birds, reptiles, fishes, and invertebrates that utilize reef habitats. In many cases, toxicological data were not available for reef organisms and the susceptibility of the receptor species to the COPCs had to be inferred or extrapolated from species used in toxicological tests and studies. As is appropriate for screening level assessments, conservative assumptions and uncertainty factors (UFs) were used to help assure that that the assessment did not underestimate potential risk (see Section 4.5).

8.5. Applicability of Water Quality Criteria Benchmarks

The water column, TSV, and BCV benchmarks were based on Water Quality Criteria (WQC). According to EPA's Aquatic Life Criteria Guidelines Committee, which is responsible

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

8.6. Applicability of Critical Body Residue Benchmarks

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

8.7. Applicability of Dietary Benchmarks

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

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

birds or mammals. Additionally, it is very difficult to obtain toxicological data for a protected species such as dolphins (Schwacke et al. 2002).

Due to the lack of toxicity data on reptiles, the lowest TRVs obtained for cormorant or dolphin for each COPC was assumed to be protective of sea turtles. Using the same scaling factors used for mammals and avians and substituting the body weight and ingestion rate of loggerhead turtles the benchmark for sea turtles were obtained. The dietary benchmarks for loggerhead sea turtle were set to lowest value obtained between TRVs based on avian or mammalian literature toxicity reference values. This assumed that if the benchmarks were protective of birds or mammals, then they would also be protective of sea turtles.

Toxicological benchmarks for PCBs in shark and barracuda were developed using the ratio of bioaccumulation factors (BAFs) between trophic level IV (TL-IV reef predator, e.g. shark) and Trophic Level III (TL-III reef forager, e.g. prey) obtained from PRAM 1.3a (Goodrich 2004). Defined as the "the ratio (in L/kg) of a substance's concentration in tissue of an aquatic organism to its concentration in the ambient water" (U.S. EPA 1995) BAFs are used to account for the trophic transfer of a contaminant in the food chain. The ratio between BAFs for TL-IV and TL-III gives the relative increase in contaminant concentrations between a shark and its prey, assuming all the shark's dietary requirements came from TL-III. This assumes that a steady state exists between the shark and its prey and that accumulation from the water through gill exchange would be negligible compared to contaminant uptake from food.

8.8. Fish Sampling

It is important to remember that the samples collected and analyzed in support of the REEFEX study are just that – samples taken from natural populations existing at the time of collection. There are at least three implications of this fact that are relevant to considerations of uncertainty: method bias, site bias, and species bias.

The degree to which the supplemental fish samples adequately represented the sampled reef populations is a function primarily of the sampling (and analysis) design. Multiple methods were employed to obtain fish, including baited traps, hook-and-line, and diver spear fishing. Each of these methods has known biases relative to the representativeness of the samples they collect. For example, a diver spear fishing selectively samples for larger (and slower) fish. The issue here is that the representativeness of the data sets is largely unknown and could not be evaluated without exhaustive sampling at the sites. It is an oversimplification to assume that sampling biases applied equally to the two reefs, as the realization of any biases can be a function of the populations sampled themselves. To illustrate, if the distribution of the sizes of individual black sea bass on one of the reefs was skewed (relative to that of the other reef) towards smaller sizes, the spear fishing method would obtain more (and presumably larger) fish from the other reef. Of course, sampling bias can play out differently among species as well. Unquantified sampling bias is one reason why comparisons of fish sizes and abundances between reefs is fairly meaningless in this study, but it also is a reason why appropriate control of covariates (such as size) was important when evaluating the similarities and differences in tissue residues, liver sizes, and so on (see Appendix 4D for plots of PCB versus size, weight, HSI, etc.).

Assuming that the samples adequately represent the natural populations present at the time of collection, the resulting data are only a "snapshot in time." That is, the invertebrates and fish actually collected were those that survived (or benefited from) any potential toxicological and ecological processes that preceded sample collection. The tissue residue-based screening approaches controlled for this phenomenon to some extent (by using conservative effects thresholds), but the actual sample data sets which were compared against the residue-based benchmarks may have been biased towards lower residue levels.

The supplemental fish sampling used multiple sampling methods, sampled during different cruises, and obtained adequate numbers of specimens from three species of fish that are sought-after by anglers and that are considered as reef residents. Since the fish were captured on the respective reefs, it was assumed that they most likely represented the exposure conditions present at the reef.

8.9. Estimating Whole Body Tissue Concentrations

In order to compare the supplemental fish data to the tissue residue benchmarks the supplement fish data obtained from the fillets with the skin on were converted into whole body residues. The assumptions used in the whole-body calculations were reasonably conservative. The faction of lipids in liver, fraction of lipids in other tissues, and other conversion factors used in the analysis were conservative and provided estimates of whole body:fillet concentrations that were comparable to values reported in the literature. The sensitivity of key parameters used in whole body calculation were also evaluated to bound the uncertainty of the estimate (see Section 6.1.3, Appendix 4C).

8.10. Estimating Background Concentrations

Background data for the ecorisk screening were obtained from Environmental Monitoring and Assessment Program (EMAP) EMAP-Estuaries for the Carolinian Province (Hyland et al. 1998). The EMAP data were used to represent environmental conditions in the region without any influences from natural or artificial reefs. Although the EMAP program was focused on coastal areas and estuaries, which can have relatively high levels of pollutants, the sample program also included many pristine and unimpacted locations as well (Hyland et al. 1998). It was assumed that this data adequately represented background conditions within the study area.

8.11. Uncertainty About Water Column Screening

The results of the empirical leaching of PCBs from shipboard solids (George et al. 2005, Appendix 8) were used to estimate water column PCB concentrations. The steady state model assumed that there is no loss of PCB from adsorption, degradation, bioaccumulation, or partitioning, but simply focused on the maximum "available" PCB released into the environment (all other loss terms are set to zero, Figure 4). The mass of the shipboard solids containing PCBs on the ex-VERMILION, a relatively large troop transport ship, was unknown and was extrapolated based on data available for the ex-AGERHOLM, a smaller destroyer. This imparts uncertainty to the loading estimates, because there are fundamental differences in the materials

present on a troop transport ship (noncombatant) versus a destroyer (combatant). Because the ex-VERMILION was a troop transport ship, there is more berthing areas, ducts, vents, etc. on the ex-VERMILION (per unit volume) than the ex-AGERHOLM, therefore, scaling by volume may underestimate the total amount of felt gaskets and other comfort materials like bulkhead insulation. Conversely, cabling and oils and greases may be overestimated because there are more electrical and power plant systems per unit volume on a destroyer (see Appendix 8).

8.12. Uncertainty About Sediment Screening

No sediment data from the South Carolina study area were available for the assessment so sediment data from the deep-water SINKEX study were screened against the sediment benchmarks. The lower temperature and higher pressure at the deep ocean site results in lower leaching rates of materials containing PCBs (George and In 2002b) than would occur at artificial reefs in much warmer and shallower water. On the other hand, the isolated environment at the deep-water site creates an essentially "closed" system for evaluating contaminant accumulation in the sediment than would occur at a shallow water reef with much higher velocity currents, open water exchange, and dissipation of contaminants released from the ship. There is a relative lack of epibenthic organisms present on the ex-AGERHOLM compared to the dense growth present on the ex-VERMILION, could be attributed to the lack of primary producers and epibenthic larvae for recruitment at the deep water site, which are abundantly plentiful in shallow, coastal waters (Figure 33). Nevertheless, the SINKEX sediment data provide an indication of the relative magnitude and types of chemicals that could be released into the surrounding environment from a "typical" ex-Navy warship that could be used for reef construction.

8.13. Uncertainty About Tissue Screening

The main sources of uncertainty for the tissue screening were the limited amount of data for screening, the uncertainty about the tissue benchmarks, the assumptions required to assess dietary exposure, and the applicability of reference and background data. Many of the tissue residue benchmarks were derived from toxicity data on freshwater species because toxicity data on reef organisms are not widely available. Uncertainty factors were used to account for some of the uncertainty, but in many cases application of the uncertainty factors may make the conclusions overly conservative. The assumption that food chain receptors would consume 100% of their diet from the target reefs is very conservative. The dietary benchmarks are based on prey consumption and direct ingestion of surface water and sediment were not included. It was assumed that exposure from incidental contact with sediment would be negligible for dolphins, sea turtles, sharks, barracuda, cormorants, and herring gulls in the reef environment.

8.14. Uncertainty About Advanced Screening Analysis

The advanced screening analysis consisted of evaluating the distributions of PCB congeners and homologs measured in the supplemental fish samples, analyzing the potential toxicity from dioxin-like coplanar congeners, and conducting a probabilistic analysis of PCB exposure. The advanced screening was conducted on the data from the supplemental fish

sampling, therefore the uncertainties associated with supplemental fish data set (estimated whole body concentration, representative of site conditions, applicability to other reefs etc.) are also applicable to the advanced screening analysis.

8.14.1. Distributions of Congeners and Homologs

An eigen-vector principal component procedure (Statistix 1996) was used to obtain multivariate principal components based on the correlation matrices calculated from the data sets grouped by site and species to evaluate the relative distribution of congeners and homolog between target and reference sites. This analysis assumed that the data conformed to a lognormal distribution. While the data set exhibited lognormal characteristics (see Figure A4E-1) not all the subsets of data satisfied the statistical parameters of a lognormal distribution. However, the results of the analyses are valid providing that one assumes that the sample population was drawn from an underlying lognormal population (Gilbert 1987).

8.14.2. Risk from Dixon-like Toxicity

Data from dioxin-like coplanar congeners were multiplied by the respective TEFs to calculate TEQs for fish eggs and to assess dietary exposure to birds and mammals. Because no data were available for PCB081, PCB156, and PCB157 in some (or all) of the samples the concentrations of these congeners were estimated assuming that they were proportional to similar congeners that were measured using empirical ratios reported in the literature. The maternal transfer of PCBs from reef fish to egg was also assumed to be proportional to the transfer ratios reported for trout. The dioxin-like TEFs and TEQ benchmarks were also assumed to be applicable to fish, birds, and mammals foraging on the reef. The potential risk estimated from TEQ exposure to fish eggs and dietary exposure to birds and mammals were based only on dioxin-like toxicity from PCBs and did not take into account any additional toxicity from the presence of dioxins and furans.

The most toxic dioxin-like PCB congener, PCB126, was not detected in more than half of the samples (58%) therefore the concentration of PCB126 was estimated as ½ the detection limit. To address the relative uncertainty associated with the ND values, the TEQs were also calculated after setting the ND results to zero (ND=0) and after setting the ND results to the detection limit (ND=DL). The sensitivity analysis indicated that the DL/2 was a reasonable estimate of the ND values and did not overly bias the TEQ calculation (see Section 6.5.2).

There is a wide range of sensitively to dioxins among fish, birds, and mammals (Gatehouse 2004). The benchmarks used in this analysis were based on data available for the most sensitive fish (salmonids), avian (order of galliformes – chicken-like birds e.g. pheasant) and mammal (mink) for which toxicity data are available (Gatehouse 2004) and it was assumed that these benchmarks would not under estimate the potential risk to receptors on the reef. Additionally, the dietary benchmarks assumed that tertiary consumers dined exclusively on the reef throughout their whole life span with an assimilation efficiency of 90%. Reducing these parameters would increase the dietary benchmarks by the same factor.

8.14.3. Probability of Exceeding Effects Level

The objective of the probabilistic analysis was to calculate the probability that harmful exposures would occur to better quantify the magnitude of ecorisk indicated by the available data. The conclusions drawn from the probabilistic analysis must factor in the assumptions and uncertainties associated with the limited data available and the ecological effects benchmarks discussed above. The exposure distribution calculated from the reference fish was assumed to represent the exposure that would be present in the absence of a ship and the difference between the target and reference distributions was interpreted to represent the incremental increase in exposure attributed to the target reef (risk). The probability of exceeding the benchmarks used in the initial screening for PCBs was calculated for the reference and target populations and the difference between target and reference (Equation [53]) was interpreted as the incremental risk of exceeding the benchmarks (Table 27, Figure 54). Arbitrary cutoff values for interpreting the incremental risk of exceeding a benchmark or an effects distribution were defined using a geometric progression (10^{-4}, 10^{-2}, 10^{-1}, $10^{-½}$, $10^{-¼}$, $10^{-1/8}$). These values provided a relative ranking for the level of risk indicated by the data. At this writing the ranking has not yet been reviewed and agreed to by the REEFEX Technical Working Group.

The probabilistic analysis quantified the potential level of risk to ecological receptors based on the benchmarks and available data (Table 28). The overall risk was determined from the combination of risk levels calculated for exceeding the conservative benchmark (i.e. TSV, NOED, and NOAEL) and the less conservative benchmark (i.e. B_{CV}, LOED, and LOAEL). The probability of exceeding the TEQ benchmarks was used to assess the potential risk of exposure to dioxin-like congeners (see Section 6.5.3).

8.14.4. Probability of Exceeding Species Sensitivity Distribution

The broader implication of potential ecotoxicolgical risk from PCBs was evaluated by comparing the PCB exposure distribution in fish to a species sensitivity distribution (SSD) for CBR in fish tissue and TEQ effects to sac-fry larvae, the most sensitivity benchmark for which species sensitivity data were available. By assuming that the toxicity data reported in Gatehouse (2004) conformed to a lognormal distribution, an SSD for “No Effect” (NOAEL) to sac fry growth, development, and survival from exposure to dioxin TEQ in fish eggs was calculated to compare to the distribution of TEQ concentrations estimated for eggs from the supplemental fish data. It was assumed that the exposure and effects distributions conformed to lognormal distributions. This is conservative because the lognormal distribution for exposure has a long tail on upper end that extends toward the lower tail of the effects distribution without the apparent threshold that is implied by a single point benchmark (see Section 6.5.4).

8.15. Summary

In this study there was a large amount of uncertainty in using data from single reefs (the ex-AGERHOLM deep reef and the ex-VERMILION shallow reef) to infer risks that could occur at other (or future) reefs. That sunken ship reefs afford ecologically beneficial habitat for reef organisms has been fairly well established (Jones and Welsford 1997, California Coastal Commission 2000a, 2000b, Bell 2001, Hess et al. 2001, Arena et al. 2002, Hynes et al. 2004, see

also Artificial Reef Society of British Columbia and San Diego Oceans Foundation for more information). Whether the ecological and economic benefits afforded by the reef are offset by the potential release of contamination is the key risk management question. The low to negligible risks from contamination from sunken ships documented by this study do not indicate unreasonable risk of using ex-Navy ships to create artificial reefs. This conclusion does not lack uncertainty. Uncertainty is reflected in the confidence of the conclusions. There was high confidence of negligible to low risk of exposure to PCBs because supplemental fish sampling and analysis for PCBs was conducted for the assessment. Owing to limited data available for screening, the confidence in the conclusions for the other chemicals of concern was low.

While uncertainty is attributed to the individual measures, independent lines of evidence that support the conclusion bolster confidence. One may be quite certain of the results from a particular measure but not very confident about the conclusions drawn from a single line of evidence. When the conclusion is based on many lines of evidence, the confidence in the conclusion will be higher even though the overall uncertainty will increase from the uncertainties associated with the individual measures (Johnston et al. 2002). Due to the conservative estimates used in this analysis, it is very unlikely that potential risks were under estimated.

The ex-VERMILION on her way down to become an artificial reef (Photo by SCDNR).

9. Conclusions and Recommendation

An initial screening-level ecorisk assessment and an advanced ecorisk screening analysis for PCBs was conducted on data from artificial reefs located off the coast of South Carolina to assess the potential risk of contaminants that could be released from sunken Navy vessels. The conclusions were based on evidence of potential ecological harm, evidence of exceeding reference and background levels, and the degree to which data were available to support the assessment.

9.1. Conclusions from Initial Screening

The initial screening level assessment of sediment data from the SINKEX study of the ex-AGERHOLM found that the risk of sediment exposure was negligible for PCB, PAH, Cr, Hg, and Pb; low for Ag and Zn; medium for Cd and Cu; and adverse for Ni. Because the sediment benchmarks for Ni are overprotective (Long et al. 1995), the finding of adverse exposure for Ni may be overly conservative. The data reliability for the sediment screening was good, but there was uncertainty associated with the sediment screening due to extrapolating from the deep ocean SINKEX site, so there was a medium level of confidence in the conclusions.

Tissue residue data from the SCDNR study (Martore et al. 1998) showed that exposure to PCBs, Pb, and Cd in tissues of fish and PCBs and Pb in invertebrates were higher in samples from Navy ship reefs than reference reefs. The data from fish tissue residues suggested negligible risk of exposure to all assessment endpoints except for primary producers and consumers, which had a medium risk of exposure due to elevated levels of Cr, Pb and Cd measured in the two fish samples from the ex-VERMILION reef. Risk of exposure inferred from data on invertebrate tissue residues (Martore et al. 1998) indicated negligible risk to all receptors except for low risk to plankton due to elevated Pb levels in invertebrates sampled from the ex-VERMILION reef. There was low confidence in the conclusions because the data available were limited to a single study with only two fish samples and nine invertebrate samples from the target reefs.

There were physical and physiological differences between the supplemental fish sampled from the reference and target reefs. Fish from the target reef had larger livers, higher HSI, and more lipids (fish from the reference reef had significantly less lipid content). On a dry weight basis, there were significantly higher PCB levels in black sea bass, vermilion snapper, and white grunt sampled from the target reef. A significant positive regression was obtained for all fish from both reefs between body weight and log of lipid-normalized PCB concentrations. The regression of data for white grunt from both reefs showed a significant positive slope for increasing PCB levels in larger white grunt and the relationship appeared to differ between the two reefs, such that for a given fish size, target reef white grunt generally had higher total PCB concentrations per gram of lipid than did reference white grunt. A significant positive slope was also detected for vermilion snapper from the combined reefs and target reef, which was probably due to the fact that smaller fish with less PCB were sampled from the reference reef. The black sea bass data did not show the same trend, instead the log of the lipid-normalized PCB concentrations in black sea bass were independent of body weight.

Based on the results of the supplemental fish data there was negligible risk of exposure to secondary consumers (demersal fish) and low risk to primary producers and consumers (plankton and zooplankton), avian consumers (herring gulls and cormorants), and tertiary consumers (dolphins and sharks). There was high confidence of negligible to low risk of exposure to PCBs because the Navy conducted supplemental fish sampling and analysis for PCBs for the assessment.

Empirical estimates of PCB leaching rates were used to simulate the leaching of PCBs from the ex-VERMILION and estimate the instantaneous steady state concentration of total PCB around the ship. The estimated concentrations were compared to the PCB water benchmarks and multiplied by bioconcentration factors to predict the resulting PCB concentration in fish and shellfish. The results showed that there was negligible risk of exceeding water column or tissue benchmarks for any of the loading scenarios evaluated. The model indicated that residual oils and grease and bulkhead insulation were the most important sources of PCB loading. If present, removing relatively small quantities of these materials would greatly reduce the amount of PCBs leached and therefore further reduce the potential risk of exposure to PCBs. Removing relatively accessible bulkhead insulation from living compartments and using extra care to mechanically clean up oils and greases in areas where they may of come into contact with PCBs would result in the greatest reduction in PCB loading per unit effort. Based on the average loading scenario, removing about 150 g of bulkhead insulation would result in about the same reduction in PCB loading as removing about 4 kg of felt gaskets, 30 kg of foam insulation, 200 kg of electrical cable, 300 kg of rubber products, or 500 kg of paint.

9.2. Conclusions from Advanced Screening for PCBs

The analysis of homologs and individual congeners showed that there were similar distributions and proportions of PCBs measured at both the target and reference reefs. The samples from the target reef had slightly more lower-chlorinated tetra- and penta- PCBs than the reference reef, but the PCA failed to discriminate any indication of a unique source of PCBs between the reefs. The most discriminating feature of the PCA was the strong relationship between PC1 and PCB concentration, which clearly separated the samples with the highest levels of tPCB or individual congeners

The analysis of exposure to dioxin-like PCB congeners showed that the TEQs calculated for fish tissue were similar between target and reference for black sea bass and vermilion snapper, but were much higher for white grunt from the target reef than from the reference reef. Based on maternal transfer from female to egg, the average TEQs calculated for white grunt fish eggs at the target reef and black sea bass eggs from both reefs exceeded the sensitive lipid-based NOED benchmark for salmonid egg mortality and white grunt eggs from the target reef also exceeded the LOED for salmonid egg mortality. The TEQs calculated for dietary exposure to birds showed that the maximum TEQ for the target reef did not exceed the site-specific cormorant or herring gull NOAEL for TEQ. The TEQs calculated for dietary exposure to dolphins showed that the average TEQ calculated for fish from the target reef exceeded the site-specific NOAEL for dolphin and the maximum TEQ from the target reef also exceeded the dolphin LOAEL for TEQ. Based on comparison to sensitive benchmarks for dioxin-like

exposure it appeared that there was negligible risk of dioxin like exposure to fish eating birds and low risk of dioxin like exposure to fish eggs and mammalian consumers on the reef.

The probability that harmful exposures would occur was calculated to better quantify the magnitude of ecorisk indicated by the available data. The probability that fish from the reference reef would exceed a benchmark was $P<0.000001$ for all benchmarks, therefore the probability of exceeding a benchmark for the target reef was equal to the incremental risk. The risk of target fish exceeding the dietary NOAEL for dolphin was low and there was very low risk that the dietary LOAEL for dolphins would be exceeded. There was low risk that the target fish would exceed the TSV benchmark and very low risk that the B_{CV} for PCBs would be exceeded. There was also low risk of exceeding the dietary NOAELs for cormorants, gulls, and sharks and very low risk that the CBR for fish NOED or LOED would be exceeded in fish at the target reef (Table 27B).

The risk calculation for dioxin-like PCBs to fish eggs showed that there was medium risk of exceeding the sensitive rainbow trout benchmark for egg mortality NOAEL and LOAEL at the target reef and very low risk of exceeding the thresholds for effects to lake trout sac-fry larvae. For dioxin-like PCB exposure to avian receptors there was very low risk of exceeding site-specific benchmarks for herring gulls or cormorants. There was medium risk of exceeding the site-specific dietary NOAEL for dolphins and low risk of exceeding the site-specific dietary LOAEL for dolphins at the target reef.

The probabilistic analysis quantified the potential level of risk to ecological receptors based on the benchmarks and available data (Table 28). The overall risk was determined from the combination of risk levels calculated for exceeding the conservative benchmark (i.e. TSV, NOED, and NOAEL) and the less conservative benchmark (i.e. B_{CV}, LOED, and LOAEL). The low risk of exceeding the TSV and very low risk of exceeding the B_{CV} was interpreted to mean that there was very low risk of potentially harmful PCB exposure to primary producers and consumers of the reef community. The very low risk of exceeding the NOED and LOED for critical body residues in fish was interpreted to mean that there was very low risk of harmful PCB residues in demersal fish. For dolphin consumption of prey (fish), the low risk of exceeding the NOAEL and very low risk of exceeding the LOAEL were interpreted to mean that there was very low risk of harmful PCB exposure to dolphins. The low risk of exceeding the NOAEL and very low risk of exceeding the LOAEL for cormorants and gulls indicated that there was very low risk of harmful PCB exposure to avian consumers. Based on the low risk of exceeding the NOAEL and negligible risk of exceeding the LOAEL for shark consumption of prey (fish), it was concluded that there was negligible risk of harmful PCB exposure to sharks.

The probability of exceeding the TEQ benchmarks was used to assess the potential risk of exposure to dioxin-like congeners. The low risk of exceeding the NOAEL and LOAEL for dioxin effects to fish eggs was interpreted to mean that there was low risk of harmful TEQ exposure to fish eggs. For dolphin consumption of prey (fish), the medium risk of exceeding the NOAEL and very low risk of exceeding the LOAEL was interpreted to mean that there was low risk of harmful TEQ exposure to dolphins. It was also concluded that there was negligible risk of harmful dioxin exposure to avian consumers because there was very low risk of exceeding the NOAEL and negligible risk of exceeding the LOAEL for herring gull and cormorant consumption of prey (fish).

The broader implications of potential ecotoxicolgical risk from PCBs were evaluated by comparing the PCB exposure distributions for reference and target reef fish to SSDs derived for CBRs in fish tissues (NOED and LOED) and effects of TEQs on sac fry larvae of fresh water fish. The cumulative distribution for the reference and target fish showed very little overlap with the cumulative distribution function estimated for fish tissue NOEDs and LOEDs, which supported the conclusion of low risk of PCB exposure to secondary consumers (demersal fish) at the target reef. There was very low risk of exceeding the SSD for sac-fry NOAEL that also supported the conclusion that there was low risk of PCB exposure to secondary consumers (demersal fish) at the target reef.

It was assumed that the exposure and effects distributions conformed to lognormal distributions. This is conservative because the lognormal distribution for exposure has a long upper tail that extends toward the lower tail of the effects distribution without the apparent threshold that is implied by a single point benchmark. The tail of the exposure distribution can be interpreted to represent the proportion of the population that are exposed to the highest concentrations of PCBs and therefore, may be more susceptible to effects from PCBs.

9.3. Implications for Future Reefs

The analysis presented in this report was a retrospective risk assessment based largely on the data available from the study of the ex-VERMILION and a nearby reference reef. The risk assessment did not address the ecological consequences of creating the reef itself, it was focused on characterizing potential toxicological risks of contaminants that may of been released from the ship. The extent to which results from the ex-VERMILION can be extrapolated to other reefs or future reefs is limited by the unknowns about how much PCBs and other contaminants that may be onboard the sunken vessel, the environmental conditions at the reef site, and other site-specific factors such as the types of organisms present, local sources of contamination, and ecological interactions at the site. However, data from the ex-VERMILION (and ex-AGERHOLM) are from actual sunken ship reefs sampled under realistic conditions and it is reasonable to expect that similar results would be obtained from ships that were sunk in the same manner without any special precaution or attention paid to reducing potential risks from exposure to shipboard materials containing PCBs.

An initial screening-level ecorisk assessment and an advanced screening ecorisk assessment for PCBs was conducted to develop a common understanding within the REEFEX Working Group regarding the decision criteria that must be satisfied to conclude a finding of no unreasonable risk. The screening-level ecorisk assessment will support a process that will enable risk management decisions to be made by the EPA and Navy regarding beneficial use of decommissioned Navy vessels for reef building projects. This report provides a framework and evaluates the potential ecotoxicological risks associated with sinking ex-Navy ships to create artificial reefs. To that end, it is hoped that information provided in this report will assist risk managers in making risk management decisions about sinking ex-Navy ships to create artificial reefs.

The primary focus of this ecorisk assessment was to address risks from exposure to PCBs. PCBs contained on ships to be sunk are regulated as PCB Bulk Product Waste (40 CFR

761.62(c)) which requires a finding of no unreasonable risk of injury to human health and the environment before sinking ships containing PCB-contaminated materials with concentrations ≥ 50 ppm of PCBs could be allowed. While data from SCDNR's study on other chemicals were also addressed in this ecorisk assessment, PCBs are the sole focus for risk-based disposal approval and were the only chemical addressed in the Navy's supplemental fish sampling. Other materials of environmental concern will be addressed in conformance with the Draft National Guidance: Best Management Practices for Preparing Vessels Intended to Create Artificial Reefs (U.S. EPA and MARAD 2004).

Results from the empirical leaching studies and hypothetical steady state model were used to evaluate the consequences of removing materials from the ship to reduce PCB loading. For the average loading scenario, the greatest reduction in potential PCB release would be gained by removing bulkhead insulation. Removing relatively small quantities of bulkhead insulation would greatly reduce the amount of PCBs leached and further reduce the potential risk of exposure to PCBs. Future ships to be reefed will be cleaned in conformance with the "Best Management Practices for Preparing Vessels for Use as Artificial Reefs" (U.S. EPA and MARAD 2004). The risk management decisions to remove solid materials containing PCBs with high leaching rates would be based on the potential risk predicted by the Prospective Risk Assessment Model (PRAM, Goodrich 2004) following the process being developed for risk-based disposal of ex-Navy vessels.

Black sea bass at the ex-VERMILION reef (Photo by SCDNR).

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11. Tables

Table 1 The species and number of specimens sampled from reef areas and analyzed for PCBs and metals (Martore et al. 1998).

Species	Endpoint	Number of Specimens Sampled					
		Navy Vessel Reef		Other Artificial Reef		Natural Reef	
DEMERSAL FISH		PCB	Metal	PCB	Metal	PCB	Metal
Gag Grouper (*Mycteroperca microlepis*)	SECONDAY CONSUMER	1	1			1	1
Red Grouper (*Epinephelus morio*)	SECONDAY CONSUMER					1	1
Scamp (*Mycteroperca phenax*)	SECONDAY CONSUMER					2	2
Black Sea Bass (*Centropristis striatia*)	SECONDAY CONSUMER	1	1	2	2	11	5
Bank Sea Bass (*Centropristis ocyurs*)	SECONDAY CONSUMER						1
Hake (*Urophycis sp.*)	SECONDAY CONSUMER			2	1		1
Leopard Toadfish (*Opsanus pardus*)	SECONDAY CONSUMER			8	4	7	4
Oyster Toadfish (*Opsanus tau*)	SECONDAY CONSUMER					2	
Gray Triggerfish (*Balistes capriscus*)	SECONDAY CONSUMER			2	2	1	1
Sheepshead (*Archosargus probatocephalus*)	SECONDAY CONSUMER			1	1		
Scorpion fish (Scorpaenidae)	SECONDAY CONSUMER					1	1
Queen Angelfish (*Holacanthus ciliaris*)	SECONDAY CONSUMER					1	1
INVERTEBRATES							
BIVALVE							
Alantic Winged Oyster (*Pteria colymbus*)	PRIMARY CONSUMER	2	1	10	8		
Crested Oyster (*Ostreola equestris*)	PRIMARY CONSUMER			2		1	
Turkey Wing (*Arca zebra*)	PRIMARY CONSUMER	4	4	2	2		
Lion's Paw Scallop (*Nodipecten nodosus*)	PRIMARY CONSUMER			2	1		
Purse Shell (*Isognomon* sp)	PRIMARY CONSUMER			1			
Arc Shell (*Anadara* sp.)	PRIMARY CONSUMER			1	1		
Florida Spiny Jewel Box (*Arcinella comuta*)	PRIMARY CONSUMER				1		1
GASTROPOD							
Atlantic Hairy Triton (*Cymatium pileare*)	PRIMARY CONSUMER	2	1				
Florida Horse Conch (*Pleuroploca gigantea*)	PRIMARY CONSUMER	1	1			1	1
Common American Auger (*Terebra dislocata*)	PRIMARY CONSUMER			1			1
Atlantic Deer Cowrie (*Cypraea cervus*)	PRIMARY CONSUMER			2	2		
Common Slipper Shell (*Crepidula fornicata*)	PRIMARY CONSUMER			2	3		1
Convex Slipper Shell (*Crepidula convexa*)	PRIMARY CONSUMER				1		
CRUSTACEAN							
Shovelnose Lobster (*Scyllarides nodifer*)	PRIMARY CONSUMER	1	1			1	1
ECHINODERM							
Sea Cucumber (Holothuroidea)	PRIMARY CONSUMER	1	1				
SPONGE							
Haliclona sp	PRIMARY CONSUMER	1					
Ircinai sp.	PRIMARY CONSUMER	1					

Table 2A. PCB Compounds measured in samples from the supplemental fish and SINKEX sediment samples used for ecorisk screening analysis.

Analyte		Abbrevation	Supplemental Fish Samples	SINKEX Sediment Samples
Polychlorinated Biphenyls		PCB		
2,4'-Dichlorobiphenyl		PCB8	PCB8	PCB8
2,2',5-Trichlorobiphenyl		PCB18	PCB18	PCB18
2,4,4'-Trichlorobiphenyl		PCB28	PCB28	PCB28
2,2',3,5'-Tetrachlorobiphenyl		PCB44	PCB44	PCB44
2,2',4,5' - Tetrachlorobiphen		PCB49	PCB49	PCB49
2,2',5,5'-Tetrachlorobiphenyl		PCB52	PCB52	PCB52
2,3',4,4'-Tetrachlorobiphenyl		PCB66	PCB66	PCB66
3,3',4,4'-Tetrachlorobiphenyl	[a]	PCB77	PCB77	PCB77
2,2',3,4,5 - Pentachlorobiphenyl		PCB87	PCB87	PCB87
2,2',4,5,5'-Pentachlorobiphenyl		PCB101	PCB101	PCB101
2,3,3',4,4'-Pentachlorobiphenyl	[b]	PCB105	PCB105	PCB105
2,3,4,4',5-Pentachlorobiphenyl	[b]	PCB114	PCB114	
2,3',4,4',5-Pentachlorobiphenyl	[b]	PCB118	PCB118	PCB118
2',3,4,4',5-Pentachlorobiphenyl	[b]	PCB123	PCB123	
3,3',4,4',5-Pentachlorobiphenyl	[a]	PCB126	PCB126	PCB126
2,2',3,3',4,4'-Hexachlorobiphenyl		PCB128	PCB128	PCB128
2,2',3,4,4',5'-Hexachlorobiphenyl		PCB138	PCB138	PCB138
2,2',4,4',5,5'-Hexachlorobiphenyl		PCB153	PCB153	PCB153
2,3,3',4,4',5-Hexachlorobiphenyl	[b]	PCB156	PCB156	PCB156
2,3,3',4,4',5'-Hexachlorobiphenyl	[b]	PCB157	PCB157	
2,3',4,4',5,5'-Hexachlorobiphenyl	[b]	PCB167	PCB167	PCB167
3,3',4,4',5,5'-Hexachlorobiphenyl	[a]	PCB169	PCB169	PCB169
2,2',3,3',4,4',5-Heptachlorobiphenyl	[c]	PCB170	PCB170	PCB170
2,2',3,4,4',5,5'-Heptachlorobiphenyl	[c]	PCB180	PCB180	PCB180
2,2',3,4,4',5',6-Heptachlorobiphenyl		PCB183	PCB183	PCB183
2,2',3,4,4',6,6'-Heptachlorobiphenyl		PCB184	PCB184	PCB184
2,2',3,4',5,5',6-Heptachlorobiphenyl		PCB187	PCB187	PCB187
2,3,3',4,4',5,5'-Heptachlorobiphenyl	[b]	PCB189	PCB189	
2,2',3,3',4,4',5,6-Octachlorobiphenyl		PCB195	PCB195	PCB195
2,2',3,3',4,4',5,5',6-Nonachlorobipheny		PCB206	PCB206	PCB206
Decachlorobiphenyl		PCB209	PCB209	PCB209
Total Monochloro Biphenyls		Mono	Mono	
Total Dichloro Biphenyls		Di	Di	
Total Trichloro Biphenyls		Tri	Tri	
Total Tetrachloro Biphenyls		Tetra	Tetra	
Total Pentachloro Biphenyls		Penta	Penta	
Total Hexachloro Biphenyls		Hexa	Hexa	
Total Heptachloro Biphenyls		Hepta	Hepta	
Total Octachloro Biphenyls		Octa	Octa	
Total Nonachloro Biphenyls		Nona	Nona	
sum of homologs (Mono - Deca)		TOTAL PCB	TOTAL PCB	

Table 2B. Metal and PAH Compounds measured in SINKEX sediment samples used for ecorisk screening analysis.

Analyte	Abbrevation	Supplemental Fish Samples[e]	SINKEX Sediment Samples
Polycyclic Aromatic Hydrocarbons	PAH		PAH[d]
Silver	Ag		Ag
Arsenic	As		As
Cadmium	Cd		Cd
Chromium	Cr		Cr
Copper	Cu		Cu
Mercury	Hg		Hg
Nickle	Ni		Ni
Lead	Pb		Pb
Zinc	Zn		Zn

[a] Non-ortho dixon-like congeners
[b] Mono-ortho dixon-like congeners
[c] Di-ortho dixon-like congeners
[d] PAH = sum of 41 measured polycyclic aromatic hydrocarbon parent, alkyl-, and methyl- homologs (fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracence, chrysene benzo(e)perylene, benzo(a)pryrene, perylene, indeno(1,2,3,cd)perylene, dibenz(a,h)anthracene, benzo(g,h,i)perylene, and the sum of benzofluoranthenes.
[e] Metals and PAHs not measured

Table 3. Variables from the supplemental fish data used in the bivariate (A) and multivariate (B) regression analysis.

A. Bivariate Regressions. Data grouped by all, species, and site.

Dependent variable		Independent Variable	
Age	AGE	Body Weight	WEIGHT
Liver Weight	LWEIGHT	Body Weight	WEIGHT
% Lipid Content (dry weight)	LIPIDD	Body Weight	WEIGHT
H S I	HSI	Body Weight	WEIGHT
Whole Body Log(tPCB)	W_LPCB	Body Weight	WEIGHT
Whole Body Log(tPCB/Lipid)	W_LPCBL	Body Weight	WEIGHT
Whole Body Log(tPCB/Lipid)	W_LPCBL	Lipid Content	LIPIDD
H S I	HSI	Lipid Content	LIPIDD
H S I	HSI	Whole Body Log(tPCB/Lipid)	W_LPCBL

B. Stepwise Multivariate Regression. Data grouped by all fish.

Dependent variable		Unforced Independent Variables	
H S I	HSI	Age	AGE
		% Dry Weight	DRY
		Fillet Log(tPCB)	F_LPCB
		Fillet Log(tPCB/Lipid)	F_LPCBL
		Fillet tPCB	F_PCB
		Fillet tPCB/Lipid	F_PCBL
		Length	LEN
		% Lipid Content (dry weight)	LIPIDD
		% Lipid Content (wet weight)	LIPIDW
		Analytical Chemistry Round	ROUND
		Sex Variable	SEXVAR
		Site Variable	SITEVAR
		Species Variable	SPVAR
		Whole Body Log(tPCB)	W_LPCB
		Whole Body Log(tPCB/Lipid)	W_LPCBL
		Whole Body tPCB	W_PCB
		Whole Body tPCB/Lipid	W_PCBL

Table 4. Benchmark concentrations for water (W_B), sediment (S_B), and tissue residues of fish (T_{Fish}) and invertebrates (T_{Invert}). The tissue benchmarks are for the bioaccumulation critical value (B_{CV}), tissue screening value (TSV), critical body residues (CBR) corresponding to the no observed effect dose (NOED) and the lowest observed effect dose (LOED) for a fish or invertebrate species, and the consumption of fish and invertebrates by herring gulls (D_{Gull}), cormorants ($D_{Cormorant}$), dolphins ($D_{Dolphin}$), sharks and barracudas (D_{Shark}), and sea turtles ($D_{SeaTurtle}$).

	Water (W_B)		Sediment (S_B)[g]		Fish Tissue (T_{Fish})			
	Chronic	Acute	ERL	ERM	B_{CV}[h]	TSV[i]	NOED[j]	LOED[k]
Chemical	ug/L	ug/L	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g
Silver (Ag)		0.95 [a]	1.000	3.700		1.48		
Arsenic (As)	36.00 [a]	69.00 [a]	8.200	70.000		6.34		
Cadmium (Cd)	9.30 [a]	42.00 [a]	1.200	9.600	2.38	0.17	1.60	3.60
Chromium (Cr)	50.00 [a]	1100.00 [a]	81.000	370.000	3.20	0.70	0.72	1.74
Copper (Cu)	3.10 [a]	4.80 [a]	34.000	270.000	2.48	12.00	0.32	3.20
Mercury (Hg)	0.94 [a]	1.80 [a]	0.200	0.700	18.78	0.24		
Nickle (Ni)	8.20 [a]	74.00 [a]	20.900	51.600	1.54	1.54		
Lead (Pb)	8.10 [a]	210.00 [a]	46.700	218.000	1.59	0.25	10.20	16.08
Zinc (Zn)	81.00 [a]	90.00 [a]	150.000	410.000	15.23	80.00		
Fluorene (FLUOR)	27.00 [d]	270.00 [b]	0.019	0.540	66.59			
Phenanthrene (PHEN)	4.60 [a]	7.70 [a]	0.240	1.500	17.17			
Anthrene (ANTH)	4.60 [e]	[c]	0.085	1.100	20.65			
Fluoranthene (FLRN)	16.00 [a]	40.00 [a]	0.600	5.100	306.32			
Pyrene (PYR)	1.40 [d]	14.00 [b]	0.665	2.600	45.52			
Chrysene (CHRY)	0.66 [f]	[c]	0.384	2.800	40.89			
Benz(a)anthracene (BAA)	0.66 [d]	6.60 [b]	0.261	1.600	40.89			
Benzo(a)pryrene (BAP)	0.19 [d]	1.90 [b]	0.430	1.600	31.68	1664.00		
Dibenz(a,h)anthracene (DIBAHA)			0.036	0.260				
[p] Low molecular weight PAHs (LPAH)			0.552	3.160				
[q] High molecular weight PAHs (HPAH)			1.700	9.600				
[r] Sum of measured PAHs (sumPAH)	30.00 [d]	300.00 [a]	4.022	44.792				
Total Polychorinated Biphenyls (tPCB)	0.03 [a]	10.00 [a]	0.023	0.180	24.31	1.75	6.00	7.20

[a] (Buchman 1999)
[b] amphipod LC50 (Swartz et al 1995)
[c] LC50 > solubility limit (Swartz et al. 1995)
[d] assume acute:chronic = 10
[e] ANTH benchmark assumed to be equal to PHEN
[f] CHRY benchmark assumed to be equal to BAA
[g] Effects Range Low, Effects Range Median, dry weight (Long et al. 1995)
[h] bioconcentratioin critical value, dry weight, see Table 6
[i] tissue screening value, dry weight, see Table 5
[j] no observed (adverse) effects dose, dry weight, see Table 8
[k] lowest observed (adverse) effects dose, dry weight, see Table 9
[m] tissue reference value for herring gull prey, see Table 10
[n] tissue reference value for cormorant prey, see Table 11
[o] tissue reference value for dolphin prey, see Table 12

Table 4. Continued

	Fish Tissue (T_{Fish})				
	D_{Gull}[m]	$D_{Cormorant}$[n]	$D_{Dolphin}$[o]	D_{Shark}[p]	
Chemical	ug/g	ug/g	ug/g	ug/g	
Silver (Ag)	30.74	29.51			
Arsenic (As)	95.19	91.38			
Cadmium (Cd)	26.85	25.78			
Chromium (Cr)	18.52	17.78			
Copper (Cu)	870.37	835.56	108.14		
Mercury (Hg)	8.33	8.00	9.24		
Nickle (Ni)	1433.33	1376.00			
Lead (Pb)	20.93	20.09			
Zinc (Zn)	268.52	257.78			
Fluorene (FLUOR)	18.70	17.96			
Phenanthrene (PHEN)	1111.11	1066.67			
Anthrene (ANTH)					
Fluoranthene (FLRN)					
Pyrene (PYR)					
Chrysene (CHRY)					
Benz(a)anthracene (BAA)					
Benzo(a)pryrene (BAP)					
Dibenz(a,h)anthracene (DIBAHA)					
[s] Low molecular weight PAHs (LPAH)					[s]
[t] High molecular weight PAHs (HPAH)					[t]
[u] Sum of measured PAHs (sumPAH)	910.44	874.03			[u]
Total Polychorinated Biphenyls (tPCB)	3.33	3.20	1.27	3.53	

[p] tissue reference value for shark prey, see Table 14

[r] tissue reference value for sea turtle prey, see Table 13c

[s] LPAH = low molecular weight PAHs (fluorene, phenanthrene, and anthracene)

[t] HPAH = high molecular weight PAHs (fluoranthene, pyrene, benz(a)anthracence, chrysene benzo(e)perylene, benzo(a)pryrene, perylene, dibenz(a,h)anthracene)

[u] sumPAH = sum of the measured polycyclic aromatic hydrocarbons (fluorene, phenanthrene, anthrene, the C1-, C2-, C3-, and C4-alkyl homologs of phenanthrene and anthracene, fluoranthene, pyrene, benz(a)anthracence, chrysene benzo(e)perylene, benzo(a)pryrene, perylene, indeno(1,2,3,cd)perylene, dibenz(a,h)anthracene, benzo(g,h,i)perylene, and the sum of benzofluoranthenes.

Table 4. Continued.

	Invertebrate Tissue (T_{Invert})						
	B_{CV}[h]	TSV[i]	NOED[j]	LOED[k]	D_{Gull}[m]	$D_{Dolphin}$[o]	$D_{SeaTurtle}$[r]
Chemical			ug/g	ug/g	ug/g	ug/g	
Silver (Ag)		1.85			38.43		430.37
Arsenic (As)		7.92			118.98		1332.59
Cadmium (Cd)	186.00	0.21	4.50	6.45	33.56		375.93
Chromium (Cr)	20.00	0.88	0.72	5.40	23.15		259.26
Copper (Cu)	62.00	15.00	36.00	40.50	1087.96	135.17	930.36
Mercury (Hg)	19.65	0.30			10.42	11.55	79.52
Nickle (Ni)	16.40	1.93	14.15	141.50	1791.67		20066.67
Lead (Pb)	81.00	0.32	20.00	101.75	26.16		292.96
Zinc (Zn)	1620.00	100.00			335.65		3759.26
Fluorene (FLUOR)	49.72				23.38		261.85
Phenanthrene (PHEN)	12.64				1388.89		
Anthrene (ANTH)	15.09						
Fluoranthene (FLRN)	212.86						
Pyrene (PYR)	31.05						
Chrysene (CHRY)	27.27						
Benz(a)anthracene (BAA)	27.27						
Benzo(a)pryrene (BAP)	20.41	2080.00					
Dibenz(a,h)anthracene (DIBAHA)							
Low molecular weight PAHs (LPAH)							
High molecular weight PAHs (HPAH)							
Sum of measured PAHs (sumPAH)					1138.06		12746.22
Total Polychorinated Biphenyls (tPCB)	4.68	2.18	3.00	5.50	4.17	1.58	10.89

Table 5. Tissue Screening values (TSV) for metals and tPCB (from URS 1996, 2002).

				dry:wet=	0.25	0.2
					TSV	
	AWQC[a]		BCF_{Lipid}[b]		Fish[d]	Shellfish[e]
	ug/L	Criterion Basis	L/kg wet	ug/g wet	ug/g dry	ug/g dry
Ag				0.37 [c]	1.48	1.85
As	36.000	Marine Chronic	44	1.58	6.34	7.92
Cd	0.660	Freshwater Chronic	64	0.04	0.17	0.21
Cr	11.000	Freshwater Chronic	16	0.18	0.70	0.88
Cu			200	3.00 [c]	12.00	15.00
Hg	0.012	Marine Chronic	4994	0.06	0.24	0.30
Ni	8.200	Marine Chronic	47	0.39	1.54	1.93
Pb	1.300	Freshwater Chronic	49	0.06	0.25	0.32
Zn			47	20.00 [c]	80.00	100.00
BAP	300.000	Marine Acute	11100	416.00 [f]	1664.00	2080.00
tPCB	0.014	Freshwater Chronic	31200	0.44	1.75	2.18

[a] Ambient Water Quality Criteria used in derivation (URS 1996, 2002)
[b] Lipid normalized BCF for aquatic species (URS 1996, 2002)
[c] Obtained from Dyer et al 2000; Values adjusted to account for bioavailability
[d] Assumes that fish contain 75% moisture resulting in a dry : wet ratio of 0.25
[e] Assumes that shellfish contain 80% moisture resulting in a dry : wet ratio of 0.2
[f] Obtained from Shepard 1998.

Table 6. The calculation of bioaccumulation critical values (BCV) from bioconcentration factors (BCF) and water benchmarks (W_B) for metals (A), PAHs (B) and tPCB (C) in fish and shellfish.

A. Metals

	W_B		BCF[a]	dry:wet= 0.2	Shellfish[b]	BCF[c]	dry:wet= 0.25	Fish[d]
chemical	ug/L		L/kg dw	ug/kg dry	ug/g dry	L/kg wet	ng/g wet	ug/g dry
Cd	9.30	chronic	20000	186000	186	64	595.2	2.38
Cr	50.00	chronic	400	20000	20	16	800.0	3.20
Cu	3.10	chronic	20000	62000	62	200	620.0	2.48
Hg (total)	0.94	chronic	20900	19646	19.646	4994	4694.4	18.78
Ni	8.20	chronic	2000	16400	16.4	47	385.4	1.54
Pb	8.10	chronic	10000	81000	81	49	396.9	1.59
Zn	81.00	chronic	20000	1620000	1620	47	3807.0	15.23

B. PAHs

	W_B		BCF[e]		Shellfish[b]	BCF[f]		Fish[d]
Chemical	ug/L	Log(Kow)	(L/kg wet)	ug/kg wet	ug/g dry	L/kg wet	ng/g wet	ug/g dry
FLUOR	27.00	4.11	368	9944	49.7	617	16648	66.6
PHEN	4.60	4.29	549	2527	12.6	933	4293	17.2
ANTH	4.60	4.37	656	3019	15.1	1122	5161	20.6
FLRN	16.00	5	2661	42571	212.9	4786	76581	306.3
PRY	1.40	5.23	4436	6210	31.0	8128	11380	45.5
CHRY	0.66	5.51	8263	5454	27.3	15488	10222	40.9
BAA	0.66	5.51	8263	5454	27.3	15488	10222	40.9
BAP	0.19	5.94	21483	4082	20.4	41687	7921	31.7

C. Total PCB

		Shellfish[b]			Fish[d]		
	W_B	BCF[c]			BCF[g]		
Chemical	ug/L	(L/kg wet)	ug/g wet	ug/g dry	(L/kg wet)	ug/g wet	ug/g dry
tPCB	0.030	31200	0.936	4.68	202542	6.076	24.31
tPCB	0.074 [h]	31200	2.309	11.54	202542	14.988	59.95
tPCB	0.120 [i]	31200	3.744	18.72	202542	24.305	97.22

[a] Metal bioaccumulation in bivalves from Thomman et al.(1995)

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

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

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

[e] PAH bioaccumulation in bivalves from Pruell et al.(1986)

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

[g] Bionconcentration factor (wet weight) for PCB based on Vermilion Snapper see Table 7

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

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

Table 7. Calculation of bioconcentration factor (BCF) for total PCB (tPCB) using the fraction of tPCB (f_{PCB}) present for each homolog group measured in vermilion snapper.

A. Percent lipid and concentration of homologs measured in 4 samples of vermilion snapper from DO26.

sample#	FS-11-VS-R	FS-07-VS-R	FS-01-VS-T	FS-13-VS-T	average
%dry	25.0	25.0	28.0	29.0	26.75
% lipid (wet weight)	3.4	4.0	5.6	5.8	4.69
PCB Concn. ng/g dry weight					
Monochlorobiphenyls	0.00	0.00	0.01	0.01	
Dichlorobiphenyls	0.03	0.04	0.07	0.07	
Trichlorobiphenyls	0.21	0.20	0.60	0.53	
Tetrachlorobiphenyls	1.39	1.03	4.61	4.07	
Pentachlorobiphenyls	8.60	5.28	16.96	15.10	
Hexachlorobiphenyls	16.48	9.16	13.25	10.86	
Heptachlrobiphenyls	4.64	2.74	2.88	2.35	
Octachlorobiphenyls	1.85	1.05	0.92	0.71	
Nonachlorobiphenyls	0.75	0.38	0.24	0.20	
209 - Decachlorobiphenyl	0.11	0.04	0.02	0.02	
Total PCB (sum)	34.08	19.92	39.56	33.91	

B. Average fraction of homologs measured in 4 samples of Vermilion Snapper from DO26.

	fraction of Total PCB (f_{PCB})				
sample#	FS-11-VS-R	FS-07-VS-R	FS-01-VS-T	FS-13-VS-T	average
Monochlorobiphenyls	0.0001	0.0001	0.0001	0.0002	0.0001
Dichlorobiphenyls	0.0010	0.0019	0.0019	0.0019	0.0017
Trichlorobiphenyls	0.0063	0.0101	0.0151	0.0158	0.0118
Tetrachlorobiphenyls	0.0408	0.0518	0.1165	0.1200	0.0823
Pentachlorobiphenyls	0.2523	0.2650	0.4289	0.4454	0.3479
Hexachlorobiphenyls	0.4836	0.4598	0.3350	0.3203	0.3997
Heptachlrobiphenyls	0.1361	0.1373	0.0727	0.0693	0.1039
Octachlorobiphenyls	0.0543	0.0528	0.0233	0.0208	0.0378
Nonachlorobiphenyls	0.0221	0.0193	0.0061	0.0058	0.0133
209 - Decachlorobiphenyl	0.0033	0.0019	0.0005	0.0005	0.0016
					1.0000

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

Homolog	$\log(K_{ow})^a$	f_{PCB}	$\log(BCF_{ww})^b$	BCF_{ww}	$BCF_{ww}*f_{PCB}$
Monochlorobiphenyls	4.7	0.0001	3.38	2398.8	0.3
Dichlorobiphenyls	5.1	0.0017	3.78	6025.6	10.1
Trichlorobiphenyls	5.5	0.0118	4.18	15135.6	178.8
Tetrachlorobiphenyls	5.9	0.0823	4.58	38018.9	3128.1
Pentachlorobiphenyls	6.3	0.3479	4.98	95499.3	33224.9
Hexachlorobiphenyls	6.7	0.3997	5.38	239883.3	95870.1
Heptachlrobiphenyls	7.1	0.1039	5.78	602559.6	62576.7
Octachlorobiphenyls	7.5	0.0378	6.18	1513561.2	57244.6
Nonachlorobiphenyls	7.9	0.0133	6.58	3801894.0	50622.3
209 - Decachlorobiphenyl	8.26	0.0016	6.94	8709635.9	13633.0
BCF_{tPBC}					316488.9
		% Lipid	factor		
BCF_{tPBC} Normalized to 3% Lipid		4.69	0.6400		202542.1

[a] Mackay et al. 1992.

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

Table 8. Critical body burdens for (A) fish and (B) invertebrate no observed (adverse) effect dose (NOED, ug/g dry weight) obtained from US Army Corps of Engineers Environmental Residue-Effects Database (ERED).

(A) Fish	dry weight µg/g		dry weight mg/Kg	wet weight mg/Kg	
Chemical	**NOED**	**UF**	**$NOED_{ERED}$**	**$NOED_{ERED}$**	**ERED Citation**
Cadmium (Cd)	1.60	1.00	1.60	0.40	NOED SEQ97-34 1978 Spehar, R.L., Leonard, E.N., Defoe, D.L. Tans. Am. Fish. Soc., 107(2): 354-360 (1978) American flagfish
Chromium (Cr)	0.72	1.00	0.72	0.18	NOED URS42 1977 Buhler, D.R., R.M. Stokes and R.S. Caldwell J. Fish. Res. Bd. Can. 34:9-18. Trout - Rainbow
Copper (Cu)	0.32	0.05	6.40	1.60	ED100 URS23 1981 Dixon, D.G. and J.B. Sprague Aquat. Toxicol. 1:69-81. Trout - Rainbow
Lead (Pb)	10.20	1.00	10.20	2.55	NOED URS124 1976 Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim J. Fish. Res. Bd. Can. 33:1731-1741. Trout - Brook
Total Polychorinated Biphenyls (tPCB)	6.00	1.00	6.00	1.50	NOED URS103 1975 Hansen, D.J., S.C. Schimmel and J. Forester Trans. Amer. Fish. Soc. 104:584-588. Sheepshead minnow
TEQ (dioxin toxicity equvalent)			5 pg TEQ /g Egg		Cook, P. M.; et al. 2003. *Environ. Sci. Technol.;* 3864-3877. Lake Trout Sac Fry mortality
TEQ (dioxin toxicity equvalent)			0.3 pg TEQ /g Roe (egg)		deBruyn, et al. 2004. Environ. Sci. Technol.; 2004; 38(23) pp 6217 - 6224; Mortality in salmon eqgs

(B) Invertebrate					
Chemical	**NOED**	**UF**	**$NOED_{ERED}$**	**$NOED_{ERED}$**	**ERED Citation**
Cadmium (Cd)	4.50	1.00	4.50	0.90	NOED SEQ98-19 1996 Rule, J.H., and R.W. Alden III Environmental Toxicology and Chemistry, Vol. 15, No. 4, pp. 466-471. 1996 Shrimp - Grass
Chromium (Cr)	0.72	0.10	7.20	1.44	ED10 SEQ97-14 1989 Poulton, B.C., T.L. Beitinger, and K.W. Stewart Arch. Environ. Contam. Toxicol. 18, 594-600 (1989) Stonefly
Copper (Cu)	36.00	1.00	36.00	7.20	NOED URS149 1987 Kosalwat, P. and A.W. Knight Arch. Environ. Contam. Toxicol. 16:283-290. Midge
Nickle (Ni)	14.15	0.05	283.00	56.60	ED50 URS236 1983 Wilson, J.G. Mar. Environ. Res. 8: 129-148 Clam
Lead (Pb)	20.00	1.00	20.00	4.00	NOED SEQ97-39 1984 Sundelin, B. Ecotoxicological Testing for the Marine Environment, Vol. 2, 588 P, 1984 Amphipod
Total Polychorinated Biphenyls (tPCB)	3.00	1.00	3.00	0.60	NOED URS223 1991 Velduizen-Tsoerkan, M.B., Holwerda, D.A., Zandee, D.I. Arch. Environ. Contam. Toxicol. 20: 259-265 Mussel

Table 9. Critical body burdens for (A) fish and (B) invertebrate lowest observed (adverse) effect dose (LOED, ug/g dry weight) obtained from US Army Corps of Engineers Environmental Residue-Effects Database (ERED).

(A) Fish	dry weight µg/g		dry weight mg/Kg	wet weight mg/Kg	
Chemical	**LOED**	**UF**	**$LOED_{ERED}$**	**$LOED_{ERED}$**	**ERED Citation**
Cadmium (Cd)	3.60	1.00	3.60	0.90	LOED URS198 1988 Meteyer, M.J., D.A. Wright and F.D. Martin Environ. Toxicol. Chem. 7:321-328. Sheepshead minnow
Chromium (Cr)	1.74	0.50	3.48	0.87	ED50 URS42 1977 Buhler, D.R., R.M. Stokes and R.S. Caldwell J. Fish. Res. Bd. Can. 34:9-18. Trout - Rainbow
Copper (Cu)	3.20	0.50	6.40	1.60	ED100 URS23 1981 Dixon, D.G. and J.B. Sprague Aquat. Toxicol. 1:69-81. Trout - Rainbow
Lead (Pb)	16.08	1.00	16.08	4.02	LOED URS124 1976 Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim J. Fish. Res. Bd. Can. 33:1731-1741. Trout - Brook
Total Polychorinated Biphenyls (tPCB)	7.20	1.00	7.20	1.80	LOED URS173 1981 Mac, M.J. and J.G. Seelye Bull. Environ. Contam. Toxicol. 27:359-367. Trout -Lake
TEQ (dioxin toxicity equvalent)			30 pg TEQ /g Egg		Cook, P. M.; et al. 2003. *Environ. Sci. Technol.; 37* (17); 3864-3877. Lake Trout Sac Fry mortality
TEQ (dioxin toxicity equvalent)			3 pg TEQ /g lipid Roe(egg)		deBruyn, et al. 2004. Environ. Sci. Technol.; 2004; 38(23) pp 6217 - 6224; Mortality in salmon eqgs

(B) Invertebrate					
Chemical	**LOED**	**UF**	**$LOED_{ERED}$**	**$LOED_{ERED}$**	**ERED Citation**
Cadmium (Cd)	6.45	1.00	6.5	1.29	LOED URS57 1985 Carr, R.S., J.W. Williams, F.I. Saksa, R.L. Buhl and J.M. Neff Environ. Toxicol. Chem. 4:181-188. Mysid
Chromium (Cr)	5.40	0.75	7.2	1.44	ED10 SEQ97-14 1989 Poulton, B.C., T.L. Beitinger, and K.W. Stewart Arch. Environ. Contam. Toxicol. 18, 594-600 (1989) Stonefly
Copper (Cu)	40.50	1.00	40.5	8.10	LOED URS150 1993 Kraak, M.H.S., M. Toussaint, E.A.J. Bleeker and D. Lavy p. 175 - 186 in Dallinger, R. et.al. Ecotoxicology of Metals in Invertebrates Mussel - Zebra
Nickle (Ni)	141.50	0.50	283.0	56.60	ED50 URS236 1983 Wilson, J.G. Mar. Environ. Res. 8: 129-148 Clam
Lead (Pb)	101.75	0.50	203.5	40.70	LC50 SEQ99_06 1997 Ritterhoff, J., and G-P. Zauke Aquatic Toxicology Calanoid copepod
Total Polychorinated Biphenyls (tPCB)	5.50	1.00	5.5	1.10	ED10 URS102 1974 Hansen, D.J., P.R. Parrish and J. Forester Environ. Res. 7:363-373. Grass shrimp

Table 10. Calcuation of dietary benchmark for AVIAN CONSUMER herring gull — D_{Gull}. The dietary benchmarks were derived from literature toxicity reference values (TRV_{lit}) of similar avian species for herring gull (*Larus argentatus*) consumption of fish and shellfish prey. The dietary exposure was calculated by assuming a body weight (bw) of 1100 g and a dietary intake of 264 g/d for herring gulls (USEPA 1995, CFR40 part132).

Omnivore - Herring Gull (HG)	food injestion rate (g) =264	R=	0.24
	Herring Gull body weight bw (g) =1100	a=	0.9
	fish dry:wet = 0.25	L=	1.0
	invert dry:wet = 0.2	d=	1.0

		Literature TRV_{lit} $NOAEL_{lit}$		Herring Gull TRV_{HG} $NOAEL_{HG}$		D_{Gull} wet	fish[a]	shellfish[b]
Chemical	Source of TRV	ug/g *bw* /day (wet weight)	UF	ug/g *bw* /day (wet weight)	*F*	ug/g (wet)	ug/g (dry)	ug/g (dry)
Ag	Mallard duckling 4 wk NOAEL (Van Vleet 1982)	8.3000	0.2	1.66	0.2160	7.69	30.74	38.43
As	Mallard duck NOAEL (Sample et al. 1996)	5.1400	1	5.14	0.2160	23.80	95.19	118.98
Cd	Mallard duck NOAEL (Sample et al. 1996)	1.4500	1	1.45	0.2160	6.71	26.85	33.56
Cr	Black duck NOAEL (Sample et al. 1996)	1.0000	1	1.00	0.2160	4.63	18.52	23.15
Cu	Chicken chick NOAEL (Sample et al. 1996)	47.0000	1	47.00	0.2160	217.59	870.37	1087.96
Hg (total)	Japanese quail NOAEL (Sample et al. 1996)	0.4500	1	0.45	0.2160	2.08	8.33	10.42
Ni	Mallard duckling NOAEL (Sample et al. 1996)	77.4000	1	77.40	0.2160	358.33	1433.33	1791.67
Pb	Japanese quail NOAEL (Sample et al. 1996)	1.1300	1	1.13	0.2160	5.23	20.93	26.16
Zn	Chicken NOAEL (Sample et al. 1996)	14.5000	1	14.50	0.2160	67.13	268.52	335.65
FLUOR	Redwing blackbird LD50 (Schafer et al. 1983)	101.0000	0.01	1.01	0.2160	4.68	18.70	23.38
PHEN	Mallard duck 7 mon LOAEL (Eisler 1987)	600.0000	0.1	60.00	0.2160	277.78	1111.11	1388.89
sumPAH	Mallard duck 7 mon LOAEL (Patton and Dieter 1980)	491.6400	0.1	49.16	0.2160	227.61	910.44	1138.06
tPCB	Ring-neck pheasant NOAEL (Sample et al. 1996)	0.1800	1	0.18	0.2160	0.83	3.33	4.17
tPCB	Ring-neck pheasant **LOAEL** (Sample et al. 1996)	1.8000	1	1.80	0.2160	8.33	33.33	41.67
DDT	Brown Pelican NOAEL (Sample et al. 1996)	0.0028	1	0.0028	0.2160	0.01	0.05	0.06
DDE	Brown Pelican (DDT) NOAEL (Sample et al. 1996)	0.0028	1	0.0028	0.2160	0.01	0.05	0.06
DDD	Brown Pelican (DDT) NOAEL (Sample et al. 1996)	0.0028	1	0.0028	0.2160	0.01	0.05	0.06
tDDx	Brown Pelican (DDT) NOAEL (Sample et al. 1996)	0.0028	1	0.0028	0.2160	0.01	0.05	0.06
		pg/g bw/d	UF	pg/g *bw* /day (wet weight)	*F*	pg/g (wet)	pg/g (dry)	pg/g (dry)
[c] TEQ_{PCB}	Max concn. that can occur in diet without harmful effects to predator species (CCME 2003).					2.4	9.6	12.0
[d] TEQ	Ring-neck pheasant NOAEL (Nosek et al. 1992, cited in Weston Inc. 2003)	14	1	14	0.2160	64.8	259.3	324.1
[d] TEQ	Ring-neck pheasant **LOAEL** (Nosek et al. 1992, cited in Weston Inc. 2003)	140	1	140	0.2160	648.1	2592.6	3240.7
[d] TEQ	American kestral threshold for reproductive effects (Weston Inc. 2003)	25000	1	25000	0.2160	115740.7	462963.0	578703.7

[a] Assumes that fish contain 75% moisture resulting in a dry : wet ratio of 0.25
[b] Assumes that shellfish contain 80% moisture resulting in a dry : wet ratio of 0.2
[c] Total dioxin toxicity equivalent quotient TEQ = sum of toxicity equivalent concentration (TEC) for dioxin-like PCBs in pg/g diet.
[d] Total dioxin toxicity equivalent quotient TEQ = sum of toxicity equivalent concentration TEC for dioxin-like TCDDs, PCDFs, and PCBs

Table 11. Calcuation of dietary benchmark for AVIAN CONSUMER (cormorant) — $D_{cormorant, based on}$ benchmarks derived from literature toxicity reference values (TRV_{lit}) of similar avian species for double-crested cormorant (*Phalacrocorax auritus*) consumption of fish prey. The dietary exposure was calculated by assuming a body weight (bw) of 1900 g and a dietary intake of 475 g/d for cormorant (Environment Canada 2004c).

Piscivore (cormorant) food injestion rate (g) =	475
cormorant body weight bw (g) =	1900
fish dry:wet =	0.25
invert dry:wet =	0.2

R=	0.25
a=	0.9
L=	1.0
d=	1.0

Chemical	Source of TRV	Literature TRV_{lit} $NOAEL_{lit}$ ug/g *bw*/day (wet weight)	UF	Cormorant $TRV_{Cormorant}$ NOAELcomorant ug/g *bw*/day (wet weight)	*F*	$D_{Cormorant}$ wet ug/g (wet)	$D_{Cormorant}$ fish[a] ug/g (dry)
Ag	Mallard duckling 4 wk NOAEL (Van Vleet 1982)	8.3	0.2	1.66	0.2250	7.38	29.51
As	Mallard duck NOAEL (Sample et al. 1996)	5.14	1	5.14	0.2250	22.84	91.38
Cd	Mallard duck NOAEL (Sample et al. 1996)	1.45	1	1.45	0.2250	6.44	25.78
Cr	Black duck NOAEL (Sample et al. 1996)	1.0	1	1.00	0.2250	4.44	17.78
Cu	Chicken chick NOAEL (Sample et al. 1996)	47.0	1	47.00	0.2250	208.89	835.56
Hg (total)	Japanese quail NOAEL (Sample et al. 1996)	0.45	1	0.45	0.2250	2.00	8.00
Ni	Mallard duckling NOAEL (Sample et al. 1996)	77.4	1	77.40	0.2250	344.00	1376.00
Pb	Japanese quail NOAEL (Sample et al. 1996)	1.13	1	1.13	0.2250	5.02	20.09
Zn	Chicken NOAEL (Sample et al. 1996)	14.5	1	14.50	0.2250	64.44	257.78
FLUOR	Redwing blackbird LD50 (Schafer et al. 1983)	101	0.01	1.01	0.2250	4.49	17.96
PHEN	Mallard duck 7 mon LOAEL (Eisler 1987)	600	0.1	60.00	0.2250	266.67	1066.67
sumPAH	Mallard duck 7 mon LOAEL (Patton and Dieter 1980)	491.64	0.1	49.16	0.2250	218.51	874.03
tPCB	Aroclor Ring-neck pheasant NOAEL (Sample et al. 1996)	0.18	1	0.18	0.2250	0.80	3.20
tPCB	Aroclor Ring-neck pheasant **LOAEL** (Sample et al. 1996)	1.8	1	1.80	0.2250	8.00	32.00
DDT	Brown Pelican NOAEL (Sample et al. 1996)	0.0028	1	0.0028	0.2250	0.01	0.05
DDE	Brown Pelican (DDT) NOAEL (Sample et al. 1996)	0.0028	1	0.0028	0.2250	0.01	0.05
DDD	Brown Pelican (DDT) NOAEL (Sample et al. 1996)	0.0028	1	0.0028	0.2250	0.01	0.05
tDDx	Brown Pelican (DDT) NOAEL (Sample et al. 1996)	0.0028	1	0.0028	0.2250	0.01	0.05
		pg/g bw/d	UF	pg/g *bw*/day (wet weight)	*F*	pg/g (wet)	pg/g (dry)
[b] TEQ_{PCB}	Max concn. that can occur in diet without harmful effects to predator species (CCME 2003).					2.40	9.60
[c] TEQ	Ring-neck pheasant NOAEL (Nosek et al. 1992, cited in Weston Inc. 2003)	14	1	14	0.2250	62.2	248.9
[c] TEQ	Ring-neck pheasant **LOAEL** (Nosek et al. 1992, cited in Weston Inc. 2003)	140	1	140	0.2250	622.2	2488.9
[c] TEQ	American kestral threshold for reproductive effects (Weston Inc. 2003)	25000	1	25000	0.2250	111111.1	444444.4

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

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

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

Table 12. Calcuation of dietary benchmark for TERTIARY CONSUMER (dolphin — $D_{Dolphin)}$, based on literature toxicity reference values (TRV_{lit}) for mink (*Mustela vison*) to derive TRV for dolphin (*Tursiops truncatus)* consumption of fish and shellfish prey. The dietary exposure was calculated by assuming a body weight (bw) of 215 kg and a dietary intake of 27 kg/d for dolphins (Seaworld 2000).

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

		Mink		TRV Dolphin				
	body weight (g)	1000		215000				
		TRV_{lit}		NOAEL		$D_{Dolphin}$		
		$NOAEL_{lit}$		NOAELlit*(bwtest/bwtarget)^.25		wet	fish[a]	shellfish[b]
Chemical	Source of TRV	ug/g *bw*/day (wet weight)	UF	ug/g *bw*/day (wet weight)	*F*	ug/g (wet)	ug/g (dry)	ug/g (dry)
Cu	Mink NOAEL (Sample et al. 1996)	11.700	1	3.06	0.1130	27.03	108.14	135.17
Hg (total)	Mink NOAEL (Sample et al. 1996)	1.000	1	0.26	0.1130	2.31	9.24	11.55
meHg	Mink NOAEL (Sample et al. 1996)	0.015	1	0.00	0.1130	0.03	0.14	0.17
tPCB	Aroclor 1254 Mink NOAEL (Sample et al. 1996)	0.137	1	0.036	0.1130	0.32	1.27	1.58
tPCB	Aroclor 1254 Mink **LOAEL** (Sample et al. 1996)	0.685	1	0.179	0.1130	1.58	6.33	7.91
tPCB	Weathered PCBs feed to Mink NOAEL decrease in male kit bw (Halbrook et al. 1999)	0.120	1	0.031	0.1130	0.28	1.11	1.39
tPCB	Weathered PCBs feed to Mink **LOAEL** decrease in male kit bw (Halbrook et al. 1999)	0.230	1	0.060	0.1130	0.53	2.13	2.66
tPCB	Weathered PCBs feed to Mink NOAEL decreased kit survival (Bursian et al. 2003)	0.170	1	0.044	0.1130	0.39	1.57	1.96
tPCB	Weathered PCBs feed to Mink **LOAEL** decreased kit survival (Bursian et al. 2003)	0.410	1	0.107	0.1130	0.95	3.79	4.74
BHC	Mink NOAEL (Sample et al. 1996)	0.140	1	0.04	0.1130	0.32	1.29	1.62
o-Cresol	Mink NOAEL (Sample et al. 1996)	219.200	1	57.24	0.1130	506.48	2025.92	2532.40
heptachlor	Mink NOAEL (Sample et al. 1996)	0.100	1	0.03	0.1130	0.23	0.92	1.16
fluoride	Mink NOAEL (Sample et al. 1996)	31.370	1	8.19	0.1130	72.48	289.93	362.42
		pg/g bw/d	UF	pg/g *bw*/day (wet weight)	*F*	pg/g (wet)	pg/g (dry)	pg/g (dry)
[c] TEQ_{PCB}	Mammalian max concn. that can occur in diet without harmful effects to predator species (Environ. Canada 2004a).					0.79	3.16	3.95
[d] tTEQ	Weathered PCBs feed to Mink NOAEL decreased kit survival (Bursian et al. 2003)	1.70	1	0.44396	0.1130	3.93	15.71	19.64
[d] tTEQ	Weathered PCBs feed to Mink **LOAEL** decreased kit survival (Bursian et al. 2003)	7.70	1	2.01086	0.1130	17.79	71.17	88.96
[d] tTEQ	Decreased kit survivability NOEAL (Heaton et al. 1995)	1.10	1	0.28727	0.1130	2.54	10.17	12.71
[d] tTEQ	Decreased kit survivability**LOEAL** (Heaton et al. 1995)	4.50	1	1.17518	0.1130	10.40	41.59	51.99
[d] tTEQ	Mink NOEAL (Brunstrom et al. 2001)	0.35	1	0.09140	0.1130	0.81	3.23	4.04
[d] tTEQ	Mink **LOEAL** (Brunstrom et al. 2001)	2.40	1	0.62676	0.1130	5.55	22.18	27.73

[a] Assumes that fish contain 75% moisture resulting in a dry : wet ratio of 0.25
[b] Assumes that shellfish contain 80% moisture resulting in a dry : wet ratio of 0.2
[c] Total dioxin toxicity equivalent quotient TEQ = sum of toxicity equivalent concentration TEC for dioxin-like PCBs

Table 12b. Calcuation of additional dietary benchmark for mammalian exposure to tPCB and TEQ (dolphin — $D_{Dolphin)}$, based on literature toxicity reference values (TRV_{lit}) for mink (*Mustela vison*) to derive TRV for dolphin (*Tursiops truncatus)* consumption of fish and shellfish prey.

Dolphin food injestion rate (g) =	27000	R=	0.1255814	*body weight (g)*			
Dolphin bw (g) =	215000	a=	0.9	Dolphin	215000		
fish dry:wet =	0.25	L=	1.0	Mink/Otter	1000		
invert dry:wet =	0.2	d=	1.0	Harbor Seal	50000		

Chemical	Source of TRV	TRV_{lit} ng/g *bw* /day (wet weight)	TRV NOAEL NOAELlit*(bwt/bwg)^.25 ng/g *bw* /day (wet weight)	*F*	$D_{Dolphin}$ wet ng/g (wet)	fish ng/g (dry)	shellfish ng/g (dry)
tPCB	Dietary NOAEL for mink reproductive effects (Heaton et al. 1995, cited in Weston Inc. 2003)	4	1.045	0.1130	9.2	37.0	46.2
tPCB	Decreased fecundity in mink (Brunstrom et al. 1991, cited in Weston Inc. 2003)	80	20.892	0.1130	184.8	739.4	924.2
tPCB	Affects to kit growth and mortality (Tillitet et al. 1996 and Heaton et al. 1995, both cited in Weston Inc. 2003)	100	26.115	0.1130	231.1	924.2	1155.3
tPCB	Weathered PCBs feed to Mink NOAEL decrease in male kit bw (Halbrook et al. 1999)	120	31.338	0.1130	277.3	1109.1	1386.4
tPCB	LOAEL for reduced growth to adult female mink (Heaton et al. 1995, cited in Weston Inc. 2003)	134	34.994	0.1130	309.6	1238.5	1548.1
tPCB	Weathered PCBs feed to Mink NOAEL decreased kit survival (Bursian et al. 2003)	170	44.396	0.1130	392.8	1571.2	1964.0
tPCB	Reduced birth weight of mink kits (Tillitet et al. 1996, cited in Weston Inc. 2003)	210	54.842	0.1130	485.2	1940.9	2426.1
tPCB	Weathered PCBs feed to Mink LOAEL decrease in male kit bw (Halbrook et al. 1999)	230	60.065	0.1130	531.4	2125.7	2657.2
tPCB	Reduced birth weight of mink kits (Heaton et al. 1995, cited in Weston Inc. 2003)	260	67.899	0.1130	600.8	2403.0	3003.8
tPCB	Increased female body weight at whelping (Heaton et al. 1995, cited in Weston Inc. 2003)	320	83.568	0.1130	739.4	2957.6	3696.9
tPCB	100% kit mortatlity at 24 h (Heaton et al. 1995, cited in Weston Inc. 2003)	360	94.014	0.1130	831.8	3327.2	4159.1
tPCB	Weathered PCBs feed to Mink LOAEL decreased kit survival (Bursian et al. 2003)	410	107.072	0.1130	947.3	3789.4	4736.7
tPCB	No live births in mink after 66 d of exposure (Jensen et al. 1977, cited in Weston Inc. 2003)	1540	402.171	0.1130	3558.3	14233.2	17791.5
tPCB	100% mortality in adults (Ringer et al. 1972, cited in Weston Inc. 2003)	4200	1096.831	0.1130	9704.5	38817.9	48522.4
tPCB	Seal Diet from Atlantic Ocean (cited in Gatehouse 2004)	5	3.472	0.1130	30.7	122.9	153.6
tPCB	Seal Diet from Wadden Sea (cited in Gatehouse 2004)	30	20.833	0.1130	184.3	737.3	921.6

Chemical	Source of TRV	pg/g bw/d	pg/g *bw*/day (wet weight)	*F*	pg/g (wet)	pg/g (dry)	pg/g (dry)
TEQ_{PCB}	Mammalian max concn. that can occur in diet without harmful effects to predator species (CCME 2003).				0.79	3.16	3.95
tTEQ	Mink NOEAL (Brunstrom et al. 2001)	0.35	0.09140	0.1130	0.81	3.23	4.04
tTEQ	Decreased kit survivability NOEAL (Heaton et al. 1995)	1.10	0.28727	0.1130	2.54	10.17	12.71
tTEQ	Weathered PCBs feed to Mink NOAEL decreased kit survival (Bursian et al. 2003)	1.70	0.44396	0.1130	3.93	15.71	19.64
tTEQ	Mink **LOEAL** (Brunstrom et al. 2001)	2.40	0.62676	0.1130	5.55	22.18	27.73
tTEQ	Decreased kit survivability **LOEAL** (Heaton et al. 1995)	4.50	1.17518	0.1130	10.40	41.59	51.99
tTEQ	Weathered PCBs feed to Mink **LOAEL** decreased kit survival (Bursian et al. 2003)	7.70	2.01086	0.1130	17.79	71.17	88.96
tTEQ	LC50 125-day exposure to mink (Hochstein et al. 1998, cited in Weston Inc. 2003)	47.00	12.27406	0.1130	108.60	434.39	542.99
tTEQ	NOAEL mink reproduction effects (Tillitt et al. 1996, cited in Weston Inc. 2003)	80.00	20.89202	0.1130	184.85	739.39	924.24
tTEQ	Depressed body weight in neonates (Aulerich et al. 1988, cited in Weston Inc. 2003)	100.00	26.11502	0.1130	231.06	924.24	1155.29
tTEQ	Mink 28-day LD50 (Hochstein et al. 1998, cited in Weston Inc. 2003)	150.00	39.17253	0.1130	346.59	1386.35	1732.94
tTEQ	17% mortality in adult mink 132-day exposure (Hochstein et al. 1998, cited in Weston Inc. 2003)	196.00	51.18544	0.1130	452.88	1811.50	2264.38
tTEQ	Dietary NOED for reproductive effects (Heaton et al. 1995, cited in Weston Inc. 2003)	250.00	65.28755	0.1130	577.65	2310.59	2888.24
tTEQ	Mink 28-day LC50 (Hochstein et al. 1998, cited in Weston Inc. 2003)	264.00	68.94366	0.1130	610.00	2439.98	3049.98
tTEQ	Reduced weight gain following 36-d exposure (Render et al. 2001, cited in Weston Inc. 2003)	336.00	87.74647	0.1130	776.36	3105.43	3881.79
tTEQ	Threshold daily dose, reproductive effects (Tillitt et al. 1996, cited in Weston Inc. 2003)	420.00	109.68309	0.1130	970.45	3881.79	4852.24
tTEQ	Periodontal lesions following 6-m exposure (Render et al. 2000, cited in Weston Inc. 2003)	700.00	182.80515	0.1130	1617	6470	8087
tTEQ	100% mortality following 12 day exposure following injection (Aulerich et al. 1988, cited in Weston Inc. 2003)	1000.00	261.15021	0.1130	2311	9242	11553
tTEQ	65% mortality in mink after 28-day and 100% mortality after 125-d exposure (Hochstein et al. 1998, cited in Weston Inc. 2003)	1400.00	365.61030	0.1130	3235	12939	16174
tTEQ	LOAEL (Tillitt et al. 1996, cited in Weston Inc. 2003)	2240.00	584.97648	0.1130	5176	20703	25879
tTEQ	Dietary LOEAL for reproductive effects (Heaton et al. 1995, cited in Weston Inc. 2003)	3600.00	940.14077	0.1130	8318	33272	41591
tTEQ	71% kit mortality at 3-w, 89% kit mortality at 6-w (Heaton et al. 1995, cited in Weston Inc. 2003)	6800.00	1775.82145	0.1130	15712	62848	78560
tTEQ	100% kit mortality at 24 hr (Heaton et al. 1995, cited in Weston Inc. 2003)	10700.00	2794.30728	0.1130	24723	98893	123616
tTEQ	100% mortality following 28-d exposure (Hochstein et al. 1998, cited in Weston Inc. 2003)	14000.00	3656.10299	0.1130	32348	129393	161741

Chemical	Source of TRV	pg/g bw/d	pg/g *bw*/day (wet weight)	*F*	pg/g (wet)	pg/g (dry)	pg/g (dry)
tTEQ	Seal Diet from Atlantic Ocean (Ross et al. 1994, cited in Gatehouse 2004)	0.58	0.40277	0.1130	3.56	14.25	17.82
tTEQ	Seal Diet from Baltic Sea (Ross et al. 1994, cited in Gatehouse 2004)	5.76	3.99996	0.1130	35.39	141.56	176.95

Table 13a. Estimate of dietary benchmarks for loggerhead sea turtle — D_{Turtle} based on literature toxicity reference values (TRV_{lit}) for avian species and normalized to loggerhead (*Caretta caretta*) consumption rate 1450 g/day and body weight 113 kg (Seaworld, 2004).

Sea Turtle (loggerhead) food injestion rate (g) = 2421 R= 0.02142857
sea turtle body weight bw (g) = 113000 a= 0.9
fish dry:wet = 0.25 L= 1.0
invert dry:wet = 0.2 d= 1.0

Chemical	Source of TRV	Literature TRV_{lit} $NOAEL_{lit}$ ug/g *bw*/day (wet weight)	UF	Turtle TRV_{Turtle} NOAELcomorant ug/g *bw*/day (wet weight)	*F*	D_{Turtle} wet ug/g (wet)	fish[a] ug/g (dry)	invertebrate[b] ug/g (dry)
Ag	Mallard duckling 4 wk NOAEL (Van Vleet 1982)	8.3	0.2	1.66	0.0193	86.07	344.30	430.37
As	Mallard duck NOAEL (Sample et al. 1996)	5.14	1	5.14	0.0193	266.52	1066.07	1332.59
Cd	Mallard duck NOAEL (Sample et al. 1996)	1.45	1	1.45	0.0193	75.19	300.74	375.93
Cr	Black duck NOAEL (Sample et al. 1996)	1.0	1	1.00	0.0193	51.85	207.41	259.26
Cu	Chicken chick NOAEL (Sample et al. 1996)	47.0	1	47.00	0.0193	2437.04	9748.15	12185.19
Hg (total)	Japanese quail NOAEL (Sample et al. 1996)	0.45	1	0.45	0.0193	23.33	93.33	116.67
Ni	Mallard duckling NOAEL (Sample et al. 1996)	77.4	1	77.40	0.0193	4013.33	16053.33	20066.67
Pb	Japanese quail NOAEL (Sample et al. 1996)	1.13	1	1.13	0.0193	58.59	234.37	292.96
Zn	Chicken NOAEL (Sample et al. 1996)	14.5	1	14.50	0.0193	751.85	3007.41	3759.26
FLUOR	Redwing blackbird LD50 (Schafer et al. 1983)	101	0.01	1.01	0.0193	52.37	209.48	261.85
PHEN	Mallard duck 7 mon LOAEL (Eisler 1987)	600	0.1	60.00	0.0193	3111.11	12444.44	15555.56
sumPAH	Mallard duck 7 mon LOAEL (Patton and Dieter 1980)	491.64	0.1	49.16	0.0193	2549.24	10196.98	12746.22
tPCB	Aroclor Ring-neck pheasant NOAEL (Sample et al. 1996)	0.18	1	0.18	0.0193	9.33	37.33	46.67
tPCB	Aroclor Ring-neck pheasant **LOAEL** (Sample et al. 1996)	1.8	1	1.80	0.0193	93.33	373.33	466.67
DDT	Brown Pelican NOAEL (Sample et al. 1996)	0.0028	1	0.0028	0.0193	0.15	0.58	0.73
DDE	Brown Pelican (DDT) NOAEL (Sample et al. 1996)	0.0028	1	0.0028	0.0193	0.15	0.58	0.73
DDD	Brown Pelican (DDT) NOAEL (Sample et al. 1996)	0.0028	1	0.0028	0.0193	0.15	0.58	0.73
tDDx	Brown Pelican (DDT) NOAEL (Sample et al. 1996)	0.0028	1	0.0028	0.0193	0.15	0.58	0.73

[a] Assumes that fish contain 75% moisture resulting in a dry : wet ratio of 0.25
[b] Assumes that invertebrate contain 80% moisture resulting in a dry : wet ratio of 0.2

Table 13b. Estimate of dietary benchmarks for loggerhead sea turtle — DTurtle based on literature toxicity reference values (TRVlit) for mink (*Mustela vison*) and normalized to loggerhead (Caretta caretta) consumption rate 1450 g/day and body weight 113 kg (Seaworld, 2004).

		food injestion rate (g/day) = 2421			R= 0.02142857			
		sea turtle body weight bw (g) = 113000			a= 0.9			
		fish dry:wet = 0.25			L= 1.0			
		invert dry:wet = 0.2			d= 1.0			
				TRV				
		Mink		Turtle				
	body weight (g)	1000		113000				
		TRV_{lit}		NOAEL		D_{Turtle}		
		$NOAEL_{lit}$		NOAELlit*(bwtest/bwtarget)^.25		wet	fish[a]	shellfish[b]
Chemical	Source of TRV	ug/g *bw* /day (wet weight)	UF	ug/g *bw* /day (wet weight)	*F*	ug/g (wet)	ug/g (dry)	ug/g (dry)
Cu	Mink NOAEL (Sample et al. 1996)	11.700	1	3.59	0.0193	186.07	744.29	930.36
Hg (total)	Mink NOAEL (Sample et al. 1996)	1.000	1	0.31	0.0193	15.90	63.61	79.52
meHg	Mink NOAEL (Sample et al. 1996)	0.015	1	0.00	0.0193	0.24	0.95	1.19
tPCB	Aroclor 1254 Mink NOAEL (Sample et al. 1996)	0.137	1	0.042	0.0193	2.18	8.72	10.89
tPCB	Aroclor 1254 Mink **LOAEL** (Sample et al. 1996)	0.685	1	0.210	0.0193	10.89	43.58	54.47
tPCB	Weathered PCBs feed to Mink NOAEL decrease in male kit bw (Halbrook et al. 1999)	0.120	1	0.037	0.0193	1.91	7.63	9.54
tPCB	Weathered PCBs feed to Mink **LOAEL** decrease in male kit bw (Halbrook et al. 1999)	0.230	1	0.071	0.0193	3.66	14.63	18.29
tPCB	Weathered PCBs feed to Mink NOAEL decreased kit survival (Bursian et al. 2003)	0.170	1	0.052	0.0193	2.70	10.81	13.52
tPCB	Weathered PCBs feed to Mink **LOAEL** decreased kit survival (Bursian et al. 2003)	0.410	1	0.126	0.0193	6.52	26.08	32.60
BHC	Mink NOAEL (Sample et al. 1996)	0.140	1	0.04	0.0193	2.23	8.91	11.13
o-Cresol	Mink NOAEL (Sample et al. 1996)	219.200	1	67.23	0.0193	3486.06	13944.25	17430.31
heptachlor	Mink NOAEL (Sample et al. 1996)	0.100	1	0.03	0.0193	1.59	6.36	7.95
fluoride	Mink NOAEL (Sample et al. 1996)	31.370	1	9.62	0.0193	498.90	1995.58	2494.48

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

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

Table 13c. Dietary benchmarks for loggerhead sea turtle (D_{Turtle}) based on the lowest value between TRVs based on avian or mammalian literature toxicity reference values.

		D_{Turtle}			
Chemical	Source of TRV	wet ug/g (wet)	fish[a] ug/g (dry)	invertebrate[b] ug/g (dry)	Factor[c] Difference
Ag	Mallard duckling 4 wk NOAEL (Van Vleet 1982)	86.1	344.3	430.4	
As	Mallard duck NOAEL (Sample et al. 1996)	266.5	1066.1	1332.6	
Cd	Mallard duck NOAEL (Sample et al. 1996)	75.2	300.7	375.9	
Cr	Black duck NOAEL (Sample et al. 1996)	51.9	207.4	259.3	
Cu	Mink NOAEL (Sample et al. 1996)	186.1	744.3	930.4	13.10
Hg (total)	Mink NOAEL (Sample et al. 1996)	15.9	63.6	79.5	1.47
meHg	Mink NOAEL (Sample et al. 1996)	0.2	1.0	1.2	
Ni	Mallard duckling NOAEL (Sample et al. 1996)	4013.3	16053.3	20066.7	
Pb	Japanese quail NOAEL (Sample et al. 1996)	58.6	234.4	293.0	
Zn	Chicken NOAEL (Sample et al. 1996)	751.9	3007.4	3759.3	
FLUOR	Redwing blackbird LD50 (Schafer et al. 1983)	52.4	209.5	261.9	
PHEN	Mallard duck 7 mon LOAEL (Eisler 1987)	3111.1	12444.4	15555.6	
sumPAH	Mallard duck 7 mon LOAEL (Patton and Dieter 1980)	2549.2	10197.0	12746.2	
tPCB	Aroclor 1254 Mink NOAEL (Sample et al. 1996)	2.179	8.715	10.894	4.28
tPCB	Aroclor 1254 Mink LOAEL (Sample et al. 1996)	10.894	43.576	54.470	8.57
tPCB	Weathered PCBs feed to Mink NOAEL decrease in male kit bw (Halbrook et al. 1999)	1.908	7.634	9.542	
tPCB	Weathered PCBs feed to Mink LOAEL decrease in male kit bw (Halbrook et al. 1999)	3.658	14.631	18.289	
tPCB	Weathered PCBs feed to Mink NOAEL decreased kit survival (Bursian et al. 2003)	2.704	10.814	13.518	
tPCB	Weathered PCBs feed to Mink LOAEL decreased kit survival (Bursian et al. 2003)	6.520	26.082	32.602	

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

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

[c] Factor difference between turtle and avian or mammalian benchmark (avian/mammalian).

Table 14. Calcuation of dietary PCB benchmark for TERTIARY CONSUMER (shark or barracuda) based on ratio of BAFs between trophic level IV (TL-IV shark) and Trophic Level III (TL-III prey) obtained from PRAM 3.1a (Goodrich 2004).

		Reef Predator (TL-IV)		Reef Forager (TL-III)		ratio
Homolog	f_{PCB}[a]	BAF4[b]	wBAF4[c]	BAF3[d]	wBAF3[c]	wBAF4/ wBAF3
Monochlorobiphenyls	0.0001	5.18E+02	6.20E-02	5.67E+02	6.79E-02	
Dichlorobiphenyls	0.0017	3.04E+04	5.08E+01	3.30E+04	5.52E+01	
Trichlorobiphenyls	0.0118	1.45E+05	1.71E+03	1.54E+05	1.82E+03	
Tetrachlorobiphenyls	0.0823	1.51E+06	1.24E+05	1.40E+06	1.15E+05	
Pentachlorobiphenyls	0.3479	5.26E+07	1.83E+07	3.34E+07	1.16E+07	
Hexachlorobiphenyls	0.3997	3.37E+08	1.35E+08	1.86E+08	7.44E+07	
Heptachlrobiphenyls	0.1039	5.68E+08	5.90E+07	3.12E+08	3.24E+07	
Octachlorobiphenyls	0.0378	1.21E+09	4.59E+07	7.24E+08	2.74E+07	
Nonachlorobiphenyls	0.0133	1.92E+09	2.56E+07	1.45E+09	1.93E+07	
209 - Decachlorobiphenyl	0.0016	1.34E+09	2.09E+06	1.94E+09	3.04E+06	
tPCB			2.86E+08		1.68E+08	1.70

				D_{Shark} prey (fish)	
Enpoint	Source	ug/g wet	ratio wBAF4/wBAF3	ug/g wet	ug/g dry
NOED	Hansen et al 1975 Sheepshead minnow	1.5	1.70	0.884	3.535
LOED	Mac and Seelye 1981 Trout -Lake	1.8	1.70	1.060	4.241

[a] fraction of tPCB (f_{PCB}) measured in representative samples of vermilion snapper (see Table 7)

[b] bioaccumation factor (BAF) obtained from Trophic Level - IV reef predator (Goodrich 2004)

[c] weighted BAF based on fraction of tPCB

[d] bioaccumation factor (BAF) obtained from Trophic Level - III reef forager (Goodrich 2004)

Table 15. Coplanar dixon-like PCB congeners and Toxicity Equivalent Factors (TEF) for mammals, birds, and fish.

	Ahlborg et al. 1994	Van den Berg et al. 1998*			Cook et al. 2003
code	All Species	Mammal_TEF	Bird_TEF	Fish_TEF	Fish
PCB077	0.0005	0.0001	0.05	0.0001	0.00016
PCB081e		0.0001	0.1	0.0005	0.00056
PCB105	0.0001	0.0001	0.0001	0.000005	0.000005
PCB114	0.0005	0.0005	0.0001	0.000005	
PCB118	0.0001	0.0001	0.00001	0.000005	0.000005
PCB123	0.0001	0.0001	0.00001	0.000005	
PCB126	0.1	0.1	0.1	0.005	0.005
PCB156e	0.0005	0.0005	0.0001	0.000005	0.000005
PCB157e	0.0005	0.0005	0.0001	0.000005	
PCB167	0.00001	0.00001	0.00001	0.000005	
PCB169	0.01	0.01	0.001	0.00005	0.01
PCB170	0.0001				
PCB180	0.00001				
PCB189	0.0001	0.0001	0.00001	0.000005	

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

Table 16. Summary of media, data sources, exposure pathways, benchmarks, endpoints, and chemicals evaluated for the ecorisk screening analysis.

Media	Data Source(s)	Exposure Pathway	Benchmarks	Endpoint/Receptor	Chemicals Evaluated
Water	Modeled from leachrate study (see Appendix 8)	Water	Water Quality Criteria Chronic, Acute	Primary Producer	PCB
				Primary Consumer	
				Secondary Consumer	
				Tertiary Consumer	
Sediment	Data from SINKEX study (Gauthier et al. 2003)	Sediment	Potential Sediment Effects ERL, ERM	Primary Producer	PCB, Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, PAH
				Primary Consumer	
				Secondary Consumer	
Tissue Residue	Martore et al. 1998; Supplemental fish sampling	Food Chain	Potential Bioaccumulation Effects TSV, Bcv	Primary Producer	PCB, Cd, Cr, Cu, Ni, Pb
				Primary Consumer	
				Secondary Consumer	
				Tertiary Consumer	
Tissue Residue	Martore et al. 1998; Supplemental fish	Food Chain	Critical Body Residues NOED, LOED	Primary Consumer (Reef Invertebrates)	PCB, Cd, Cr, Cu, Ni, Pb
				Secondary Consumer (Demersal Fish)	
Tissue Residue	Martore et al. 1998; Supplemental fish sampling	Food Chain	Dietary Exposure NOAEL, LOAEL	Avian Omnivore (Herring Gull)	PCB, Cd, Cr, Cu, Ni, Pb
				Avian Piscivore (Cormorant)	
				Secondary Consumer (Sea Turtle)	
				Tertiary Consumer (Dolphin)	PCB, Cu
				Tertiary Consumer (Shark)	PCB

Table 17. Decision matrix for determining the risk of exposure from artificial reefs constructed of a sunken ex-Navy vessel.

	Is exposure greater than Reference and Background?		
Is exposure harmful?	Less	Similar	Higher
Very unlikely	***Negligible Exposure***	***Negligible Exposure***	***Negligible Exposure***
Unlikely	***Negligible Exposure***	***Negligible Exposure***	***Low Exposure***
Moderate likelihood	***Negligible Exposure***	***Negligible Exposure***	***Medium Exposure***
Likely	***Negligible Exposure***	***Low Exposure***	***High Exposure***
Very likely	***Negligible Exposure***	***Medium Exposure***	***Adverse Exposure***

Table 18. Comparison of data obtained from vermilion snapper fillets collected from the target and reference reefs for samples analyzed by AXYS and ADL.

	Vermilion Snapper										
	Reference					Target					
Variable	**n**	**Mean**	**SD**	**Min**	**Max**	**n**	**Mean**	**SD**	**Min**	**Max**	**p**
Length (mm)	22 *	284.2	14.3	265.0	315.0	20 *	322.0	21.5	295.0	360.0	<0.0001
Weight (g)	22 *	341.0	54.6	270.0	463.0	20	515.6	117.2	381.0	777.0	<0.0001
Liver Weight (g)	21 *	3.0	1.2	1.3	5.7	20 *	7.5	2.6	3.6	12.2	<0.0001
Age (yr)	22 *	4.0	0.7	3.0	5.0	20	4.6	0.8	4.0	6.0	0.0103
Axys Analytical Services											
Dry Weight (%)	22 *	26.8	1.9	22.5	30.0	20	29.6	4.0	25.7	43.0	0.0042
Lipid Weight Wet (%)	22 *	5.0	1.9	1.1	10.6	20	5.3	1.3	1.7	6.9	0.8400
Total PCB ng/g dry	22	26.1	10.4	14.2	53.8	20	51.3	40.7	7.7	171.4	0.0077
Total PCB ng/g lipid	22	170.2	117.6	51.8	567.9	20	294.8	246.9	126.0	1164.8	0.0403
Log (Total PCB ng/g)	22 *	1.3889	0.1559	1.1532	1.7312	20 *	1.6164	0.2857	0.8841	2.2340	0.0024
Log (Total PCB ng/g lipid)	22 *	2.1543	0.2547	1.7146	2.7542	20	2.3832	0.2504	2.1004	3.0663	0.0055
Arthur D. Little Inc.											
Dry Weight (%)	9 *	25.6	1.8	23.2	28.5	7 *	27.5	1.3	26.0	30.3	0.0384
Lipid Weight Wet (%)	9	4.6	2.9	1.5	9.9	7 *	5.1	1.0	3.8	6.3	0.6693
Total PCB ng/g dry	9 *	42.7	21.4	14.0	80.0	7	86.0	62.9	47.3	212.0	0.0730
Total PCB ng/g lipid	9	277.1	158.7	98.8	640.0	7	509.5	469.8	205.7	1514.3	0.1814
Log (Total PCB ng/g)	9 *	1.5778	0.2361	1.1461	1.9031	7	1.8582	0.2575	1.6749	2.3263	0.0398
Log (Total PCB ng/g lipid)	9 *	2.3876	0.2294	1.9948	2.8062	7 *	2.5940	0.3116	2.3131	3.1802	0.1485

* Indicates variable was normally distributed in the sample population.

Table 19. Comparison of data obtained from white grunt fillets collected from the target and reference reefs for samples analyzed by AXYS and ADL

	White Grunt										
	Reference					Target					
Variable	**n**	**Mean**	**SD**	**Min**	**Max**	**n**	**Mean**	**SD**	**Min**	**Max**	**p**
Length (mm)	20 *	320.0	53.8	232.0	405.0	20 *	320.3	73.6	233.0	440.0	0.9883
Weight (g)	20	624.6	321.3	223.0	1433.0	20	718.1	496.4	227.0	1709.0	0.4838
Liver Weight (g)	20	6.2	8.4	1.4	40.2	20	14.7	12.1	1.7	39.0	0.0143
Age (yr)	20 *	5.7	1.9	3.0	9.0	20	5.8	2.7	3.0	11.0	0.8938
Axys Analytical Services											
Dry Weight (%)	20 *	22.4	1.8	18.5	27.7	20 *	26.1	2.0	23.1	29.4	<0.0001
Lipid Weight Wet (%)	20	1.2	1.3	0.4	6.4	20 *	4.4	1.7	1.6	7.3	<0.0001
Total PCB ng/g dry	20	16.7	31.4	2.6	143.2	20	1118.9	1509.4	85.9	5122.0	0.0023
Total PCB ng/g lipid	20	309.0	437.8	78.6	2063.6	20	5883.2	6381.4	541.8	20733.0	0.0004
Log (Total PCB ng/g)	20	0.9434	0.4136	0.4096	2.1560	20 *	2.7016	0.5586	1.9339	3.7094	<0.0001
Log (Total PCB ng/g lipid)	20	2.3247	0.3192	1.8953	3.3146	20 *	3.5071	0.5056	2.7338	4.3167	<0.0001
Arthur D. Little Inc.											
Dry Weight (%)	7 *	22.2	1.2	20.2	24.1	7 *	25.0	1.9	23.2	27.7	0.0072
Lipid Weight Wet (%)	7 *	5.1	1.4	3.6	7.6	7 *	9.7	2.8	6.0	13.6	0.0029
Total PCB ng/g dry	7	31.2	67.6	0.3	184.0	7	621.5	625.9	170.9	1789.0	0.0288
Total PCB ng/g lipid	7	448.4	878.8	6.5	2427.4	7 *	6257.3	5178.8	1256.6	14086.0	0.0127
Log (Total PCB ng/g)	7 *	0.7560	0.8540	-0.4949	2.2648	7 *	2.6252	0.3962	2.2327	3.2526	0.0002
Log (Total PCB ng/g lipid)	7 *	2.0588	0.7947	0.8132	3.3851	7 *	3.6567	0.3882	3.0992	4.1488	0.0004

* Indicates variable was normally distributed in the sample population.

Table 20. Comparison of data obtained from black sea bass fillets collected from the target and reference reef for samples analyzed by AXYS and ADL.

	Black Sea Bass										
	Reference					Target					
Variable	**n**	**Mean**	**SD**	**Min**	**Max**	**n**	**Mean**	**SD**	**Min**	**Max**	**p**
Length (mm)	20 *	311.7	45.9	252.0	422.0	11 *	321.1	41.5	267.0	425.0	0.5758
Weight (g)	20	483.7	228.3	265.0	1128.0	11	652.6	236.5	391.0	1231.0	0.0614
Liver Weight (g)	20	3.5	2.3	1.5	11.8	11	16.3	5.7	5.5	26.8	<0.0001
Age (yr)	20	4.5	1.5	3.0	9.0	11	4.6	1.6	3.0	9.0	0.8108
Axys Analytical Services											
Dry Weight (%)	20 *	21.0	1.0	18.0	22.8	11 *	26.5	2.3	21.6	29.7	<0.0001
Lipid Weight Wet (%)	20	0.5	0.6	0.1	2.8	11	5.3	2.4	1.2	9.1	<0.0001
Total PCB ng/g dry	20	27.3	27.9	13.5	142.7	11	149.5	86.6	40.0	347.0	<0.0001
Total PCB ng/g lipid	20	1398.7	1014.2	585.7	4871.8	11	928.2	742.9	272.5	2388.3	0.1880
Log (Total PCB ng/g)	20	1.3491	0.2312	1.1296	2.1543	11	2.1039	0.2711	1.6021	2.5403	<0.0001
Log (Total PCB ng/g lipid)	20	3.0778	0.2262	2.7677	3.6877	11	2.8620	0.3065	2.4353	3.3781	0.0329
Arthur D. Little Inc.											
Dry Weight (%)	20 *	20.2	1.3	18.2	24.3	11 *	25.3	3.3	19.5	30.7	<0.0001
Lipid Weight Wet (%)	20	2.9	2.9	1.1	14.2	11	18.6	9.8	7.8	38.3	<0.0001
Total PCB ng/g dry	20	27.6	52.5	2.7	228.9	11	197.2	111.2	49.2	424.0	<0.0001
Total PCB ng/g lipid	20	811.1	1054.2	74.7	4536.6	11	1343.1	1203.8	484.6	3714.3	0.2110
Log (Total PCB ng/g)	20	0.9956	0.5885	0.4281	2.3596	11	2.2245	0.2732	1.6920	2.6274	<0.0001
Log (Total PCB ng/g lipid)	20 *	2.6302	0.5061	1.8734	3.6567	11 *	3.0087	0.3136	2.6854	3.5699	0.0326

* Indicates variable was normally distributed in the sample population.

Table 21. The sample id, length, weight, age, lipid content, HSI, and total PCB concentration of fish samples that had a HSI > 2%.

Site	Sample Identification	Total Length	Total Weight	Liver Weight (g)	Sex	Age	Lipid Wet Weight	Total PCB	Total PCB/Lipid dry	HSI
Black Seabass		mm	g	g		yr	%	ng/g dry	ng/g lipid	%
Target	FS-08-SB-T	310	513	17.47	Immature	4	2.16	211.88	2388.3	3.41%
Target	FS-10-SB-T	296	515	16.08	F	4	6.30	86.07	382.5	3.12%
Target	FS-04-SB-T	315	663	19.49	M	4	5.93	150.37	684.7	2.94%
Target	FS-06-SB-T	355	917	26.84	F	5	7.46	180.85	654.2	2.93%
Target	FS-05-SB-T	300	530	14.75	F	4	3.67	40.00	272.5	2.78%
Target	FS-09-SB-T	336	713	19.82	F	5	5.34	68.34	350.5	2.78%
Target	FS-11-SB-T	267	391	10.83	M	3	5.04	141.48	758.4	2.77%
Target	FS-03-SB-T	321	639	16.47	F	5	9.05	192.41	616.6	2.58%
Target	FS-02-SB-T	292	520	11.44	F	4	7.78	157.12	600.6	2.20%
Vermilion Snapper										
Target	FS-13-VS-T	320	525	12.22	F	5	5.80	33.90	169.5	2.33%
Target	FS-12-VS-T	334	513	11.77	F	5	1.70	7.66	171.2	2.29%
Target	FS-17-VS-T	295	400	8.13	F	4	5.60	45.00	225.0	2.03%
Target	FS-04-VS-T	335	615	11.82	F	5	4.30	48.89	307.3	1.92%
White Grunt										
Target	FS-04-WG-T	274	424	13.13	F	4	5.54	281.20	1444.0	3.10%
Target	FS-10-WG-T	378	999	28.78	M	7	4.40	2446.64	14068.2	2.88%
Reference	FS-01-WG-R	405	1433	40.24	F	9	6.41	49.37	212.9	2.81%
Target	FS-03-WG-T	293	489	12.93	F	5	6.13	350.34	1680.3	2.64%
Target	FS-02-WG-T	422	1329	32.01	M	10	7.09	5121.95	20733.4	2.41%
Target	FS-17-WG-T	440	1709	39.03	F	11	4.87	645.79	3391.6	2.28%
Target	FS-18-WG-T	432	1592	34.87	F	10	7.31	4808.36	18878.2	2.19%
Target	FS-12-WG-T	365	928	20.2	F	7	5.61	1683.17	8428.9	2.18%
Target	FS-05-WG-T	250	304	6.55	F	3	3.70	85.89	575.7	2.15%
Target	FS-11-WG-T	315	568	11.61	M	5	4.41	150.99	866.2	2.04%
Target	FS-15-WG-T	422	1464	29.46	M	10	4.50	2261.04	12511.1	2.01%

Table 22. Summary of correlations obtained for HSI and liver weight (LWEIGHT) for all fish (A), vermilion snapper (B), white grunt (C), and black sea bass (D).

All fish.	n=113	HSI				LWEIGHT	
	variable	r	p		variable	r	p
Liver Weight	LWEIGHT	**0.7664**	0.0000	Body Weight	WEIGHT	**0.8100**	0.0000
Fillet log(tPCB)	F_LPCB	**0.5717**	0.0000	Hepatosomatic Index	HSI	**0.7664**	0.0000
Whole Body log(tPCB)	W_LPCB	**0.5670**	0.0000	Age in Years	AGE	**0.6704**	0.0000
%Lipid Dry Weight	LIPIDD	**0.5440**	0.0000	Total Length	LEN	**0.6586**	0.0000
Body Weight	WEIGHT	**0.3447**	0.0002	Fillet log(tPCB)	F_LPCB	**0.6405**	0.0000
Whole Body tPCB	W_PCB	**0.3172**	0.0006	Whole Body log(tPCB)	W_LPCB	**0.6399**	0.0000
Fillet tPCB	F_PCB	**0.3134**	0.0007	Whole Body tPCB	W_PCB	**0.5879**	0.0000
Fillet log(tPCB/ Lipid)	F_LPCBL	**0.2601**	0.0054	Fillet tPCB	F_PCB	**0.5851**	0.0000
Fillet tPCB/lipid	F_PCBL	**0.2571**	0.0060	Fillet tPCB/lipid	F_PCBL	**0.5236**	0.0000
Whole Body tPCB/lipid	W_PCBL	**0.2303**	0.0141	Whole Body tPCB/lipid	W_PCBL	**0.4890**	0.0000
Whole Body Log(tPCB/lipid)	W_LPCBL	**0.2285**	0.0149	%Lipid Dry Weight	LIPIDD	**0.4453**	0.0000
Total Length	LEN	**0.2125**	0.0239	Fillet log(tPCB/ Lipid)	F_LPCBL	**0.4238**	0.0000
Age in Years	AGE	0.1751	0.0636	Whole Body Log(tPCB/lipid)	W_LPCBL	**0.3886**	0.0000

Vermilion Snapper		HSI				LWEIGHT	
	var	r	p		var	r	p
Liver Weight	LWEIGHT	**0.9127**	0.0000	Hepatosomatic Index	HSI	**0.9127**	0.0000
Total Length	LEN	**0.4874**	0.0011	Total Length	LEN	**0.7684**	0.0000
Body Weight	WEIGHT	**0.4660**	0.0019	Body Weight	WEIGHT	**0.7604**	0.0000
Age in Years	AGE	0.2855	0.0669	Age in Years	AGE	**0.5671**	0.0001
Whole Body log(tPCB)	W_LPCB	0.1196	0.4506	Whole Body log(tPCB)	W_LPCB	0.2882	0.0642
Whole Body Log(tPCB/lipid)	W_LPCBL	0.0915	0.5645	Whole Body Log(tPCB/lipid)	W_LPCBL	0.2749	0.0781
Whole Body tPCB	W_PCB	0.0826	0.6029	Whole Body tPCB	W_PCB	0.2463	0.1159
Fillet log(tPCB)	F_LPCB	0.0770	0.6278	Fillet log(tPCB/ Lipid)	F_LPCBL	0.2454	0.1173
Fillet tPCB	F_PCB	0.0695	0.6617	Fillet log(tPCB)	F_LPCB	0.2449	0.1180
%Lipid Dry Weight	LIPIDD	0.0618	0.6976	Fillet tPCB	F_PCB	0.2341	0.1356
Fillet log(tPCB/ Lipid)	F_LPCBL	0.0563	0.7232	Whole Body tPCB/lipid	W_PCBL	0.1486	0.3475
Whole Body tPCB/lipid	W_PCBL	-0.0390	0.8061	Fillet tPCB/lipid	F_PCBL	0.1299	0.4121
Fillet tPCB/lipid	F_PCBL	-0.0612	0.7002	%Lipid Dry Weight	LIPIDD	-0.0244	0.8782

White Grunt		HSI				LWEIGHT	
	var	r	p		var	r	p
%Lipid Dry Weight	LIPIDD	**0.8656**	0.0000	Body Weight	WEIGHT	**0.8531**	0.0000
Liver Weight	LWEIGHT	**0.7609**	0.0000	Age in Years	AGE	**0.7618**	0.0000
Fillet log(tPCB)	F_LPCB	**0.6881**	0.0000	Hepatosomatic Index	HSI	**0.7609**	0.0000
Whole Body log(tPCB)	W_LPCB	**0.6876**	0.0000	%Lipid Dry Weight	LIPIDD	**0.7513**	0.0000
Fillet log(tPCB/ Lipid)	F_LPCBL	**0.5468**	0.0003	Total Length	LEN	**0.7394**	0.0000
Whole Body Log(tPCB/lipid)	W_LPCBL	**0.5375**	0.0003	Whole Body tPCB	W_PCB	**0.6341**	0.0000
Whole Body tPCB	W_PCB	**0.4649**	0.0025	Fillet tPCB	F_PCB	**0.6309**	0.0000
Fillet tPCB	F_PCB	**0.4594**	0.0029	Whole Body log(tPCB)	W_LPCB	**0.6088**	0.0000
Whole Body tPCB/lipid	W_PCBL	**0.4433**	0.0042	Fillet log(tPCB)	F_LPCB	**0.6082**	0.0000
Fillet tPCB/lipid	F_PCBL	**0.4388**	0.0046	Whole Body tPCB/lipid	W_PCBL	**0.5887**	0.0001
Body Weight	WEIGHT	**0.4032**	0.0099	Fillet tPCB/lipid	F_PCBL	**0.5875**	0.0001
Age in Years	AGE	0.2950	0.0646	Fillet log(tPCB/ Lipid)	F_LPCBL	**0.5206**	0.0006
Total Length	LEN	0.2918	0.0677	Whole Body Log(tPCB/lipid)	W_LPCBL	**0.5146**	0.0007

Black Sea Bass		HSI				LWEIGHT	
		r	p		var	r	p
Liver Weight	LWEIGHT	**0.8793**	0.0000	Hepatosomatic Index	HSI	**0.8793**	0.0000
%Lipid Dry Weight	LIPIDD	**0.8286**	0.0000	%Lipid Dry Weight	LIPIDD	**0.8650**	0.0000
Fillet log(tPCB)	F_LPCB	**0.7397**	0.0000	Fillet log(tPCB)	F_LPCB	**0.8463**	0.0000
Whole Body log(tPCB)	W_LPCB	**0.7330**	0.0000	Whole Body log(tPCB)	W_LPCB	**0.8300**	0.0000
Fillet tPCB	F_PCB	**0.6340**	0.0001	Fillet tPCB	F_PCB	**0.8025**	0.0000
Whole Body tPCB	W_PCB	**0.6296**	0.0001	Whole Body tPCB	W_PCB	**0.7815**	0.0000
Whole Body Log(tPCB/lipid)	W_LPCBL	**-0.4820**	0.0060	Body Weight	WEIGHT	**0.5981**	0.0004
Fillet log(tPCB/ Lipid)	F_LPCBL	**-0.4408**	0.0131	Whole Body Log(tPCB/lipid)	W_LPCBL	**-0.4351**	0.0144
Fillet tPCB/lipid	F_PCBL	-0.2725	0.1380	Total Length	LEN	**0.3576**	0.0483
Whole Body tPCB/lipid	W_PCBL	-0.2627	0.1534	Fillet log(tPCB/ Lipid)	F_LPCBL	**-0.3486**	0.0546
Age in Years	AGE	-0.0907	0.6275	Age in Years	AGE	0.3005	0.1004
Total Length	LEN	-0.0367	0.8444	Whole Body tPCB/lipid	W_PCBL	-0.2587	0.1599
Body Weight	WEIGHT	0.2176	0.2396	Fillet tPCB/lipid	F_PCBL	-0.2187	0.2371

Table 23. Results of the stepwise multivariate regression of Hepatosomatic Index (HIS) and independent variables from the supplemental fish data.

STEPWISE REGRESSION OF HSI
UNFORCED VARIABLES: AGE DRY F_LPCB F_LPCBL F_PCB F_PCBL LEN LIPIDD LIPIDW ROUND SEXVAR
SITEVAR SPVAR W_LPCB W_LPCBL W_PCB W_PCBL
P TO ENTER 0.0500
P TO EXIT 0.0500
Note: WEIGHT and LWEIGHT not included in model

STEP	R SQ	MSE	P		AGE	DRY	F_LPCB	F_LPCBL	F_PCB	F_PCBL	LEN	LIPIDD	LIPIDW	ROUND	SEXVAR	SITEVAR	SPVAR	W_LPCB	W_LPCBL	W_PCB	W_PCBL	VARIANCE
1	0.0000	5.70E-05			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
2	0.4778	3.00E-05	0.0000	+	.	.	.	.	.	.	.	.	.	.	.	L	.	.	.	.	.	0.4778
3	0.5263	2.75E-05	0.0011	+	.	.	.	.	.	.	.	H	.	.	.	L	.	.	.	.	.	0.0485
4	0.5440	2.67E-05	0.0421	+	.	.	.	.	.	.	.	H	.	.	.	L	.	.	O	.	.	0.0177
5	0.6035	2.34E-05	0.0001	+	.	.	.	D	.	.	.	H	.	.	.	L	.	.	O	.	.	0.0595
6	0.6687	1.98E-05	0.0000	+	.	.	.	D	.	.	.	H	.	.	.	L	.	N	O	.	.	0.0652
7	0.6664	1.97E-05	0.3883	-	.	.	.	D	.	.	.	.	.	.	.	L	.	N	O	.	.	-0.0023
8	0.6785	1.92E-05	0.0466	+	A	.	.	D	.	.	.	.	.	.	.	L	.	N	O	.	.	0.0121
																						0.6785

NAME	VARIABLE	COEF.	STD ERROR	T	P	r^2*
	CONSTANT	0.01214	0.00299	4.06	0.00010	
Site	SITEVAR	0.00660	0.00123	5.37	0.00000	0.4778
Whole body Log(tPCB)	W_LPCB	0.01785	0.00229	7.78	0.00000	0.0652
Fillet Log(tPCB/lipid)	F_LPCBL	-0.10508	0.01464	-7.18	0.00000	0.0595
Whole Body Log(tPCB/lipid)	W_LPCBL	0.08696	0.01259	6.91	0.00000	0.0177
Age	AGE	0.00053	0.00026	2.01	0.04660	0.0121

* Variance in HSI explained when variable first entered into the regression

HSI = 0.01214 + 0.0066(**SITEVAR**) + 0.01785(**W_LPCB**) - 0.10508(**F_LPCBL**) + 0.08696(**W_LPCBL**) + 0.00053(**AGE**)

CASES INCLUDED 113 R SQUARED 0.6785 MSE 1.919E-05
MISSING CASES 0 ADJ R SQ 0.6635 SD 0.00438

VARIABLES NOT IN THE MODEL

Name	VARIABLE	CORRELATIONS MULTIPLE	CORRELATIONS PARTIAL	T	P
% Dry Weight	DRY	0.7943	-0.1550	-1.6200	0.1091
Fillet Log(tPCB)	F_LPCB	1.0000	0.0000	0.0000	1.0000
Fillet tPCB	F_PCB	0.7547	0.0061	0.0600	0.9502
Fillet tPCB/lipid	F_PCBL	0.8140	-0.0905	-0.9400	0.3517
Total Length	LEN	0.9371	-0.0179	-0.1800	0.8544
%Lipid Dry Weight	LIPIDD	0.9507	-0.0925	-0.9600	0.3410
%Lipid Wet Weight	LIPIDW	0.9305	-0.1222	-1.2700	0.2075
Analytical Chemistry Round	ROUND	0.4236	0.1126	1.1700	0.2461
Sex Variable	SEXVAR	0.3525	-0.1513	-1.5800	0.1181
Species Variable	SPVAR	0.4230	-0.0630	-0.6500	0.5174
Whole Body tPCB	W_PCB	0.7581	0.0116	0.1200	0.9052
Whole Body tPCB/lipid	W_PCBL	0.8203	-0.1600	-1.6700	0.0982

Table 24. Risk of Exposure inferred from data on fish tissue residues and low (L), medium (M), or high (H) confidence in conclusion.

Degree Exposure could be harmful	Exposure Relative to Reference and Background: Less	Similar	Higher
Very Unlikely	Ni -Plankton (L) Ni - Demersal Fish (L) Ni - Cormorant (L) Ni - Herring Gull (L)	Cu - Plankton (L) Cu - Dolphin (L) Cu - Cormorant (L) Cu - Herring Gull (L) Cr - Cormorant (L) Cr - Cormorant (L)	PCB - Demersal Fish (H) Cd - Demersal Fish (L) Cd - Piscivore (L) Cd - Omnivore (L) Pb - Demersal Fish (L) Pb - Cormorant (L) Pb - Herring Gull (L)
Unlikely			PCB - Plankton (H) PCB - Dolphin (H) PCB - Herring Gull (H) PCB - Cormorant (H) PCB - Shark (H)
Moderate Likelihood		Cu - Demersal Fish (L)	Cd - Plankton (L)
Likely		Cr - Plankton Cr - Demersal Fish (L)	
Very Likely			Pb - Plankton (L)

Negligible Exposure
Low Exposure
Medium Exposure
High Exposure
Adverse Exposure

Table 25. Risk of Exposure inferred from data on invertebrate tissue residues and low (L), medium (M), or high (H) confidence in conclusion.

	Exposure Relative to Reference and Background		
	Less	**Similar**	**Higher**
Very Unlikely	Ni - Plankton (L) Ni - Reef Invertebrates (L) Ni - Herring Gull (L) Ni - Sea Turtle (L)	Cd - Herring Gull (L) Cd - Sea Turtle (L) Cu - Dolphin (L) Cu - Herring Gull (L) Cu - Reef Invertebrates (L) Cu - Sea Turtle Cr - Herring Gull (L) Cr - Sea Turtle	PCB - Reef Invertebrates (L) PCB - Herring Gull (L) PCB - Dolphin (L) PCB - Sea Turtle (L) Pb - Reef Invertebrates (L) Pb - Herring Gull (L) Pb - Sea Turtle (L)
Unlikely		Cd - Reef Invertebrates (L) Cu - Plankton (L)	
Moderate Likelihood		Cd - Plankton (L) Cr - Plankton (L) Cr - Reef Invertebrates (L)	Pb - Plankton (L)
Likely			
Very Likely			

Negligible Exposure
Low Exposure
Medium Exposure
High Exposure
Adverse Exposure

Table 26. The average and maximum HI (or HQ) calculated for the Navy Vessel Reef and Natural Reef, the assessment endpoints, interpretation, comparison to reference, and conclusions derived for HIs based on fish tissue residues (A) and invertebrate tissue residues (B) from the SCDNR study and PCB HQs based on the supplemental fish study (C).

A. HI based on Fish Tissue Residues (data from Martore et al. 1996)

Benchmark	Navy Vessel Reef Fish avg	Navy Vessel Reef Fish max	Natural Reef Fish avg	Natural Reef Fish max	Assessment Endpoint	Interpretation	Comparison to Reference	Conclusion
TSV	23.60	32.50	3.04	21.81	Bioaccumulation in Primary Producers and Consumers	Moderate likelihood exposure is harmful to Producers and Consumers	HI range is higher than Reference	Medium risk of exposure to Primary Producers and Consumers
Bcv	3.85	5.05	0.94	4.43				
NOED	4.69	7.68	2.48	11.41	CBR In Secondary Consumers (Fish)	Moderate likelihood exposure is harmful to fish	HI range is similar to reference	Negligible risk of exposure to Demersal Fish
LOED	1.72	2.94	0.81	4.34				
$D_{HerringGull}$	0.35	0.51	0.11	0.81	Dietary Exposure to Avian Omnivores (Gull)	Very unlikely exposure is harmful to Herring Gull	HI range is lower than reference	Negligible risk of exposure to Herring Gulls
$D_{Cormorant}$	0.36	0.53	0.12	0.84	Dietary Exposure to Avian Piscivores (Cormorant)	Very unlikely exposure is harmful to Cormorant	HI range is lower than reference	Negligible risk of exposure to Cormorants
D_{Shark} [a]	0.03	0.06	0.05	0.38	Dietary Exposure to Tertiary Consumers (Shark)	Very unlikely exposure is harmful to Sharks	HI range is lower than reference	Negligible risk of exposure to Sharks
$D_{Dolphin}$ [b]	0.10	0.17	0.13	1.08	Dietary Exposure to Tertiary Consumers (Dolphin)	Very unlikely exposure is harmful to Dolphins	HI range is lower than reference	Negligible risk of exposure to Dolphins

[a] HQ based on PCB only

[b] HI based on PCB and Cu only.

B. HI based on Invertebrate Tissue Residues (data from Martore et al. 1996)

	Navy Vessel Reef Invertebrate avg	Navy Vessel Reef Invertebrate max	Natural Reef Invertebrate avg	Natural Reef Invertebrate max	Assessment Endpoint	Interpretation	Comparison to Reference	Conclusion
TSV	17.41	45.66	42.11	77.72	Bioaccumulation in Primary Producers and Consumers	Unlikely exposure is harmful to marine organisms	HI range is less than reference	Negligible risk of exposure to Primary Consumers and Producers
Bcv	0.37	1.05	1.77	5.34				
NOED	2.44	8.84	6.06	13.77	CBR In Primary Consumers (Invertebrates)	Unlikely exposure is harmful to Invertebrates	HI range is similar to reference	Negligible risk of exposure to Invertebrates
LOED	0.96	2.66	3.13	7.66				
$D_{HerringGull}$	0.22	0.73	0.37	0.74	Dietary Exposure to Avian Piscivores (Gull)	Very unlikely exposure is harmful to Herring Gulls	HI range is similar to reference	Negligible risk of exposure to Herring Gulls
$D_{SeaTurtle}$	0.06	0.19	0.12	0.33	Dietary Exposure to 2nd Consumers (Sea Turtle)	Very unlikely exposure is harmful to Sea Turtles	Hi range is similar to reference	Negligible risk of exposure to Sea Turtles
$D_{Dolphin}$ [a]	0.30	0.97	0.67	1.99	Dietary Exposure to Tertiary Consumers (Dolphin)	Very unlikely exposure is harmul to Dolphins	HI range is similar to reference	Negligibe risk of exposure to dolphins

[a] HI based on PCB and Cu only.

Table 26. Continued

C. PCB HQ from Supplemental Fish Sampling

	Navy Vessel Reef		Natural Reef					
	Fish		Fish					
	avg	max	avg	max	**Assessment Endpoint**	**Interpretation**	**Comparison to Reference**	**Conclusion**
TSV	0.320	3.220	0.020	0.100	Bioaccumulation of PCBs in Primary Consumers and Producers	Unlikely that exposure to PCB may be harmful to Primary Producers and Consumers	HQ range is higher than reference	Low risk of exposure to PCB for Primary Producers and Consumers
Bcv	0.020	0.230	0.001	0.010				
NOED	0.090	0.940	0.005	0.030	PCB residues exceed CBR Secondary Consumers (Fish)	Very Unlikely PCB exposure is harmful to Secondary Consumers (Fish)	HQ range is higher than reference	Negligble risk of exposure to PCB for Secondary Consumers (Demersal Fish)
LOED	0.080	0.780	0.004	0.020				
$D_{HerringGull}$	0.170	1.690	0.009	0.050	Dietary Exposure of PCBs to Herring Gulls	Unlikely PCB exposure is harmful to Herring Gulls	HQ range is higher than reference	Low risk of exposure to PCB for Avian Consumers (Herring Gulls)
$D_{Cormorant}$	0.17	1.76	0.009	0.05	Dietary Exposure of PCBs to Cormorant	Unlikely PCB exposure is harmful to Cormorants	HQ range is higher than reference	Low risk of exposure to PCB for Avian Consumers (Cormorants)
D_{Shark}	0.160	1.600	0.010	0.050	Dietary Exposure to Tertiary Consumers (Shark)	Unlikely exposure to PCB is harmful to Sharks	HQ range is higher than reference	Low risk of exposure to PCB to Tertiary Consumers (Shark)
$D_{Dolphin}$	0.430	4.440	0.020	0.130	Dietary Exposure to Tertiary Consumers (Dolphins)	Unlikely PCB exposure is harmful to Dolphins	HQ range is higher than reference	Low risk of exposure to PCB for Tertiary Consumers (Dolphins)

Table 27. The probability of exceeding tissue residue benchmarks for Reference and Target Reefs and the incremental risk of exceeding benchmarks.

			Exposure Distribution							
			Reference				Target			
A. Exposure Distributi	Contaminant	units	GeoMean	LogMean	LogStdev	n	GeoMean	LogMean	LogStdev	n
	tPCB (whole body)	ng/g dry weight	21.46	1.3317	0.3366	62	157.80	2.1981	0.6335	51
	TEQ Egg	pg/g wet weight	0.04	-1.4080	0.3942	39	0.06	-1.2212	0.5583	31
	TEQ Egg	pg/g lipid	0.36	-0.4459	0.3942	39	0.55	-0.2591	0.5583	31
	Bird TEQ	pg/g wet weight	0.31	-0.5045	0.3918	62	1.60	0.2036	0.5009	51
	Mammal TEQ	pg/g wet weight	0.26	-0.5870	0.3316	62	1.50	0.1760	0.5990	51

			Probability of Exceeding Benchmark							
					Reference		Target			Risk
	Species	units	B	log(B)	CriticalB	P(Ref)	CriticalB	P(Target)	RISK	Level
B. Screening Benchmarks										
NOAEL	Dolphin	tPCB ng/g dry	1266	3.1025	5.2609	0.00000	1.4276	0.07670	0.07670	Low
NOAEL	TSV	tPCB ng/g dry	1750	3.2430	5.6784	0.00000	1.6495	0.04953	0.04953	Low
NOAEL	Cormorant	tPCB ng/g dry	3200	3.5051	6.4571	0.00000	2.0632	0.01955	0.01955	Low
NOAEL	Gull	tPCB ng/g dry	3330	3.5224	6.5084	0.00000	2.0905	0.01829	0.01829	Low
NOAEL	Shark	tPCB ng/g dry	3530	3.5478	6.5837	0.00000	2.1305	0.01656	0.01656	Low
NOED	NOED	tPCB ng/g dry	6000	3.7782	7.2681	0.00000	2.4942	0.00631	0.00631	Very Low
LOAEL	Dolphin	tPCB ng/g dry	6331	3.8015	7.3374	0.00000	2.5310	0.00569	0.00569	Very Low
LOED	LOED	tPCB ng/g dry	7200	3.8573	7.5034	0.00000	2.6192	0.00441	0.00441	Very Low
Chronic WQC	Bcv	tPCB ng/g dry	24310	4.3858	9.0733	0.00000	3.4533	0.00028	0.00028	Very Low
LOAEL	Cormorant	tPCB ng/g dry	32000	4.5051	9.4280	0.00000	3.6418	0.00014	0.00014	Very Low
LOAEL	Gull	tPCB ng/g dry	33300	4.5224	9.4793	0.00000	3.6691	0.00012	0.00012	Very Low
LOAEL	Shark	tPCB ng/g dry	42410	4.6275	9.7913	0.00000	3.8348	0.00006	0.00006	Negligible
C. TEQ Exposure to Fish Egg										
NOAEL	[a] Rainbow trout	TEQ pg/g wet	0.3	-0.5229	2.2454	0.01237	1.2508	0.10550	0.09313	Low
NOAEL	[b] Lake Trout	TEQ pg/g wet	5.0	0.6990	5.3449	0.00000	3.4393	0.00029	0.00029	Very Low
LOAEL	[b] Lake Trout	TEQ pg/g wet	30.0	1.4771	7.3189	0.00000	4.8331	0.00000	0.00000	Negligible
LOAEL	[a] Rainbow trout	TEQ pg/g lipid	3.0	0.4771	2.3415	0.00960	1.3187	0.09364	0.08403	Low
D. TEQ Dietary Exposure to Herring Gulls										
NOAEL	[d] Ring-neck pheasant	TEQ pg/g wet	64.8	1.8117	5.9116	0.00000	3.2104	0.00066	0.00066	Very Low
LOAEL	[e] Ring-neck pheasant	TEQ pg/g wet	648.1	2.8117	8.4639	0.00000	5.2068	0.00000	0.00000	Negligible
LOAEL	[f] American kestral	TEQ pg/g wet	115740.7	5.0635	14.2113	0.00000	9.7023	0.00000	0.00000	Negligible
E. TEQ Dietary Exposure to Double-Crested Cormorants										
NOAEL	[d] Ring-neck pheasant	TEQ pg/g wet	62.2	1.7939	5.8664	0.00000	3.1750	0.00075	0.00075	Very Low
LOAEL	[e] Ring-neck pheasant	TEQ pg/g wet	622.2	2.7939	8.4187	0.00000	5.1714	0.00000	0.00000	Negligible
LOAEL	[f] American kestral	TEQ pg/g wet	111111.1	5.0458	14.1660	0.00000	9.6669	0.00000	0.00000	Negligible

		Species	units	B	log(B)	Probability of Exceeding Benchmark: Reference CriticalB	Reference P(Ref)	Target CriticalB	Target P(Target)	RISK	Risk Level
F. TEQ Dietary Exposure to Dolphin											
NOAEL	[h]	Mink	TEQ pg/g wet	3.9	0.5942	3.5620	0.00018	0.6981	0.24255	0.24237	Medium
LOAEL	[i]	Mink	TEQ pg/g wet	17.8	1.2502	5.5405	0.00000	1.7933	0.03646	0.03646	Low
Additional Endpoints											
G. tPCB Effects of dietary exposure to mammals (Dolphin)											
NOAEL	[1]	Mink	tPCB ng/g dry	37	1.5678	0.7016	0.24148	-0.9949	0.84010	0.59862	Very High
	[2]	Mink	tPCB ng/g dry	739	2.8689	4.5668	0.00000	1.0588	0.14484	0.14483	Medium
	[3]	Mink	tPCB ng/g dry	924	2.9658	4.8547	0.00000	1.2118	0.11279	0.11279	Medium
NOAEL	[4]	Mink	tPCB ng/g dry	1109	3.0450	5.0899	0.00000	1.3368	0.09064	0.09064	Low
LOAEL	[5]	Mink	tPCB ng/g dry	1238	3.0929	5.2323	0.00000	1.4125	0.07891	0.07891	Low
NOAEL	[6]	Mink	tPCB ng/g dry	1571	3.1962	5.5393	0.00000	1.5756	0.05756	0.05756	Low
	[7]	Mink	tPCB ng/g dry	1941	3.2880	5.8119	0.00000	1.7204	0.04268	0.04268	Low
LOAEL	[8]	Mink	tPCB ng/g dry	2126	3.3275	5.9293	0.00000	1.7828	0.03731	0.03731	Low
	[9]	Mink	tPCB ng/g dry	2700	3.4314	6.2379	0.00000	1.9467	0.02578	0.02578	Low
	[10]	Mink	tPCB ng/g dry	2958	3.4709	6.3554	0.00000	2.0092	0.02226	0.02226	Low
	[11]	Mink	tPCB ng/g dry	3327	3.5221	6.5074	0.00000	2.0900	0.01831	0.01831	Low
LOAEL	[12]	Mink	tPCB ng/g dry	3789	3.5786	6.6752	0.00000	2.1791	0.01466	0.01466	Low
	[13]	Mink	tPCB ng/g dry	14233	4.1533	8.3827	0.00000	3.0864	0.00101	0.00101	Very Low
	[14]	Mink	tPCB ng/g dry	38818	4.5890	9.6772	0.00000	3.7742	0.00008	0.00008	Negligible
	[15]	Harbor Seal diet Atlantic	tPCB ng/g dry	123	2.0895	2.2513	0.01218	-0.1714	0.56806		
	[16]	Harbor Seal diet Wadden	tPCB ng/g dry	737	2.8676	4.5631	0.00000	1.0569	0.14528		
H. TEQ Effects of dietary exposure to mammals (Dolphin)											
NOAEL	[17]	Mink	TEC pg/g wet	0.79	-0.1024	1.4615	0.07194	-0.4647	0.67894	0.60700	Very High
NOAEL	[18]	Mink	TEC pg/g wet	0.81	-0.0922	1.4921	0.06783	-0.4478	0.67284	0.60501	Very High
NOAEL	[19]	Mink	TEC pg/g wet	2.54	0.4051	2.9919	0.00139	0.3825	0.35105	0.34966	High
NOAEL	**[20]**	**Mink**	**TEC pg/g wet**	**3.93**	**0.5942**	**3.5620**	**0.00018**	**0.6981**	**0.24255**	**0.24237**	**Medium**
LOAEL	[21]	Mink	TEC pg/g wet	5.55	0.7439	4.0137	0.00003	0.9481	0.17153	0.17150	Medium
LOAEL	[22]	Mink	TEC pg/g wet	10.40	1.0169	4.8370	0.00000	1.4039	0.08017	0.08017	Low
LOAEL	**[23]**	**Mink**	**TEC pg/g wet**	**17.79**	**1.2502**	**5.5405**	**0.00000**	**1.7933**	**0.03646**	**0.03646**	**Low**
LOAEL	[24]	Mink	TEC pg/g wet	108.60	2.0358	7.9096	0.00000	3.1049	0.00095	0.00095	Very Low
LOAEL	[25]	Mink	TEC pg/g wet	184.85	2.2668	8.6062	0.00000	3.4905	0.00024	0.00024	Very Low
	[26]	Mink	TEC pg/g wet	231.06	2.3637	8.8984	0.00000	3.6523	0.00013	0.00013	Very Low
LD50	[27]	Mink	TEC pg/g wet	346.59	2.5398	9.4295	0.00000	3.9463	0.00004	0.00004	Negligible
	[28]	Mink	TEC pg/g wet	452.88	2.6560	9.7798	0.00000	4.1402	0.00002	0.00002	Negligible
NOED	[29]	Mink	TEC pg/g wet	577.65	2.7617	10.0985	0.00000	4.3166	0.00001	0.00001	Negligible
LC50	[30]	Mink	TEC pg/g wet	610.00	2.7853	10.1699	0.00000	4.3561	0.00001	0.00001	Negligible
	[31]	Mink	TEC pg/g wet	776.36	2.8901	10.4857	0.00000	4.5310	0.00000	0.00000	Negligible
	[32]	Mink	TEC pg/g wet	970.45	2.9870	10.7780	0.00000	4.6928	0.00000	0.00000	Negligible

		Species	units	B	log(B)	Probability of Exceeding Benchmark: Reference CriticalB	Reference P(Ref)	Target CriticalB	Target P(Target)	RISK	Risk Level
	[33]	Mink	TEC pg/g wet	1617.41	3.2088	11.4470	0.00000	5.0631	0.00000	0.00000	Negligible
	[34]	Mink	TEC pg/g wet	2310.59	3.3637	11.9141	0.00000	5.3217	0.00000	0.00000	Negligible
	[35]	Mink	TEC pg/g wet	3234.82	3.5099	12.3548	0.00000	5.5657	0.00000	0.00000	Negligible
LOAEL	[36]	Mink	TEC pg/g wet	5175.72	3.7140	12.9704	0.00000	5.9065	0.00000	0.00000	Negligible
LOAEL	[37]	Mink	TEC pg/g wet	8318.12	3.9200	13.5918	0.00000	6.2505	0.00000	0.00000	Negligible
	[38]	Mink	TEC pg/g wet	15712.00	4.1962	14.4247	0.00000	6.7116	0.00000	0.00000	Negligible
	[39]	Mink	TEC pg/g wet	24723.29	4.3931	15.0184	0.00000	7.0402	0.00000	0.00000	Negligible
	[40]	Mink	TEC pg/g wet	32348.24	4.5099	15.3705	0.00000	7.2351	0.00000	0.00000	Negligible
	[41]	Harbor Seal diet Atlantic	TEC pg/g wet	3.56	0.5519	3.4345	0.00030	0.6275	0.26515		
	[42]	Harbor Seal diet Baltic	TEC pg/g wet	35.39	1.5489	6.4412	0.00000	2.2920	0.01095		
I.	**TEQ Effects to Sac fry larave (Fish Egg)**										
NOEAL	[43]	Lake trout	TEC pg/g wet	3	0.4771	4.7821	0.00000	3.0420	0.00118	0.00117	Very Low
NOEAL	[45]	Japanese medaka	TEC pg/g wet	100	2.0000	8.6454	0.00000	5.7697	0.00000	0.00000	Negligible
NOEAL	[44]	Brook trout	TEC pg/g wet	135	2.1303	8.9760	0.00000	6.0031	0.00000	0.00000	Negligible
NOEAL	[47]	Lake herring	TEC pg/g wet	175	2.2430	9.2619	0.00000	6.2050	0.00000	0.00000	Negligible
NOEAL	[46]	Rainbow trout	TEC pg/g wet	194	2.2878	9.3754	0.00000	6.2852	0.00000	0.00000	Negligible
NOEAL	[48]	Fathead minnow	TEC pg/g wet	235	2.3711	9.5867	0.00000	6.4343	0.00000	0.00000	Negligible
NOEAL	[49]	Channel catfish	TEC pg/g wet	385	2.5855	10.1305	0.00000	6.8183	0.00000	0.00000	Negligible
NOEAL	[53]	Zebra fish	TEC pg/g wet	425	2.6284	10.2394	0.00000	6.8952	0.00000	0.00000	Negligible
NOEAL	[50]	Medaka Sac	TEC pg/g wet	455	2.6580	10.3146	0.00000	6.9483	0.00000	0.00000	Negligible
NOEAL	[51]	White sucker	TEC pg/g wet	848	2.9284	11.0005	0.00000	7.4326	0.00000	0.00000	Negligible
NOEAL	[52]	Northern Pike	TEC pg/g wet	1190	3.0755	11.3738	0.00000	7.6961	0.00000	0.00000	Negligible
LOEAL	[43]	Lake trout	TEC pg/g wet	55	1.7404	7.9867	0.00000	5.3046	0.00000	0.00000	Negligible
LOEAL	[44]	Brook trout	TEC pg/g wet	185	2.2672	9.3231	0.00000	6.2482	0.00000	0.00000	Negligible
LOEAL	[47]	Lake herring	TEC pg/g wet	270	2.4314	9.7396	0.00000	6.5423	0.00000	0.00000	Negligible
LOEAL	[46]	Rainbow trout	TEC pg/g wet	291	2.4639	9.8222	0.00000	6.6006	0.00000	0.00000	Negligible
LOEAL	[45]	Japanese medaka	TEC pg/g wet	300	2.4771	9.8557	0.00000	6.6243	0.00000	0.00000	Negligible
LOEAL	[48]	Fathead minnow	TEC pg/g wet	425	2.6284	10.2394	0.00000	6.8952	0.00000	0.00000	Negligible
LOEAL	[49]	Channel catfish	TEC pg/g wet	885	2.9469	11.0475	0.00000	7.4658	0.00000	0.00000	Negligible
LOEAL	[50]	Medaka Sac	TEC pg/g wet	949	2.9773	11.1245	0.00000	7.5201	0.00000	0.00000	Negligible
LOEAL	[51]	White sucker	TEC pg/g wet	1220	3.0864	11.4012	0.00000	7.7155	0.00000	0.00000	Negligible
LOEAL	[52]	Northern Pike	TEC pg/g wet	1800	3.2553	11.8297	0.00000	8.0180	0.00000	0.00000	Negligible
LOEAL	[53]	Zebra fish	TEC pg/g wet	2000	3.3010	11.9458	0.00000	8.1000	0.00000	0.00000	Negligible
LC50	[43]	Lake trout	TEC pg/g wet	65	1.8129	8.1708	0.00000	5.4346	0.00000	0.00000	Negligible
LC51	[44]	Brook trout	TEC pg/g wet	439	2.6425	10.2752	0.00000	6.9204	0.00000	0.00000	Negligible
LC52	[46]	Rainbow trout	TEC pg/g wet	439	2.6425	10.2752	0.00000	6.9204	0.00000	0.00000	Negligible
LC53	[48]	Fathead minnow	TEC pg/g wet	539	2.7316	10.5012	0.00000	7.0800	0.00000	0.00000	Negligible
LC54	[49]	Channel catfish	TEC pg/g wet	644	2.8089	10.6973	0.00000	7.2185	0.00000	0.00000	Negligible
LC55	[47]	Lake herring	TEC pg/g wet	902	2.9552	11.0685	0.00000	7.4806	0.00000	0.00000	Negligible

					Probability of Exceeding Benchmark					
					Reference		Target			Risk
	Species	units	B	log(B)	CriticalB	P(Ref)	CriticalB	P(Target)	RISK	Level
LC56 [50]	Medaka Sac	TEC pg/g wet	1,110	3.0453	11.2971	0.00000	7.6420	0.00000	0.00000	Negligible
LC57 [51]	White sucker	TEC pg/g wet	1,890	3.2765	11.8835	0.00000	8.0560	0.00000	0.00000	Negligible
LC58 [52]	Northern Pike	TEC pg/g wet	2,460	3.3909	12.1739	0.00000	8.2610	0.00000	0.00000	Negligible
LC59 [53]	Zebra fish	TEC pg/g wet	2,610	3.4166	12.2391	0.00000	8.3071	0.00000	0.00000	Negligible

References

[a] deBruyn, et al. 2004. Environ. Sci. Technol.; 2004; 38(23) pp 6217 - 6224; Mortality in rainbow trout eqgs
[b] Cook, P. M.; et al. 2003. Environ. Sci. Technol.; 37(17); 3864-3877. Lake Trout Sac Fry mortality
[c] Max concn. that can occur in diet without harmful effects to predator species (CCME 2003).
[d] Ring-neck pheasant NOAEL (Nosek et al. 1992, cited in Weston Inc. 2003)
[e] Ring-neck pheasant LOAEL (Nosek et al. 1992, cited in Weston Inc. 2003)
[f] American kestral threshold for reproductive effects (Weston Inc. 2003)
[g] Mammalian max concn. that can occur in diet without harmful effects to predator species (Environ. Canada 2004a).
[h] Weathered PCBs feed to Mink NOAEL decreased kit survival (Bursian et al. 2003)
[i] Weathered PCBs feed to Mink LOAEL decreased kit survival (Bursian et al. 2003)

[1] Dietary NOAEL for mink reproductive effects (Heaton et al. 1995, cited in Weston Inc. 2003)
[2] Decreased fecundity in mink (Brunstrom et al. 1991, cited in Weston Inc. 2003)
[3] Affects to kit growth and mortality (Tillitet et al. 1996 and Heaton et al. 1995, both cited in Weston Inc. 2003)
[4] Weathered PCBs feed to Mink NOAEL decrease in male kit bw (Halbrook et al. 1999)
[5] LOAEL for reduced growth to adult female mink (Heaton et al. 1995, cited in Weston Inc. 2003)
[6] Weathered PCBs feed to Mink NOAEL decreased kit survival (Bursian et al. 2003)
[7] Reduced birth weight of mink kits (Tillitet et al. 1996, cited in Weston Inc. 2003)
[8] Weathered PCBs feed to Mink LOAEL decrease in male kit bw (Halbrook et al. 1999)
[9] Reduced birth weight of mink kits (Heaton et al. 1995, cited in Weston Inc. 2003)
[10] Increased female body weight at whelping (Heaton et al. 1995, cited in Weston Inc. 2003)
[11] 100% kit mortatlity at 24 h (Heaton et al. 1995, cited in Weston Inc. 2003)
[12] Weathered PCBs feed to Mink LOAEL decreased kit survival (Bursian et al. 2003)
[13] No live births in mink after 66 d of exposure (Jensen et al. 1977, cited in Weston Inc. 2003)
[14] 100% mortality in adults (Ringer et al. 1972, cited in Weston Inc. 2003)
[15] Seal Diet from Atlantic Ocean (cited in Gatehouse 2004)
[16] Seal Diet from Wadden Sea (cited in Gatehouse 2004)

[17] Mammalian max concn. that can occur in diet without harmful effects to predator species (CCME 2003).
[18] Mink NOEAL (Brunstrom et al. 2001)
[19] Decreased kit survivability NOEAL (Heaton et al. 1995)
[20] Weathered PCBs feed to Mink NOAEL decreased kit survival (Bursian et al. 2003)
[21] Mink LOEAL (Brunstrom et al. 2001)
[22] Decreased kit survivability LOEAL (Heaton et al. 1995)
[23] Weathered PCBs feed to Mink LOAEL decreased kit survival (Bursian et al. 2003)
[24] LC50 125-day exposure to mink (Hochstein et al. 1998, cited in Weston Inc. 2003)

[25] NOAEL mink reproduction effects (Tillitt et al. 1996, cited in Weston Inc. 2003)
[26] Depressed body weight in neonates (Aulerich et al. 1988, cited in Weston Inc. 2003)
[27] Mink 28-day LD50 (Hochstein et al. 1998, cited in Weston Inc. 2003)
[28] 17% mortality in adult mink 132-day exposure (Hochstein et al. 1998, cited in Weston Inc. 2003)
[29] Dietary NOED for reproductive effects (Heaton et al. 1995, cited in Weston Inc. 2003)
[30] Mink 28-day LC50 (Hochstein et al. 1998, cited in Weston Inc. 2003)
[31] Reduced weight gain following 36-d exposure (Render et al. 2001, cited in Weston Inc. 2003)
[32] Threshold daily dose, reproductive effects (Tillitt et al. 1996, cited in Weston Inc. 2003)
[33] Periodontal lesions following 6-m exposure (Render et al. 2000, cited in Weston Inc. 2003)
[34] 100% mortality following 12 day exposure following injection (Aulerich et al. 1988, cited in Weston Inc. 2003)
[35] 65% mortality in mink after 28-day and 100% mortality after 125-d exposure (Hochstein et al. 1998, cited in Weston Inc. 2003)
[36] LOAEL (Tillitt et al. 1996, cited in Weston Inc. 2003)
[37] Dietary LOEAL for reproductive effects (Heaton et al. 1995, cited in Weston Inc. 2003)
[38] 71% kit mortality at 3-w, 89% kit mortality at 6-w (Heaton et al. 1995, cited in Weston Inc. 2003)
[39] 100% kit mortality at 24 hr (Heaton et al. 1995, cited in Weston Inc. 2003)
[40] 100% mortality following 28-d exposure (Hochstein et al. 1998, cited in Weston Inc. 2003)
[41] Seal Diet from Atlantic Ocean (Ross et al. 1994, cited in Gatehouse 2004)
[42] Seal Diet from Baltic Sea (Ross et al. 1994, cited in Gatehouse 2004)

[43] Lake trout Sac fry mortality Walker et al. (1991) cited in Gatehouse (2004)
[45] Japanese medaka Lesions, etc. Wisk and Cooper (1990) cited in Gatehouse (2004)
[44] Brook trout Sac fry mortality Walker and Peterson (1994) cited in Gatehouse (2004)
[47] Lake herring Sac fry growth and mortality Elonen et al., (1998) cited in Gatehouse (2004)
[46] Rainbow trout Sac fry mortality Walker et al. (1992) cited in Gatehouse (2004)
[48] Fathead minnow Sac fry growth and mortality Elonen et al. (1998) cited in Gatehouse (2004)
[49] Channel catfish Sac fry growth and mortality Elonen et al. (1998) cited in Gatehouse (2004)
[53] Zebra fish Sac fry growth and mortality Elonen et al. (1998) cited in Gatehouse (2004)
[50] Medaka Sac fry mortality Elonen et al. (1998) cited in Gatehouse (2004)
[51] White sucker Sac fry growth and mortality Elonen et al. (1998) cited in Gatehouse (2004)
[52] Northern Pike Sac fry growth and mortality Elonen et al. (1998) cited in Gatehouse (2004)

Table 28. Summary of overall risk to the assessment endpoints determined by the probability of exceeding effects levels for PCBs.

Endpoint	Risk of exceeding benchmark Benchmark		Overall Risk to Endpoint
Potentially Harmful PCB Exposure to Primary Producers and Consumers of the Reef Community	TSV	Bcv	Very Low
	Low	Very Low	
Critical Body Residues of PCBs in Demersal Fish	NOED	LOED	Very Low
	Very Low	Very Low	
Harmful PCB Exposure to Dolphins from Consumption of Prey (Fish)	NOAEL	LOAEL	Very Low
	Low	Very Low	
Harmful PCB Exposure to Gulls from Consumption of Prey (Fish)	NOAEL	LOAEL	Very Low
	Low	Very Low	
Harmful PCB Exposure to Cormorants from Consumption of Prey (Fish)	NOAEL	LOAEL	Very Low
	Low	Very Low	
Harmful PCB Exposure to Sharks from Consumption of Prey (Fish)	NOAEL	LOAEL	Negligible
	Low	Negligible	
Harmful TEQ Exposure to Fish Eggs	NOAEL	LOAEL	Low
	Low	Low	
Harmful TEQ Exposure to Dolphins from Consumption of Prey (Fish)	NOAEL	LOAEL	Low
	Medium	Very Low	
Harmful TEQ Exposure to Gulls from Consumption of Prey (Fish)	NOAEL	LOAEL	Negligible
	Very Low	Negligible	
Harmful TEQ Exposure to Cormorants from Consumption of Prey (Fish)	NOAEL	LOAEL	Negligible
	Very Low	Negligible	

12. Figures

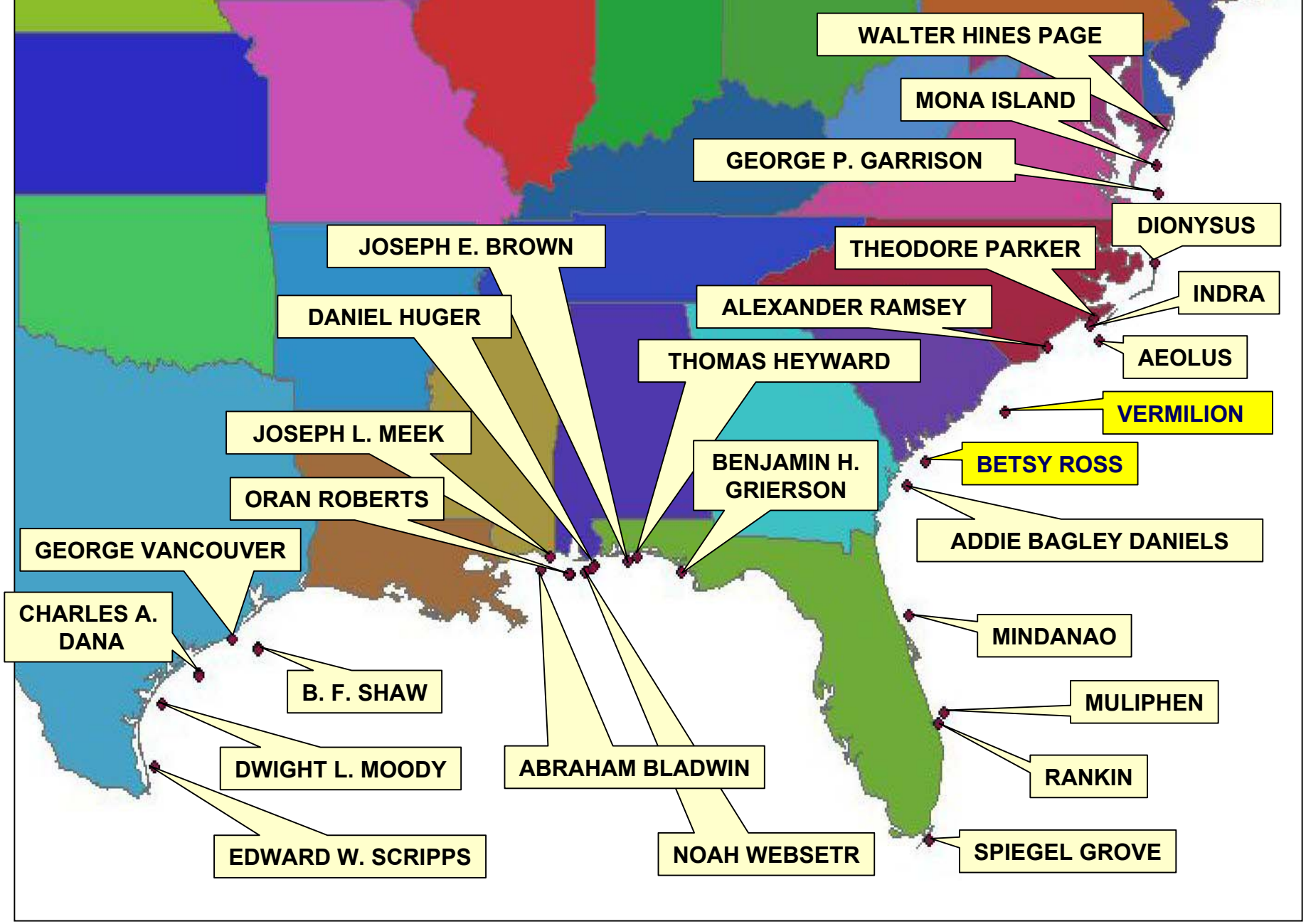


Figure 1. Location of MARAD ships sunk to create artificial reefs along the SE coast of US from 1986 – 1992. (Note SPIEGEL GROVE was sunk June 10, 2002).

ID	Ship/Reef
1	VERMILION, Navy Victory Ship
2	Northern Area Natural Reef
3	Y-73, Army Liquid Tanker
4	COMANCHE, Coast Guard Cutter
5	EDISTO, Civilian Barge
6	Central Area Natural Reef
7	BETSY ROSS, Navy Victory Ship
8	Eagle's Nest, Army Landing Craft & Tug
9	Southern Area Natural Reef

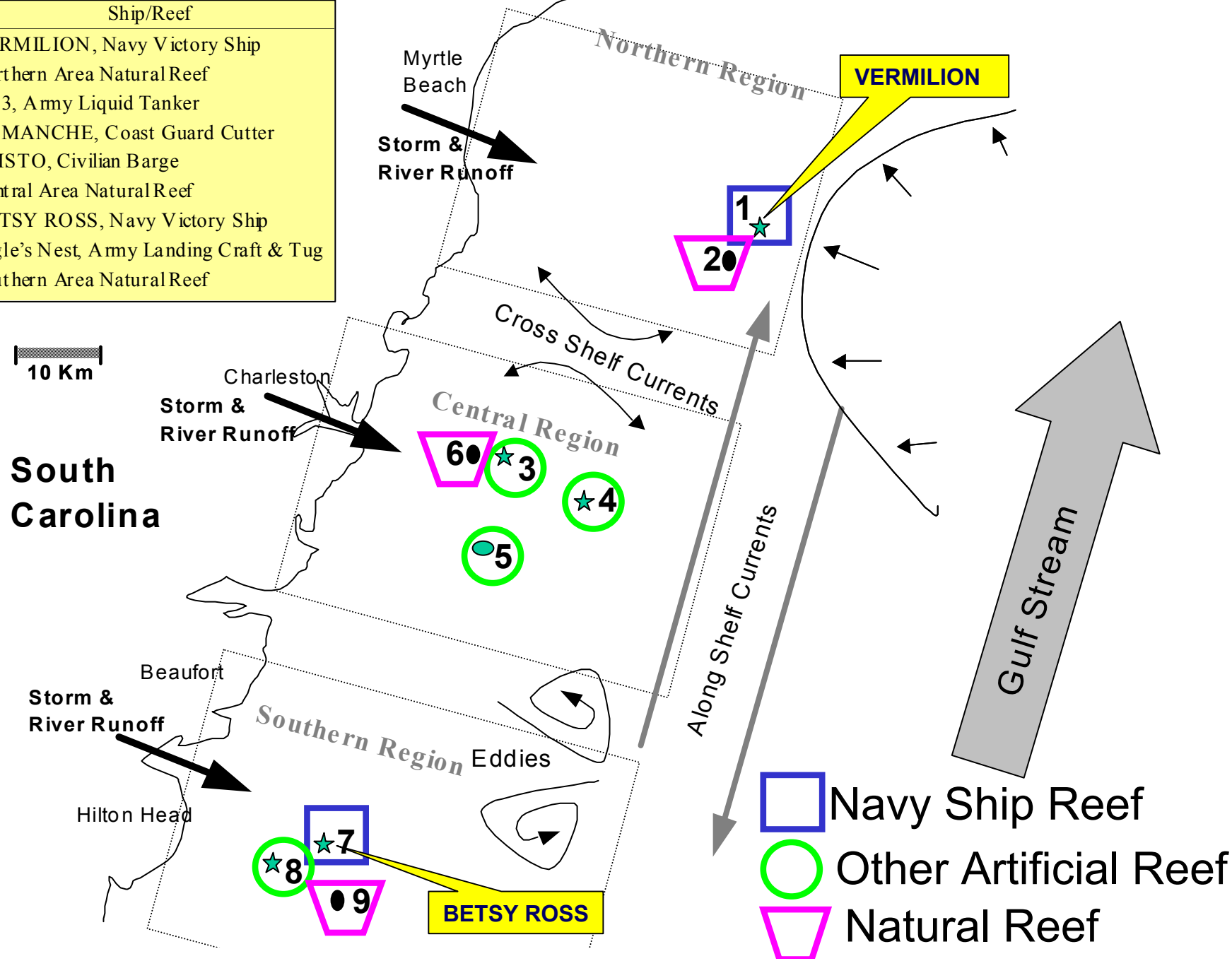


Figure 2A. Conceptual model of study area and reef areas sampled by SCDNR (Martore et al. 1998) .

Figure 2B. Locations of artificial reefs and reefs sampled for tissue residue analysis off the coast of SC, USA.

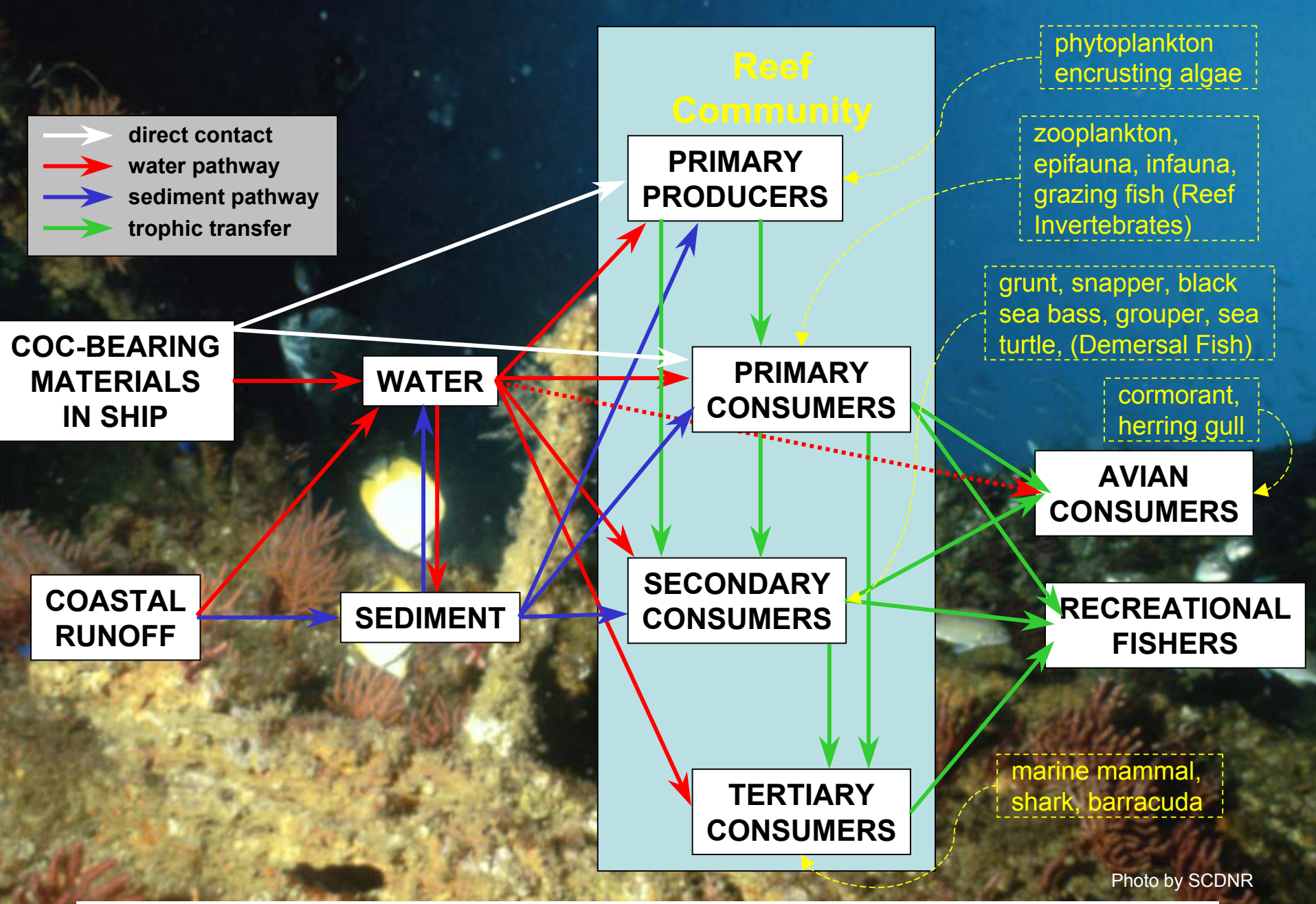
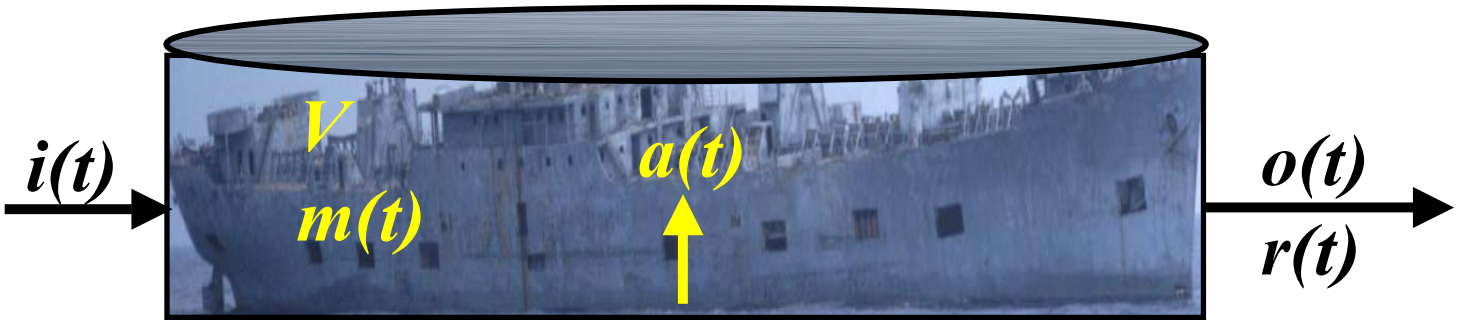


Figure 3. Exposure pathways and assessment endpoints evaluated for the ecorisk screening. Note that exposure to recreational fishers was evaluated by the Human Health Risk Assessment (NEHC 2004).

V = Well mixed volume of water around the ship

$m(t)$ = mass of PCBs present in water around ship at time t



$a(t)$ = rate of leaching from solids containing PCBs on the sunken ship

$o(t) = i(t)$ = Rate of exchange with surrounding water

$r(t)$ = mass of PCBs removed due to flushing at time t

Other loss terms = 0

Figure 4. Model used to estimate the instantaneous steady state concentration of total PCBs in a well-mixed volume of water around a sunken ship.

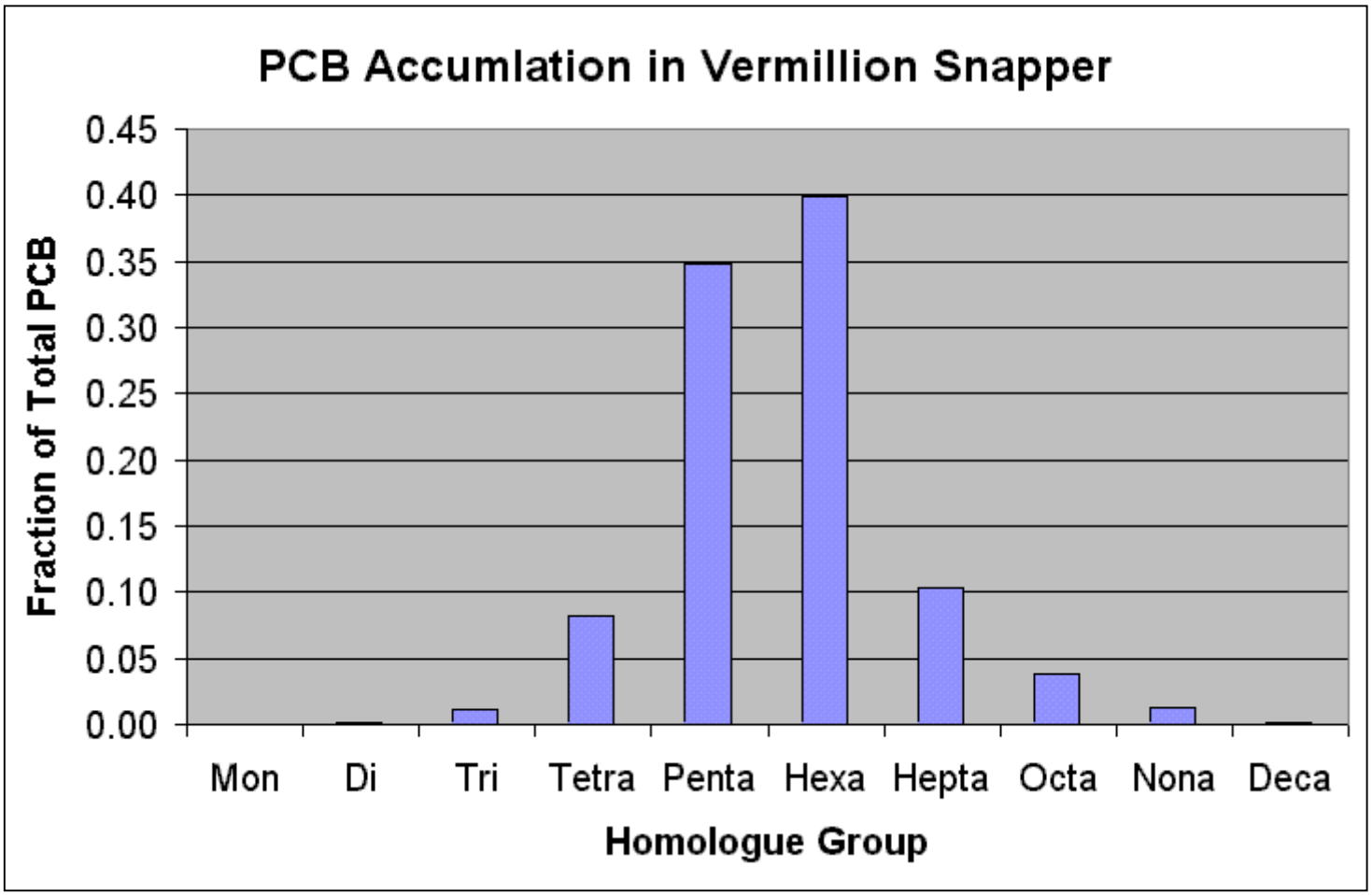


Figure 5. Fraction of total PCB measured in each homolog group in subset of vermilion snapper samples coll ected off the coast of South Carolina (see Table 7).

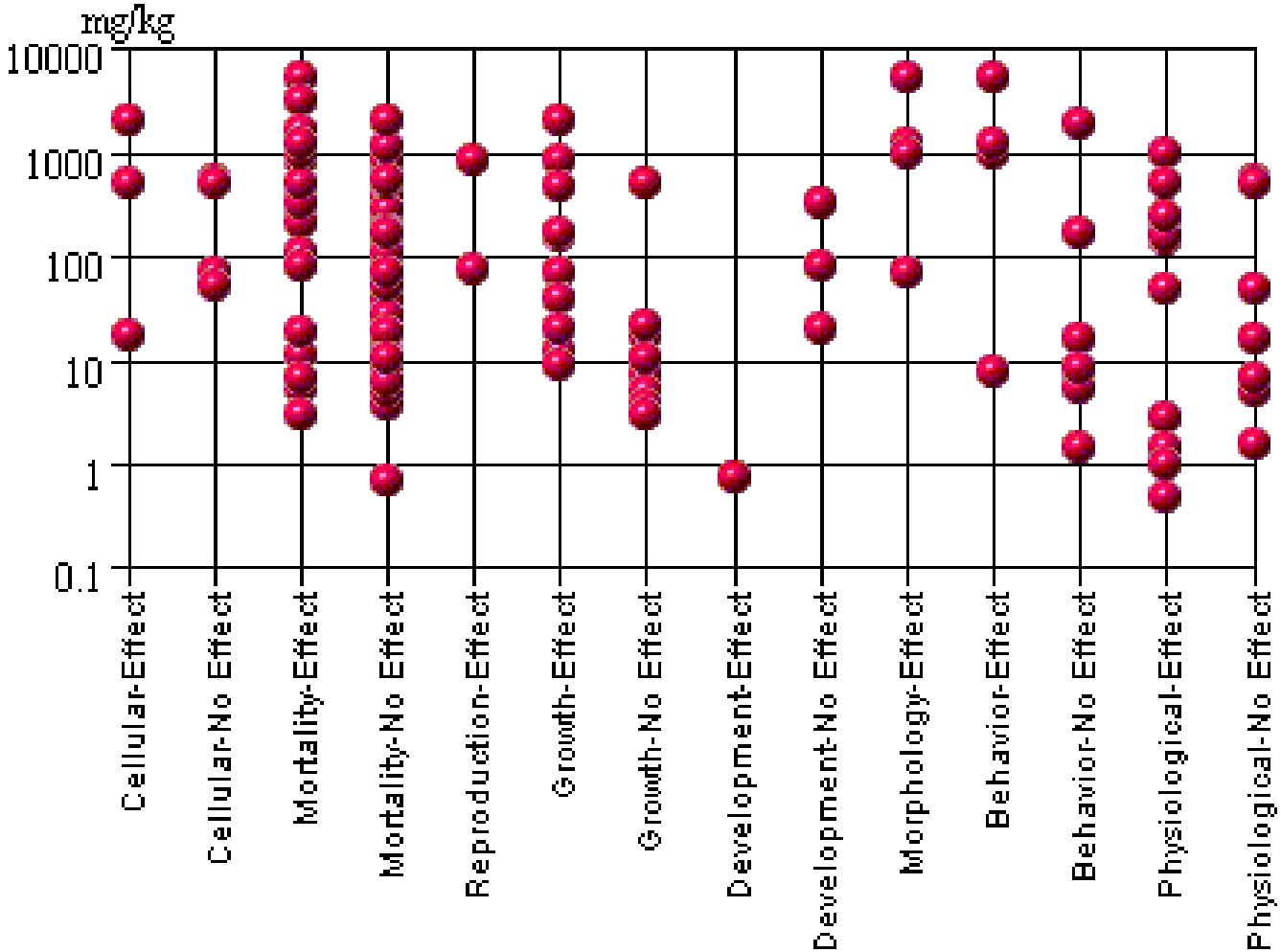


Figure 6. Example of tissue residue effects data for PCB obtained from the ERED database. (http://www.wes.army.mil/el/ered) If available, benchmarks were selected for any fish species and marine invertebrates.

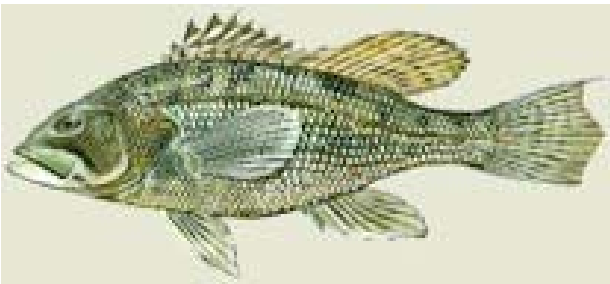
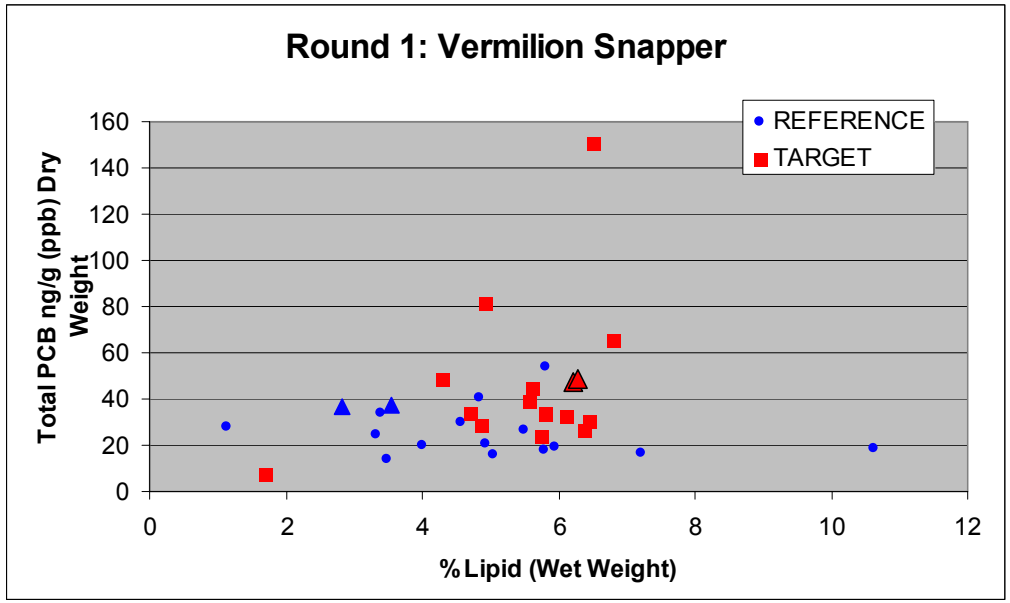
	White Grunt *Haemulon plumieri* Illustration (SMS 2003) "Feeds on crustaceans, small molluscs, and small fishes" (FishBase 2003) Diet composition Trophic Level (TL) = 3.4 (FishBase 2003)
	Vermilion Snapper *Rhomboplites aurorubens* Illustration (TFA 2003) "Feeds on fishes, shrimps, crabs, polychaetes, other benthic invertebrates, cephalopods and planktonic organisms" (FishBase 2003). "Unlike most snappers, which feed on large fishes and crustaceans on the bottom, Vermilion Snappers forage on small animals high in the water column. Favorite foods are small crustaceans (copepods, amphipods, stomatopods, crabs, and shrimps), squids, small fishes, and fish eggs)" (TFA 2003). Diet composition TL=3.9 (FishBase 2003)
	**Black Sea Bass *Centropristis striata*** Illustration (CBPO 2003) "Visual feeders during daylight hours, black sea bass rely on swift currents and their large mouths to capture their prey, which include other fish, crabs, mussels and razor clams" (CBPO 2003). "Black Sea Bass are protogynous hermaphrodites. Large fish are males. Females reach reproductive condition for the first time during their second year, when they are about 7.5 inches long. The spawning season is protracted, extending from… February through May in the South Atlantic Bight. (TFA 2003). Diet composition TL=3.8 (FishBase 2003)

Figure 7. Species of fish collected for the supplemental fish sampling program.

Triangles are samples analyzed by ADL



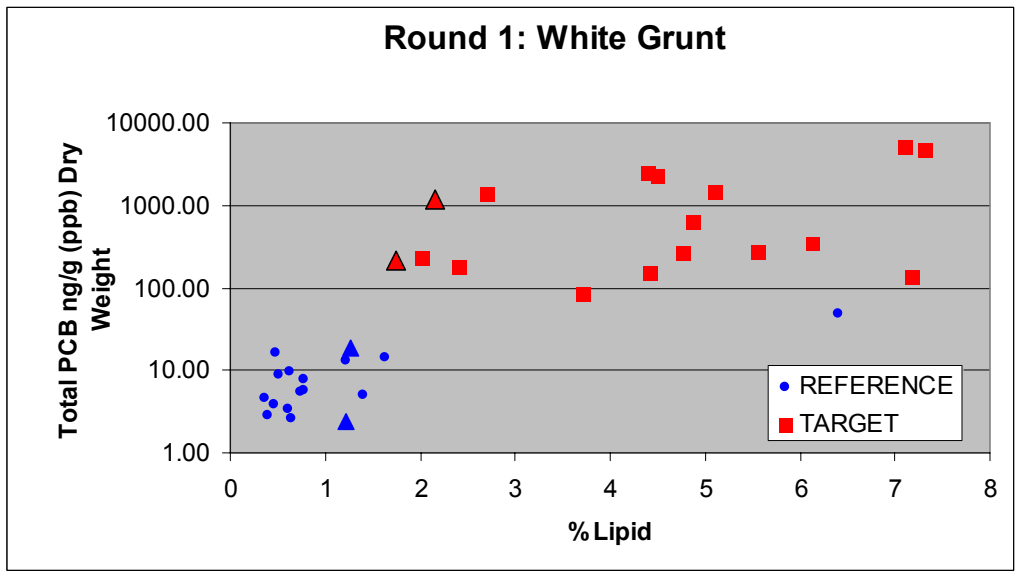


Figure 8. Relationship between % lipid and total PCB measured in samples of vermilion snapper and white grunt analyzed by Axys and ADL for Round 1.

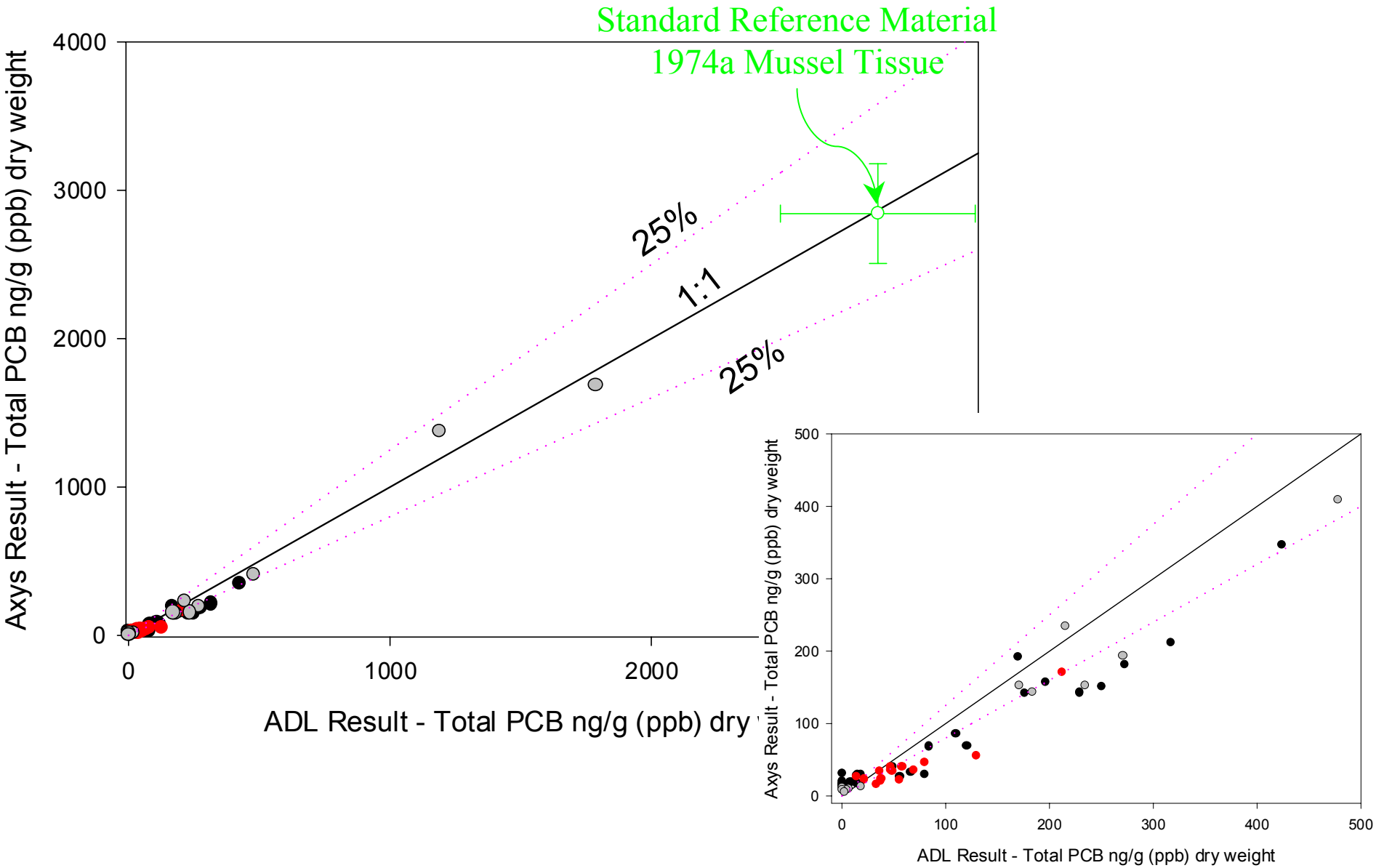


Figure 9. Comparability of the analytical methods used by Axys (y-axis) and ADL (x-axis). Inset shows expanded axis for low concentrations.

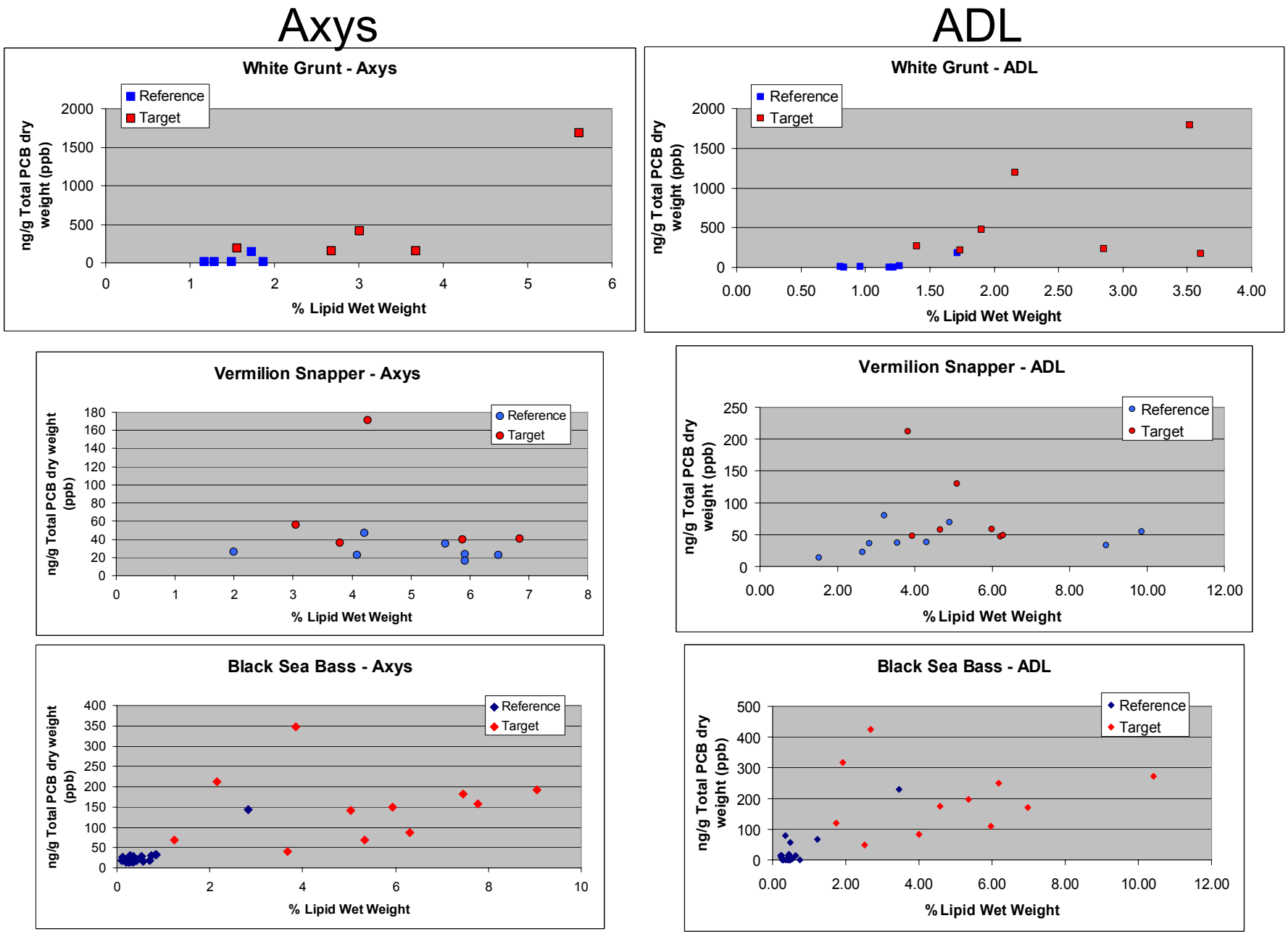


Figure 10. Relationship between % lipid and total PCB measured in samples of white grunt, vermilion snapper, and black sea bass analyzed by Axys and ADL for Round 2.

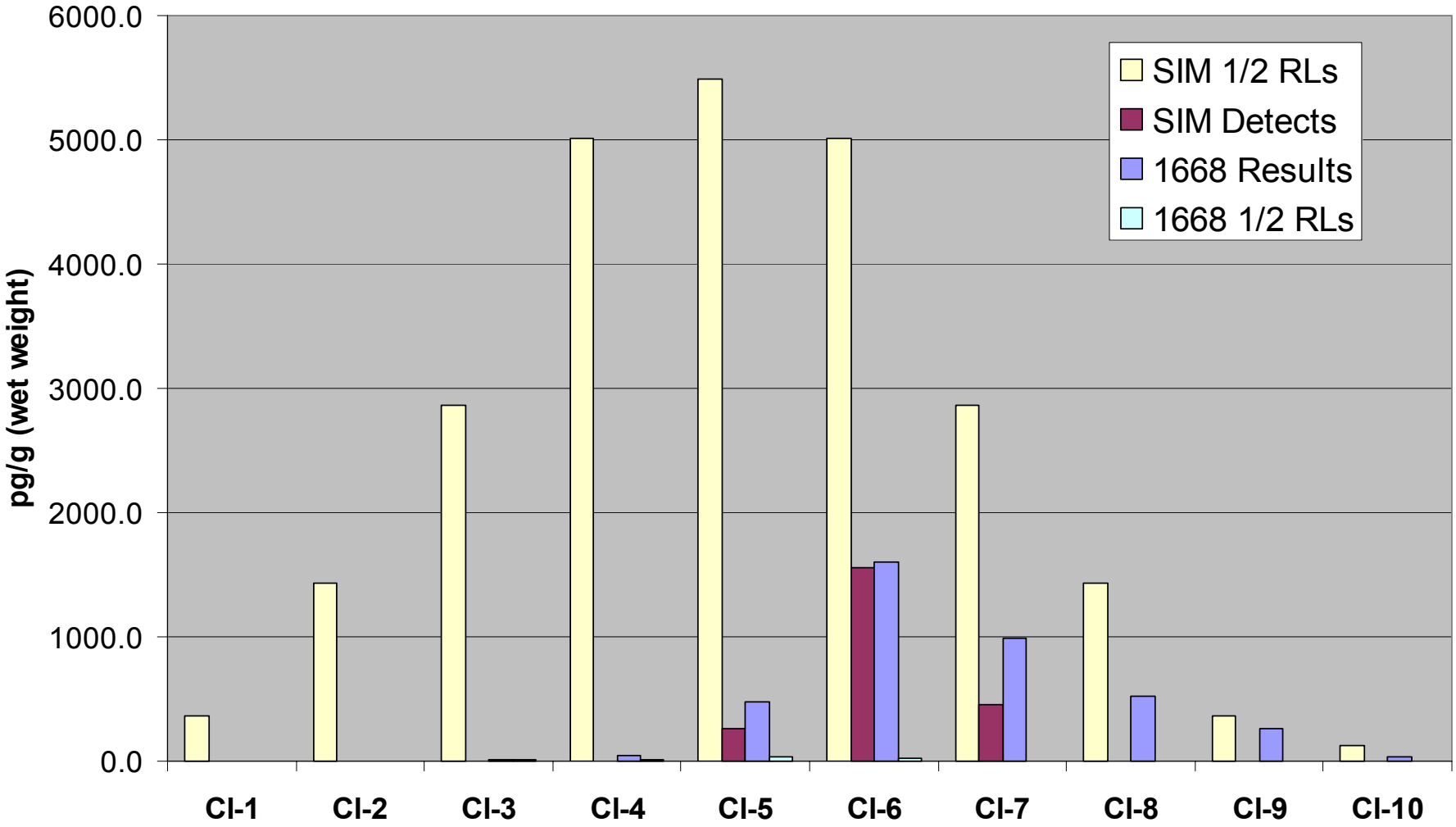


Figure 11. Homolog group results for FS-04-SB-R a low concentration sample analyzed by both SIM (ADL) and 1668 (AXYS) methods.

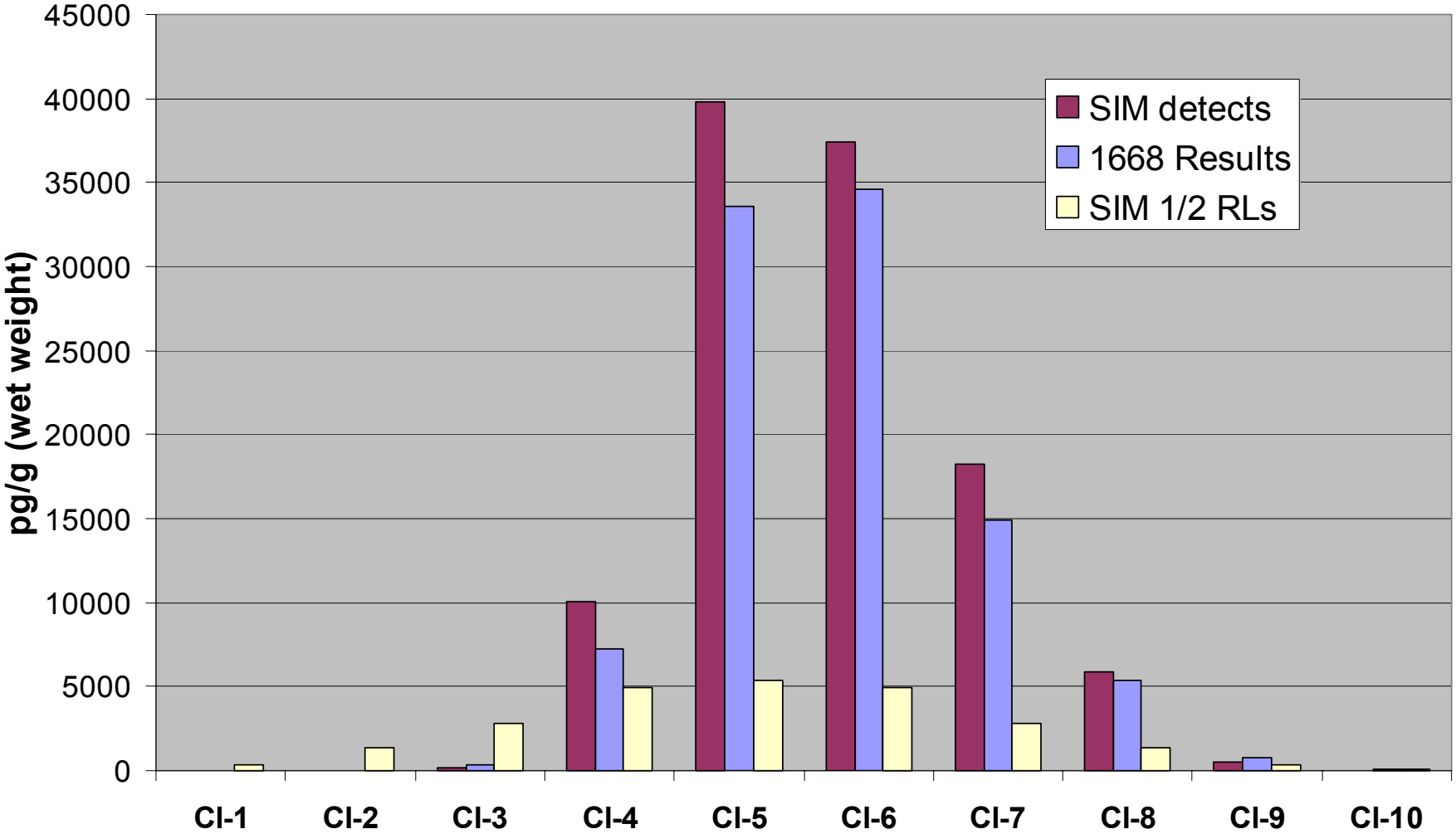
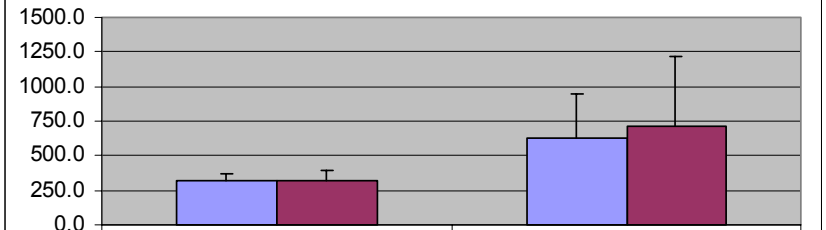


Figure 12. Homolog group results for FS-20-WG-T a high concentration sample analyzed by both SIM (ADL) and 1668 (AXYS) methods.

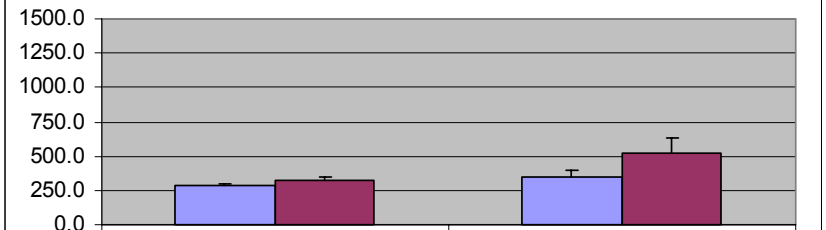
(A) Total Length and Weight

White Grunt



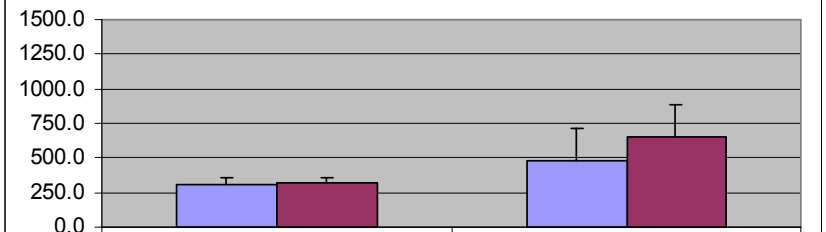
	Length (mm)	Weight (g)
Ref	320.0	624.6
Target	320.3	718.1

Vermilion Snapper



	Length (mm)	Weight (g)
Ref	284.2	341.0
Target	322.0	515.6

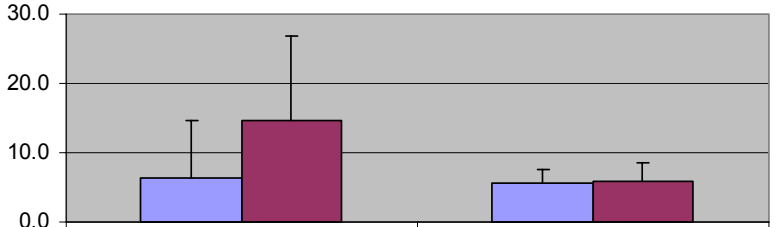
Black Sea Bass



	Length (mm)	Weight (g)
Ref	311.7	483.7
Target	321.1	652.6

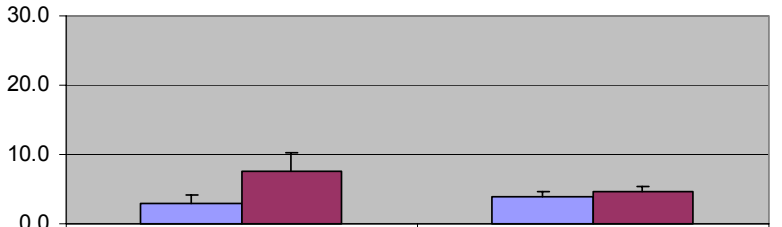
(B) Liver Weight and Age

White Grunt



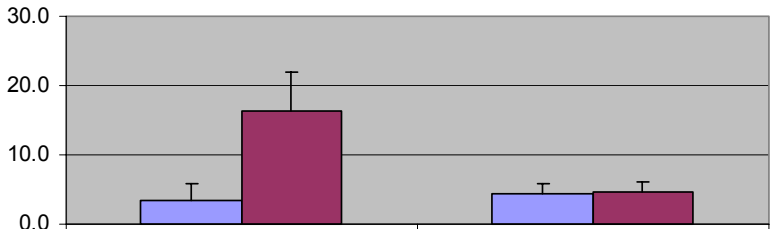
	Liver Weight (g)	Age (yr)
Ref	6.2	5.7
Target	14.7	5.8

Vermilion Snapper



	Liver Weight (g)	Age (yr)
Ref	3.0	4.0
Target	7.5	4.6

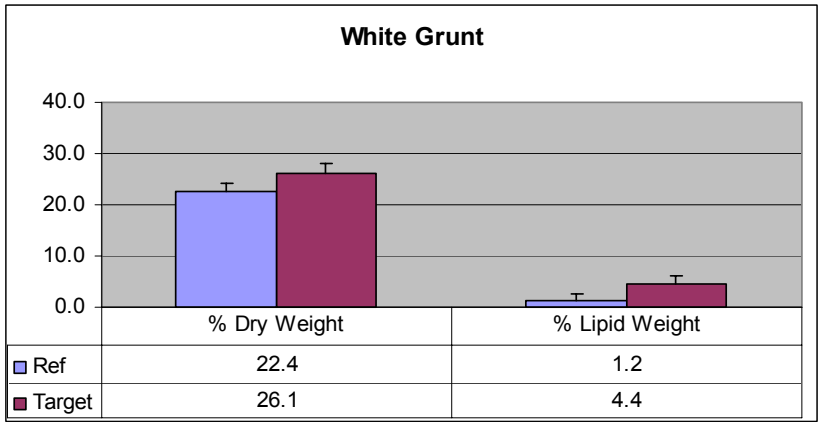
Black Sea Bass



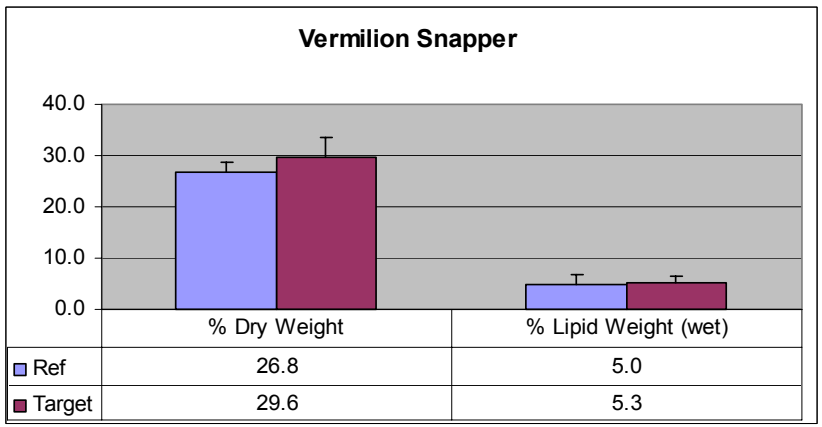
	Liver Weight (g)	Age (yr)
Ref	3.5	4.5
Target	16.3	4.6

Figure 13. The mean and standard deviation of total length and weight (A) and liver weight and age (B) of white grunt, vermilion snapper, and black sea bass samples.

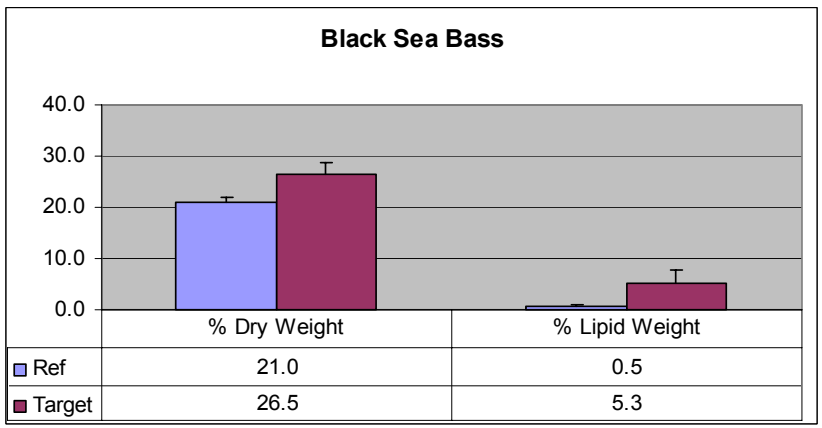
(A) Dry and Lipid Weight



	% Dry Weight	% Lipid Weight
Ref	22.4	1.2
Target	26.1	4.4

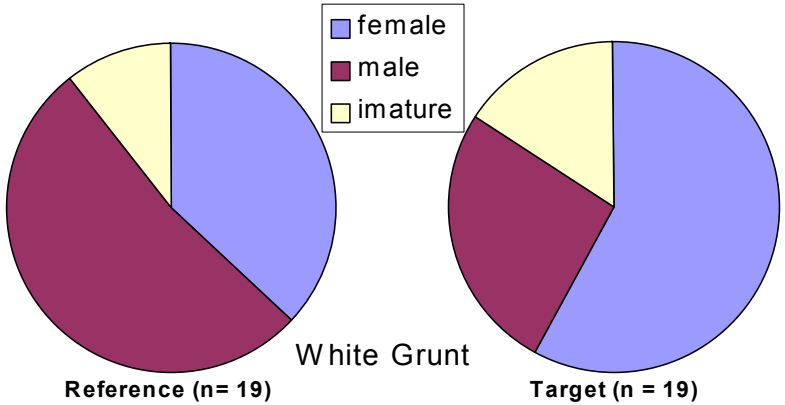


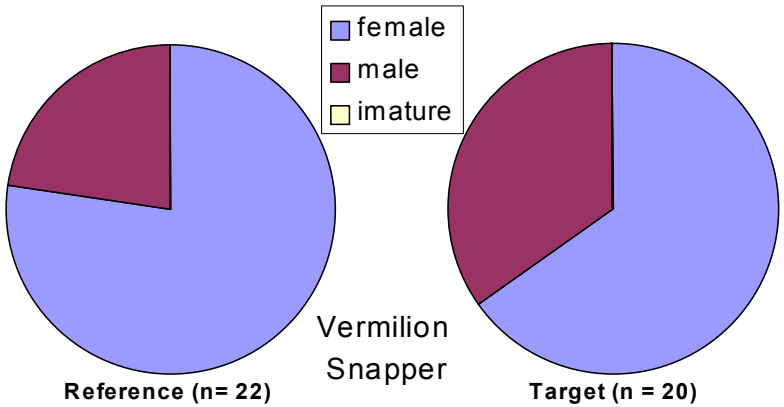
	% Dry Weight	% Lipid Weight (wet)
Ref	26.8	5.0
Target	29.6	5.3



	% Dry Weight	% Lipid Weight
Ref	21.0	0.5
Target	26.5	5.3

(B) Sex Ratio





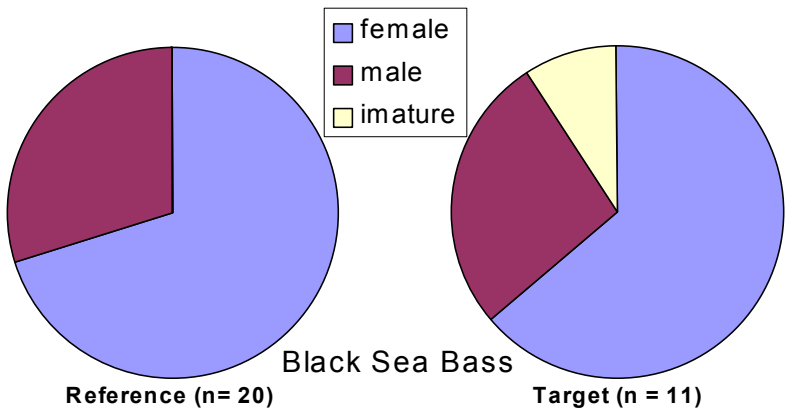
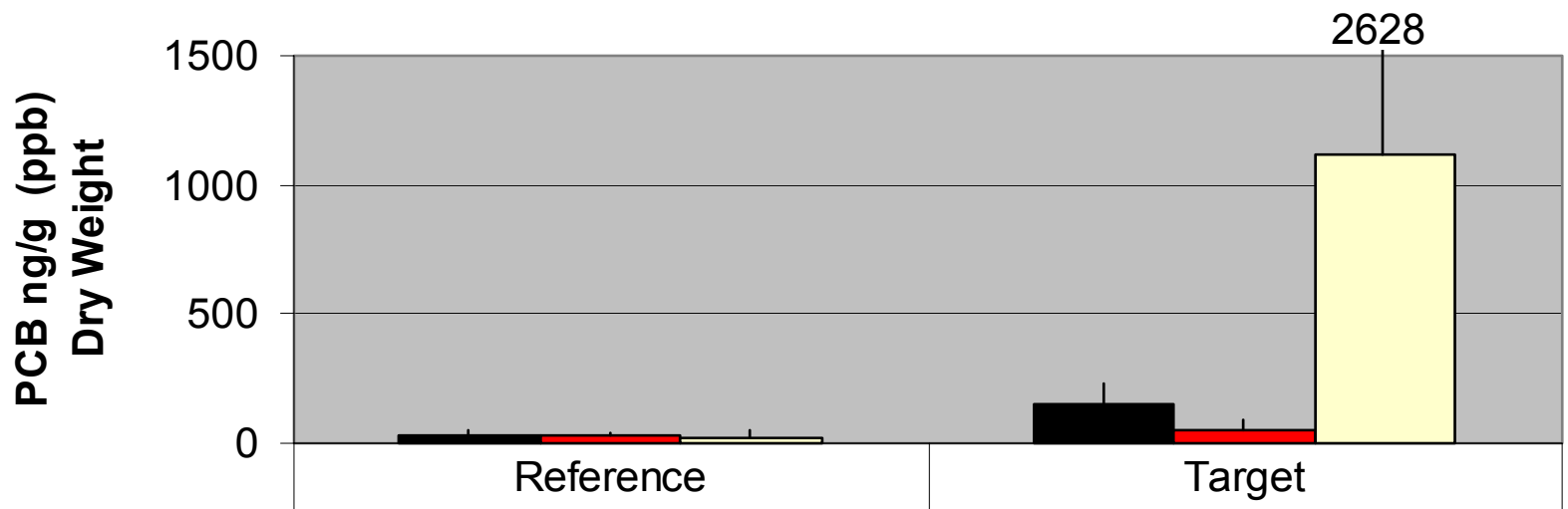
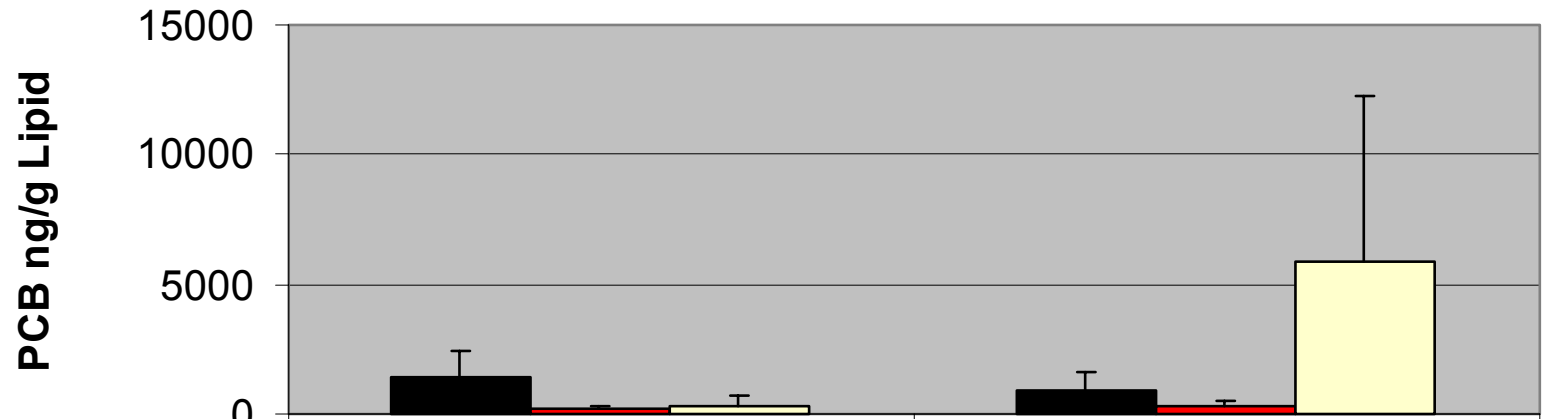


Figure 14. The mean and standard deviation of percent dry and percent lipid weight (A) and sex ratio (B) of white grunt, vermilion snapper, and black sea bass samples.



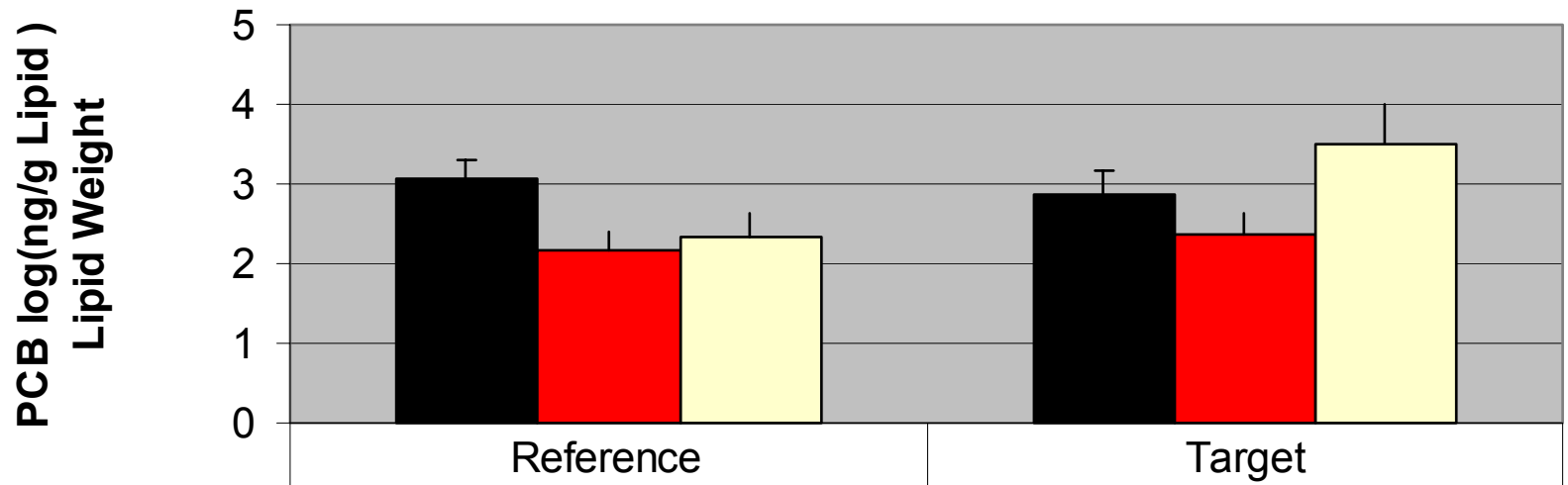
	Reference		Target		
Black Sea Bass	27.3	(n=20)	(n=11)	149.5	**p<.0001**
Vermilion Snapper	26.1	(n=22)	(n=20)	51.3	**p=.0077**
White Grunt	16.7	(n=20)	(n=20)	1118.9	**p=.0023**

Figure 15. The mean and standard deviation of Total PCB ng/g fillet dry weight measured by Axys for black sea bass, vermilion snapper, and white grunt samples.



	Reference		Target		
Black Sea Bass	1398.7	(n=20)	(n=11)	928.2	**NS**
Vermilion Snapper	170.2	(n=22)	(n=20)	294.8	**p=.0403**
White Grunt	309.0	(n=20)	(n=20)	5883.2	**p=.0004**

Figure 16. The mean and standard deviation of Total PCB ng/g fillet lipid measured by Axys for black sea bass, vermilion snapper, and white grunt samples.



	Reference		Target		
Black Sea Bass	3.1	(n=20)	(n=11)	2.9	**p=.0329**
Vermilion Snapper	2.2	(n=22)	(n=20)	2.4	**p=.0055**
White Grunt	2.3	(n=20)	(n=20)	3.5	**p<.0001**

Figure 17. The mean and standard deviation of Log(Total PCB/g fillet lipid) measured by Axys for black sea bass, vermilion snapper, and white grunt samples.

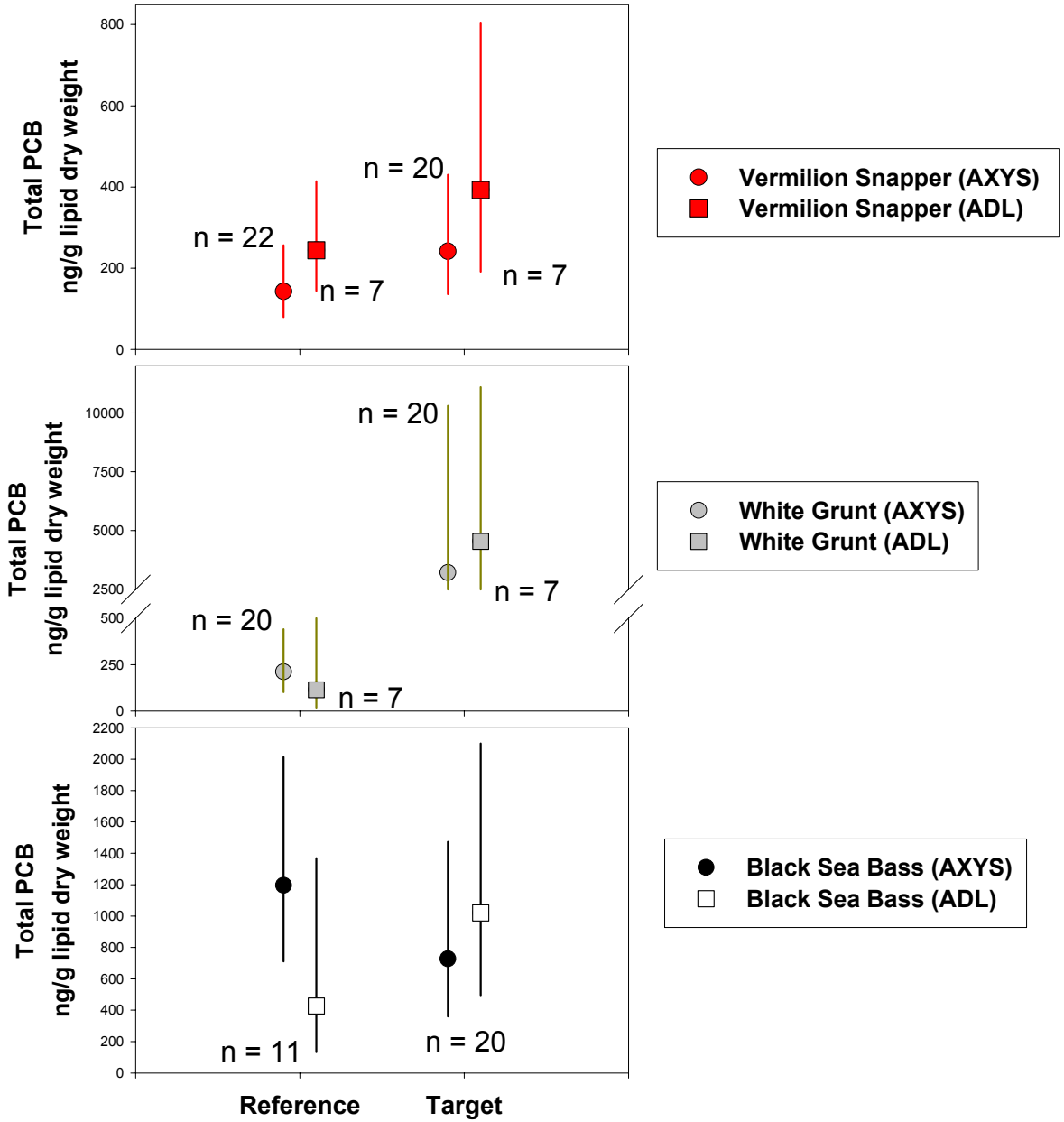
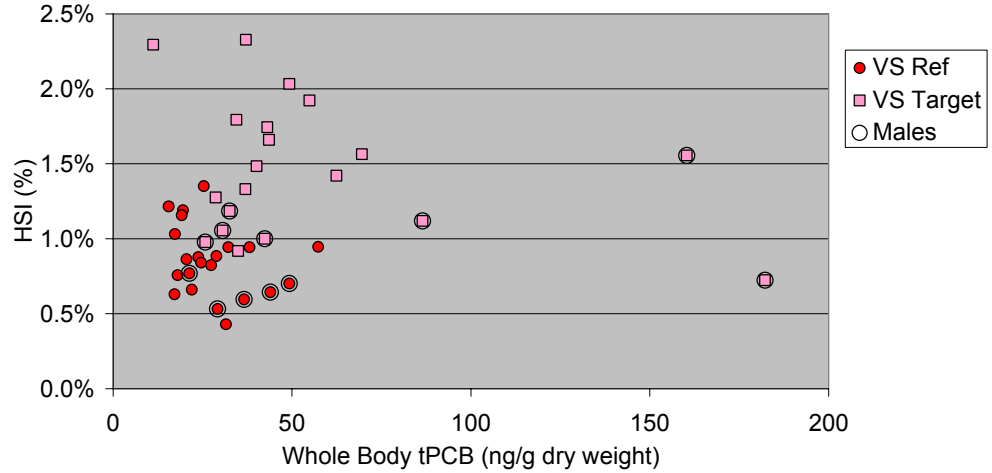
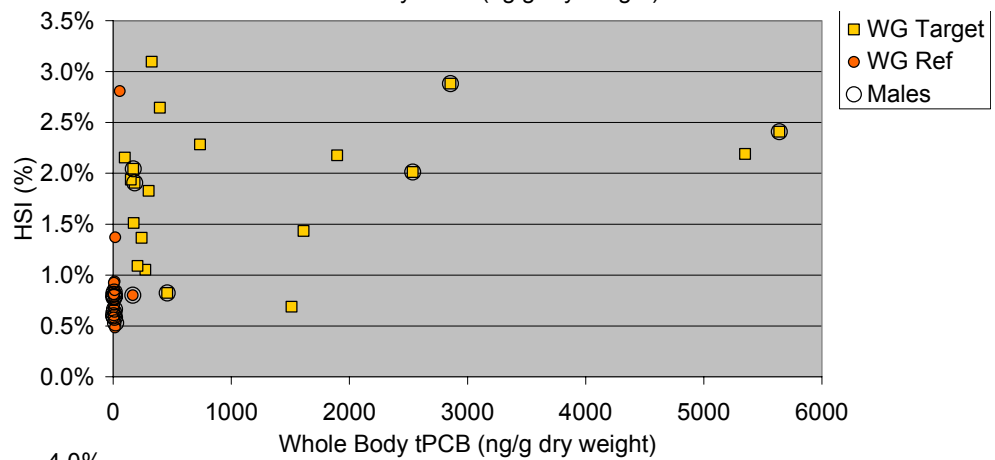


Figure 18. The mean and standard deviation of total PCB per unit fillet lipid, assuming the data conformed to a lognormal distribution, for vermilion snapper, white grunt, and black sea bass, sampled at the reference and target reefs.

Vermilion Snapper



White Grunt



Black Sea Bass

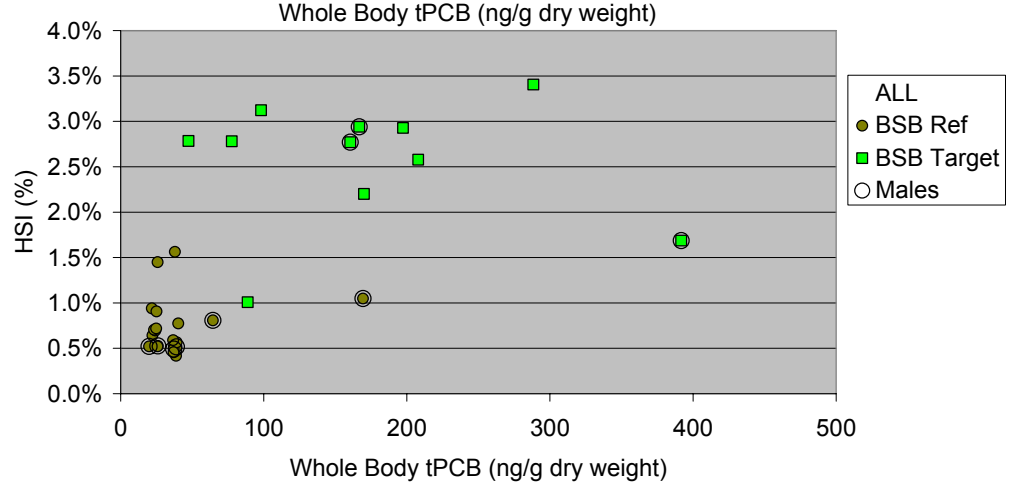


Figure 19. The relationship between the hepatosomatic Index (HSI, liver:body weight ratio) and whole body tPCB measured in vermilion snapper, white grunt, and black sea bass samples.

Figure 19

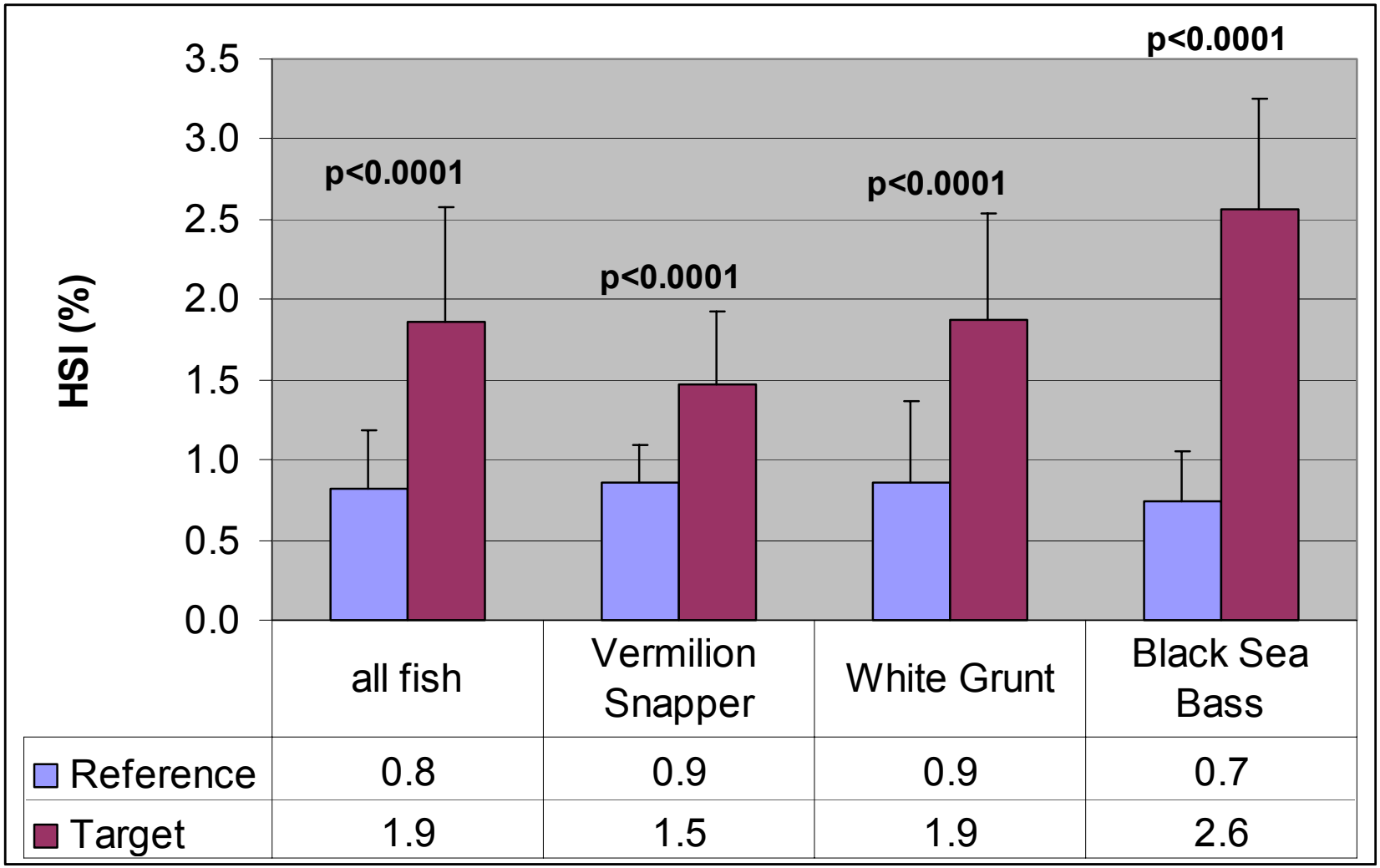


Figure 20. Comparison of the hepatosomatic index (HSI %) measured in fish from the reference and target reefs. The mean HSI is shown for each group. Statistically significant differences are indicated for p-values < 0.05.

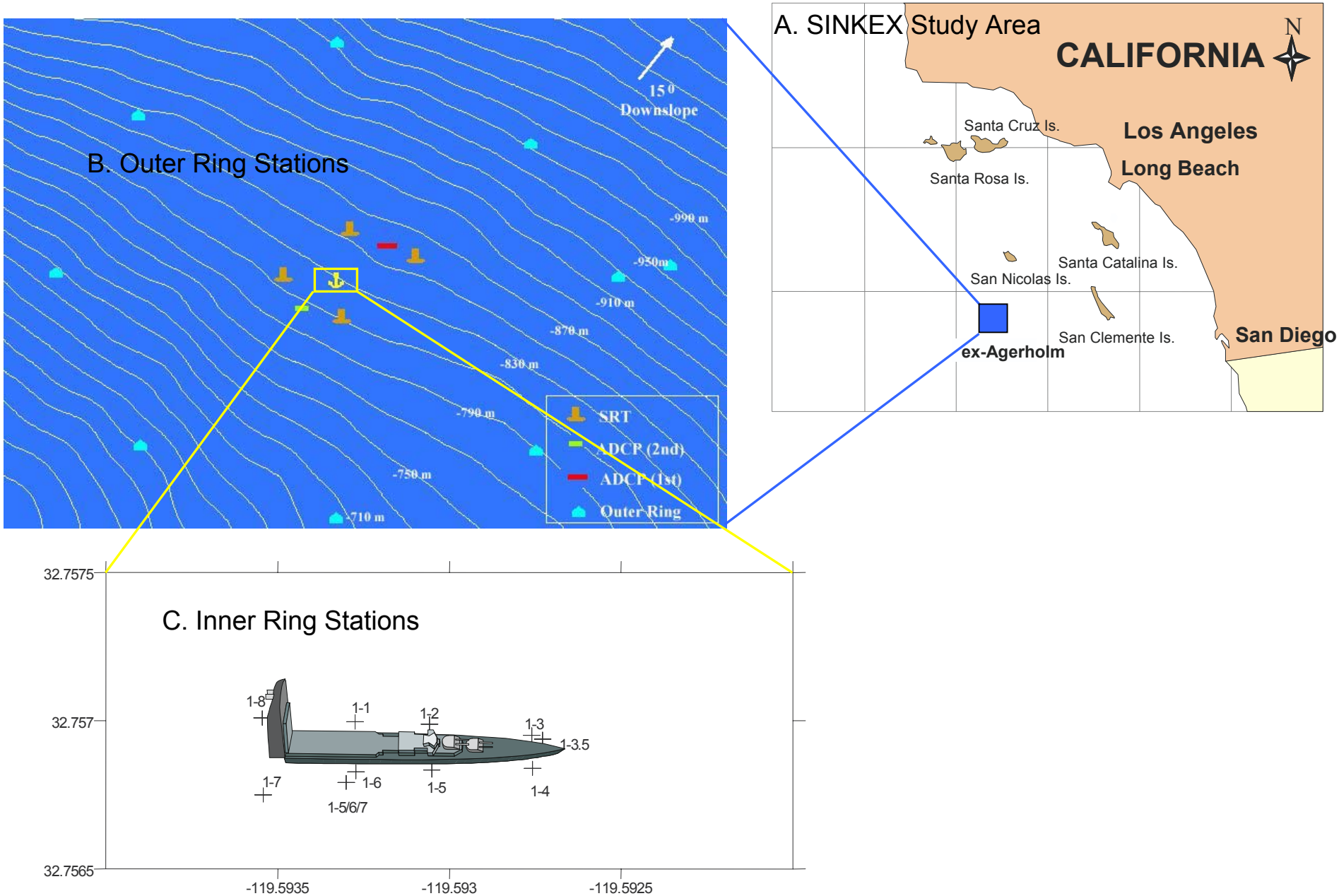


Figure 21. Location of the SINKEX study area (A), the outer ring stations (B), and the inner ring stations (C). From Gauthier et al. in prep.

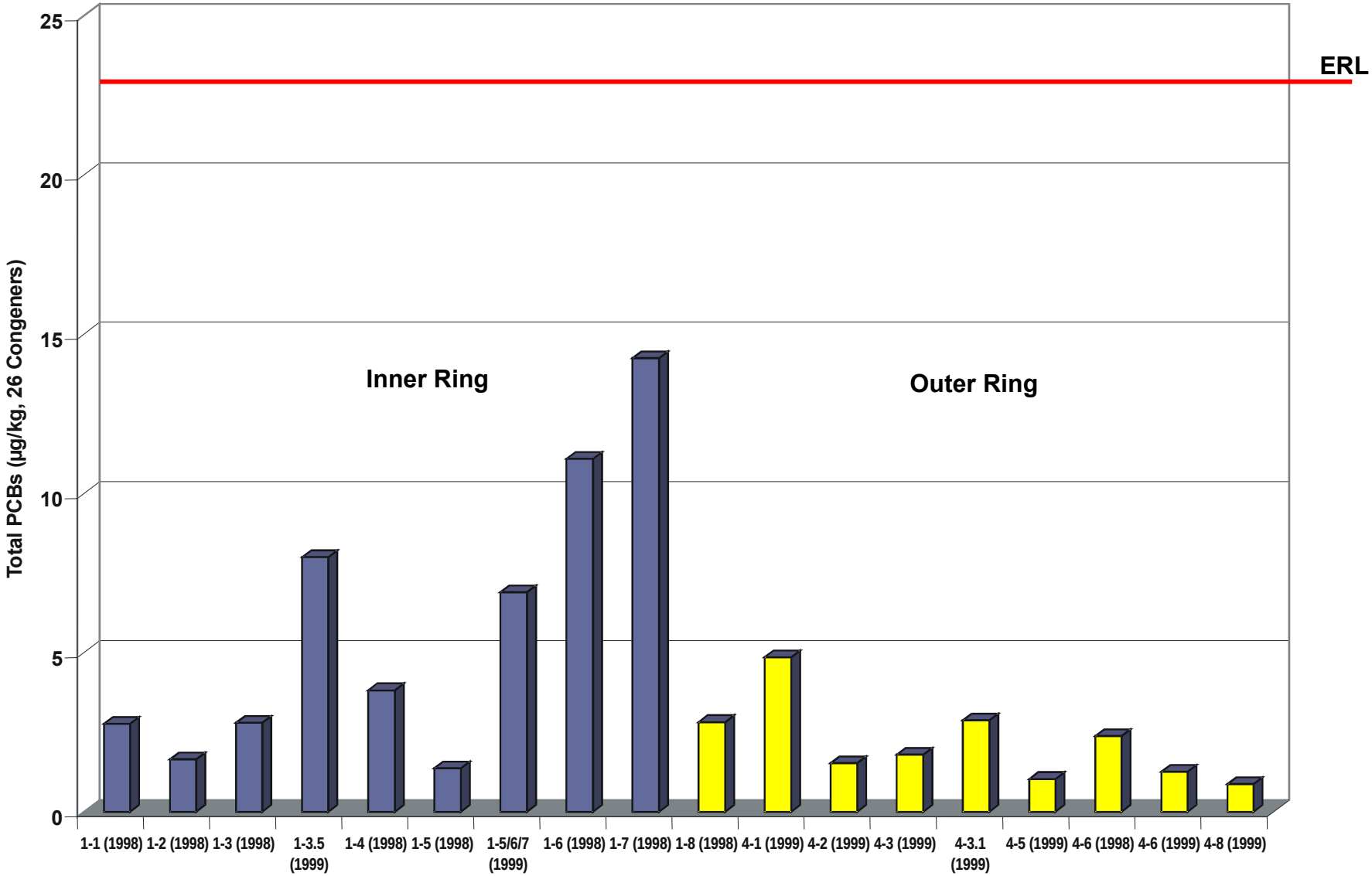


Figure 22. Graphical screening for total PCB measured in surface sediments collected in 1998 and 1999 from the SINKEX study site (from Gauthier et al. 2003). Inner ring concentrations were higher than outer ring, but the difference was not statistically significant.

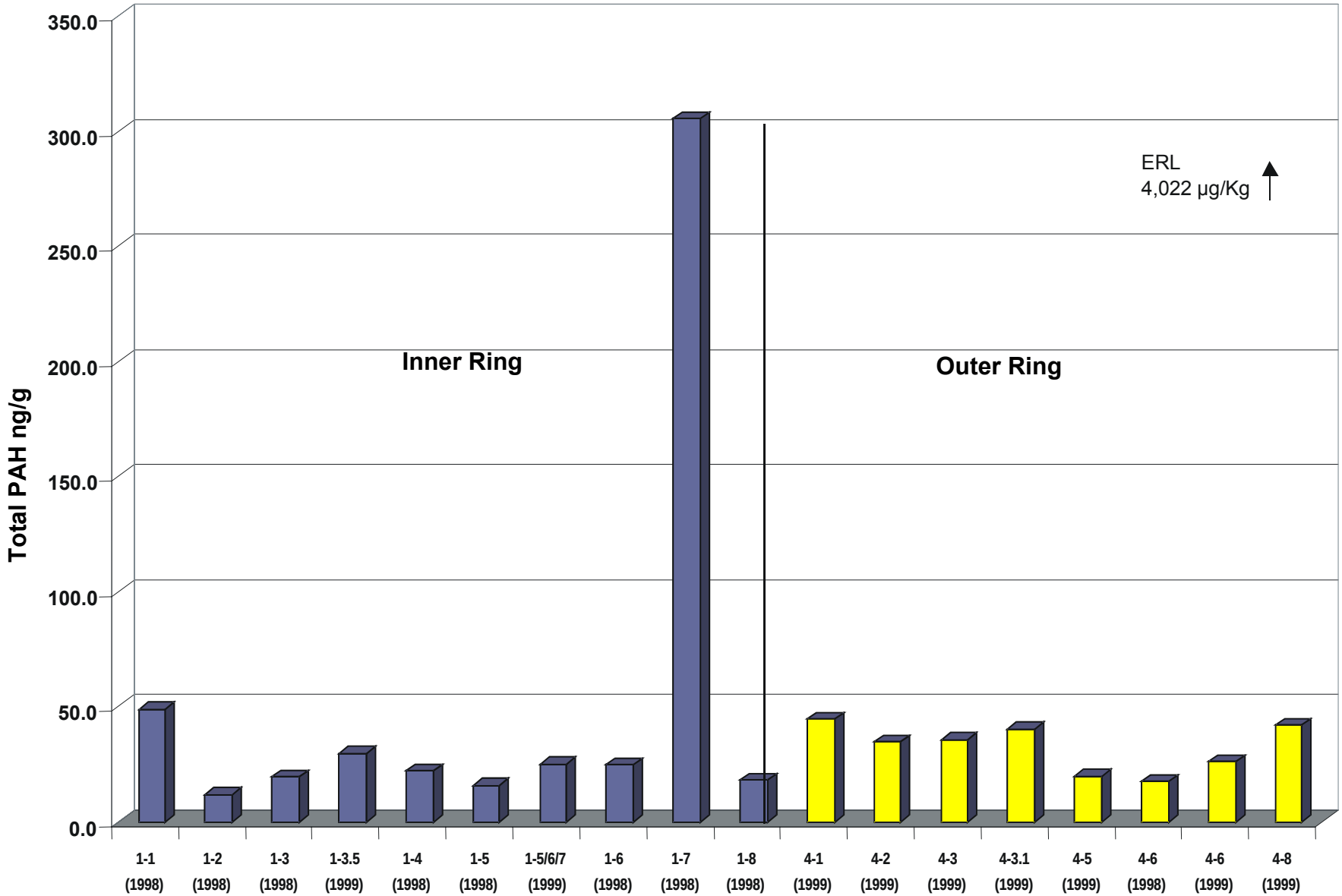


Figure 23. Graphical screening for total polycyclic aromatic hydrocarbons (PAHs) measured in surface sediments collected in 1998 and 1999 from the SINKEX study site (from Gauthier et al. 2003).

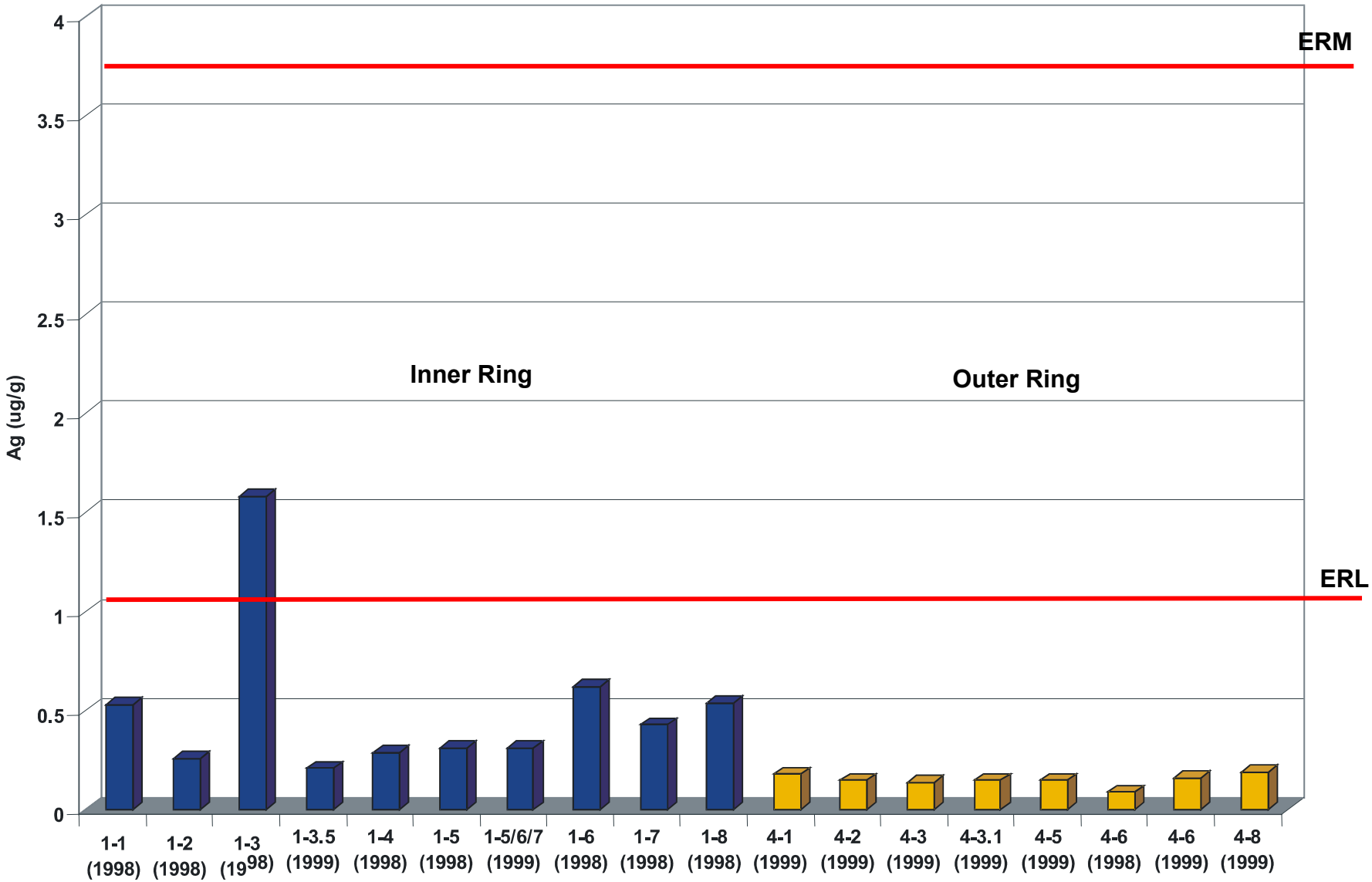


Figure 24. Graphical screening of silver (Ag) concentrations measured in surface sediments collected in 1998 and 1999 from the SINKEX study site (from Gauthier et al. 2003).

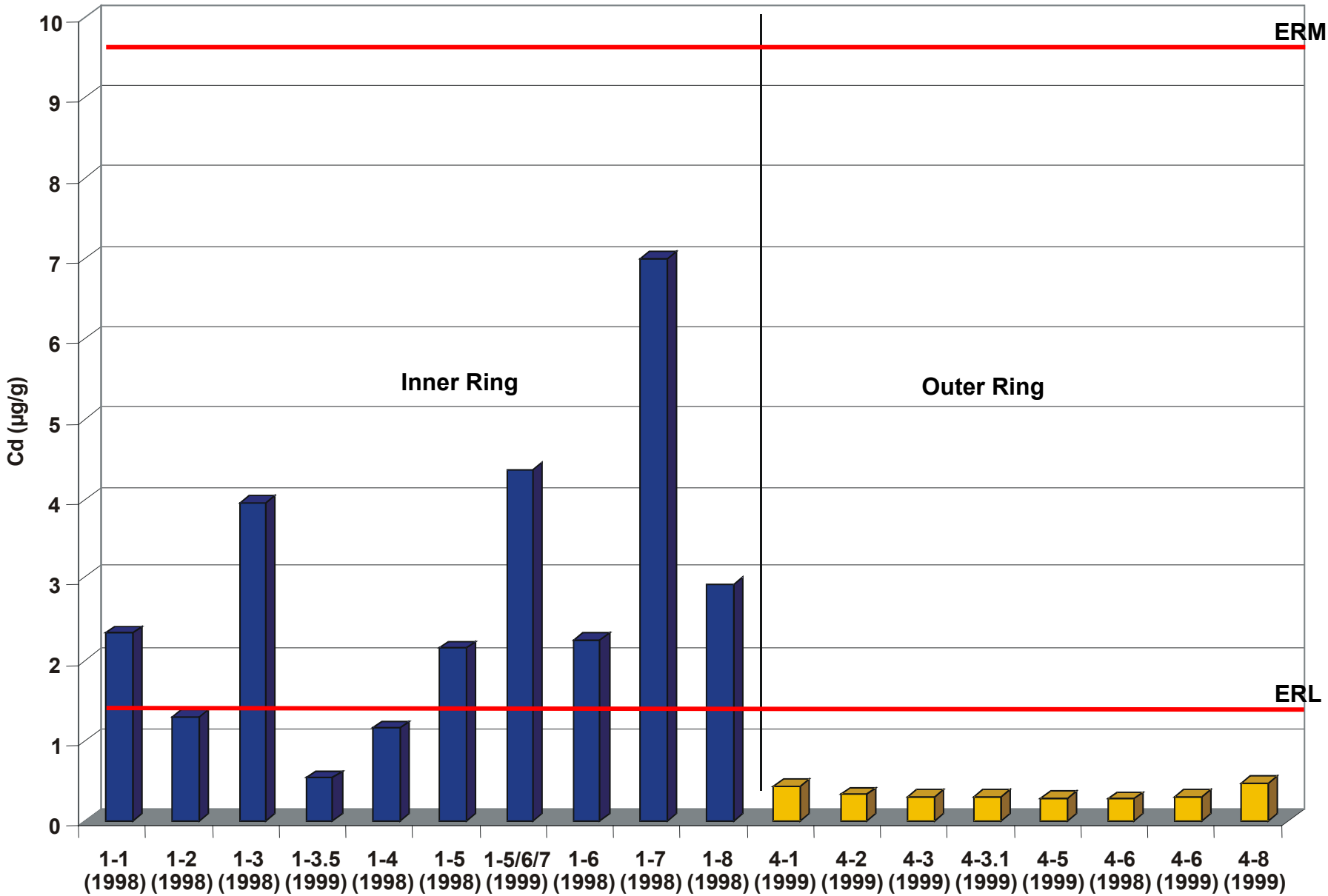


Figure 25. Graphical screening for cadmium (Cd) concentrations measured in surface sediments collected in 1998 and 1999 from the SINKEX study site (from Gauthier et al. 2003).

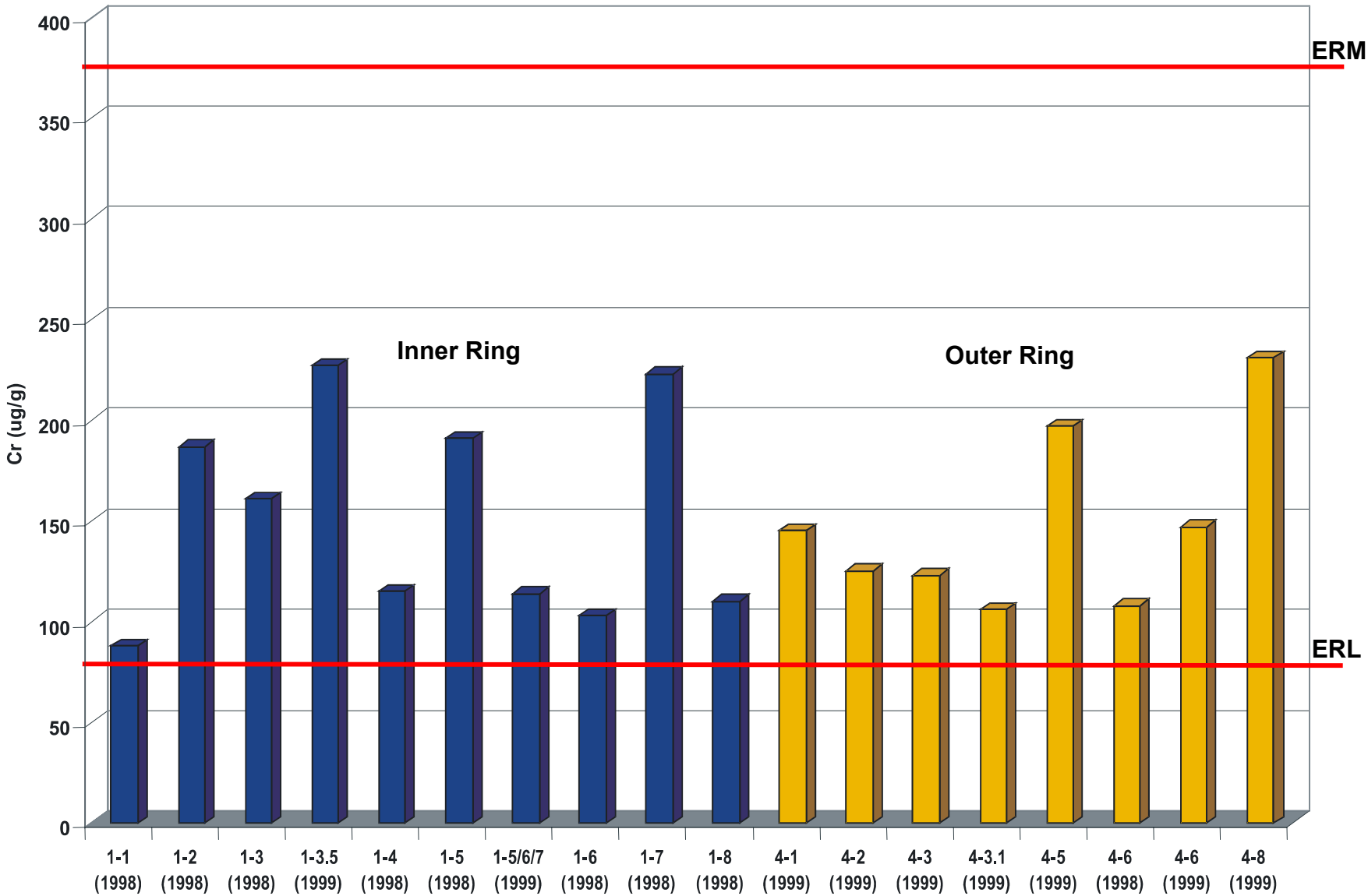


Figure 26. Graphical screening for chromium (Cr) concentrations measured in surface sediments collected in 1998 and 1999 from the SINKEX study site (from Gauthier et al. 2003).

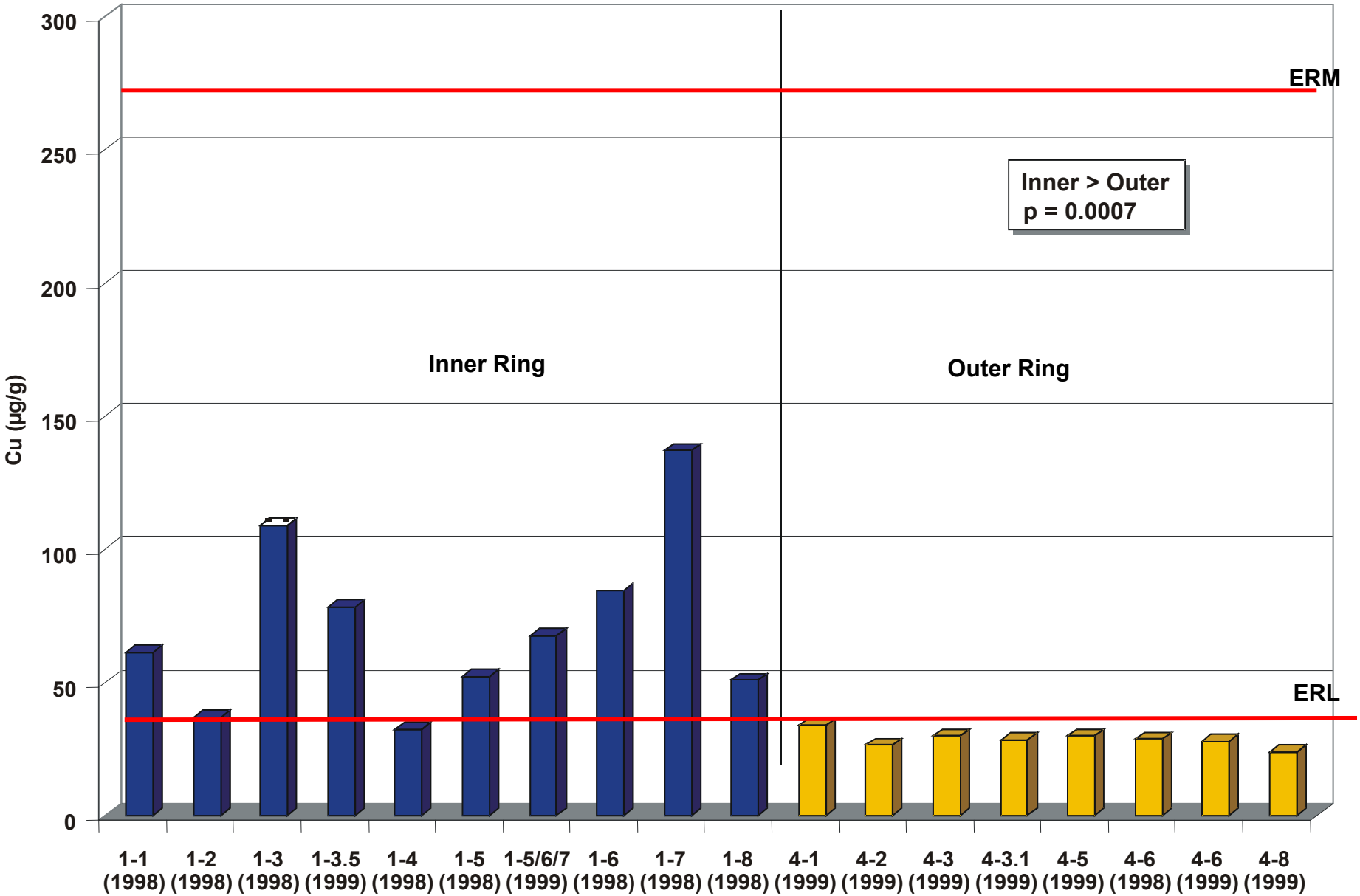


Figure 27. Graphical screening for copper (Cu) concentrations measured in surface sediments collected in 1998 and 1999 from the SINKEX study site (from Gauthier et al. 2003).

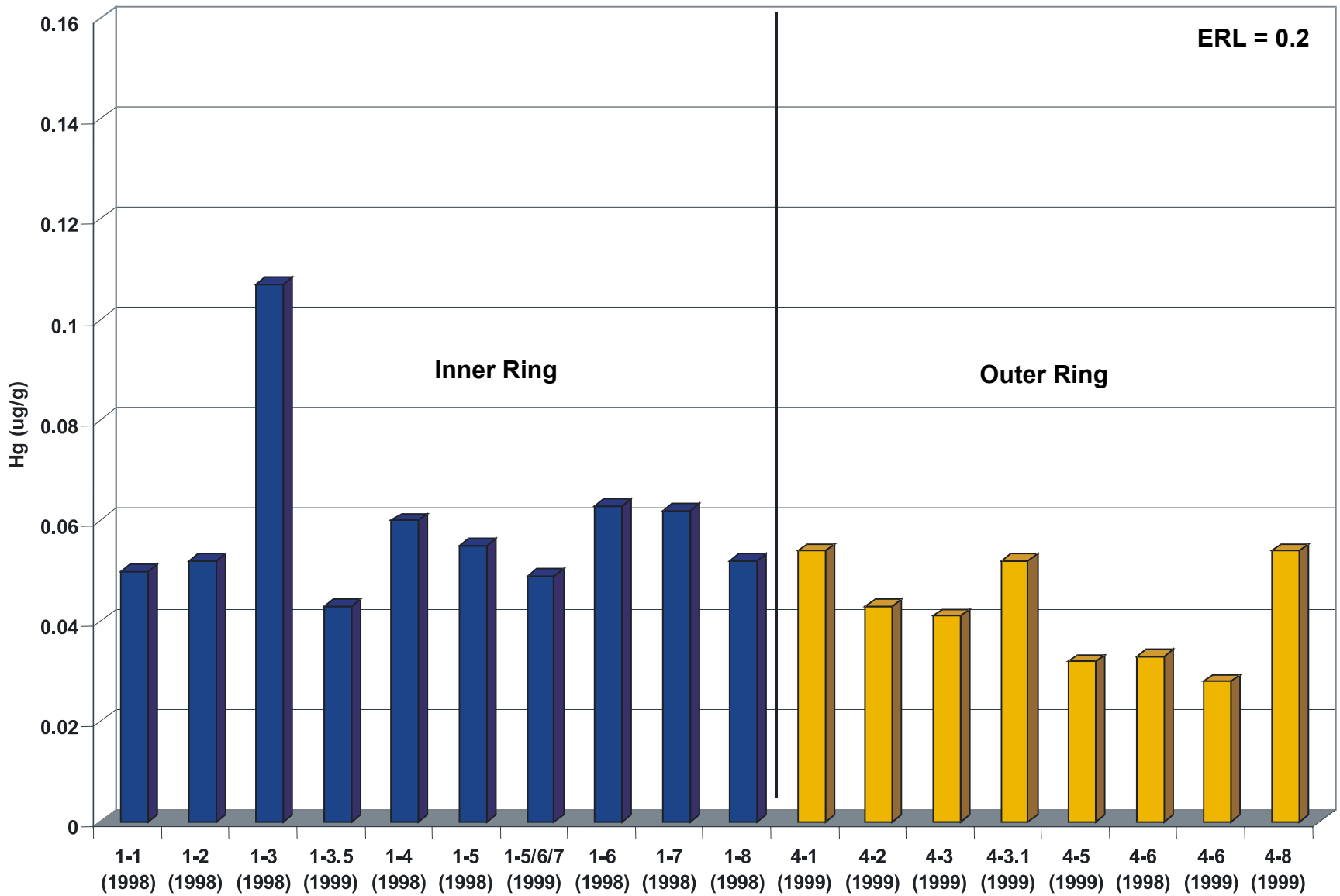


Figure 28. Graphical screening for mercury (Hg) concentrations measured in surface sediments collected in 1998 and 1999 from the SINKEX study site (from Gauthier et al. 2003).

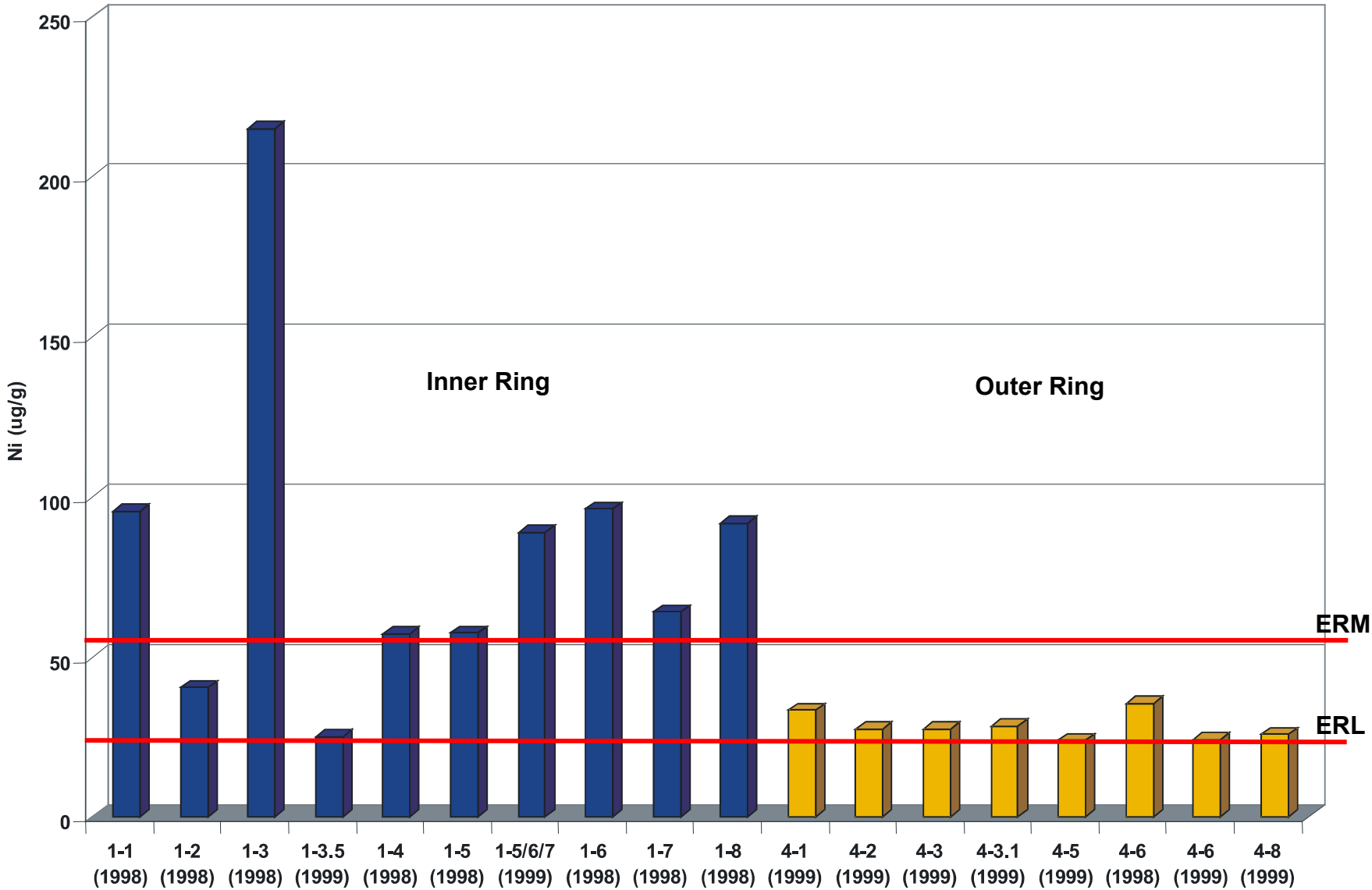


Figure 29. Graphical screening for nickel (Ni) concentrations measured in surface sediments collected in 1998 and 1999 from the SINKEX study site (from Gauthier et al. 2003).

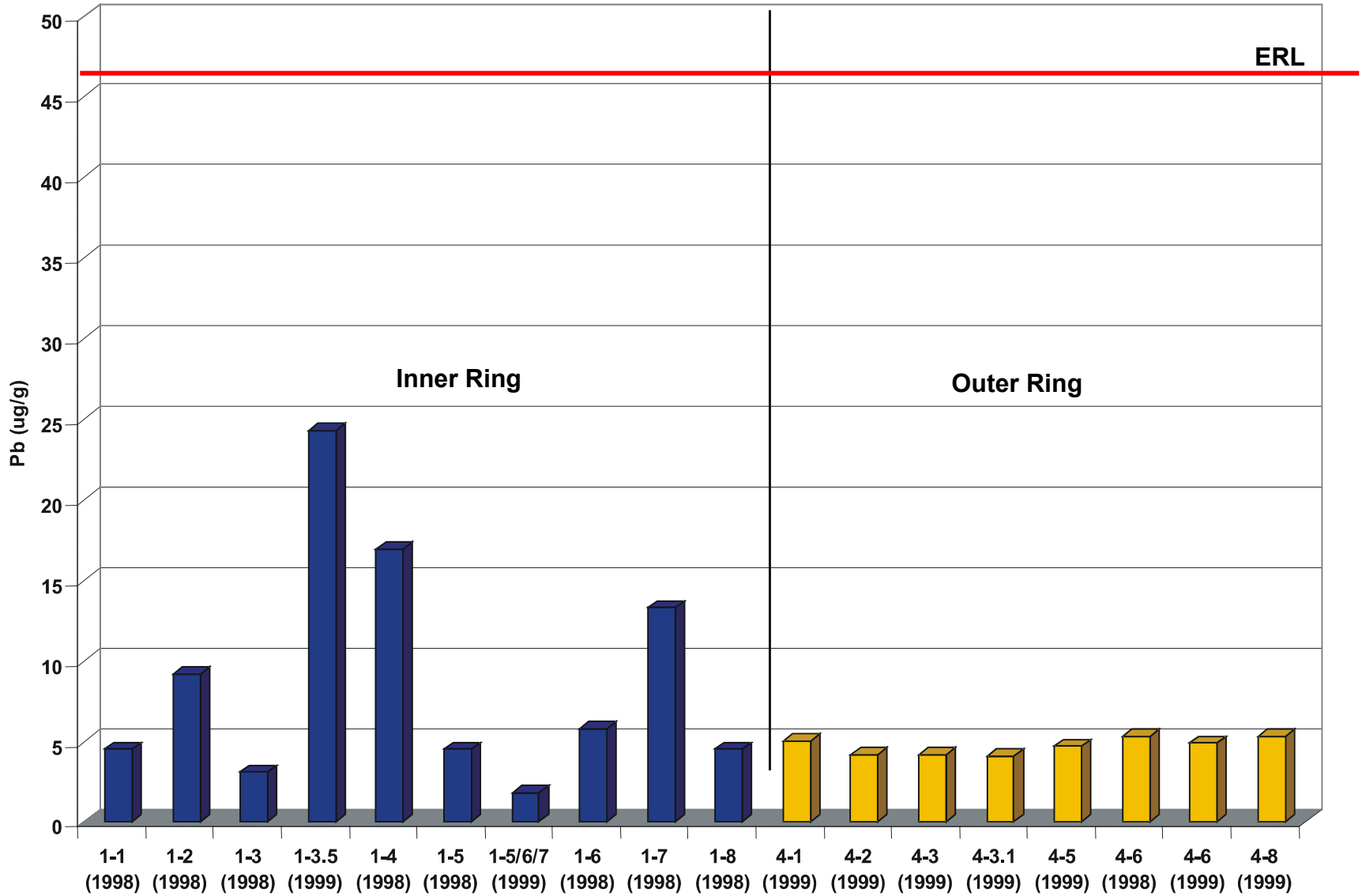


Figure 30. Graphical screening for lead (Pb) concentrations measured in surface sediments collected in 1998 and 1999 from the SINKEX study site (from Gauthier et al. 2003).

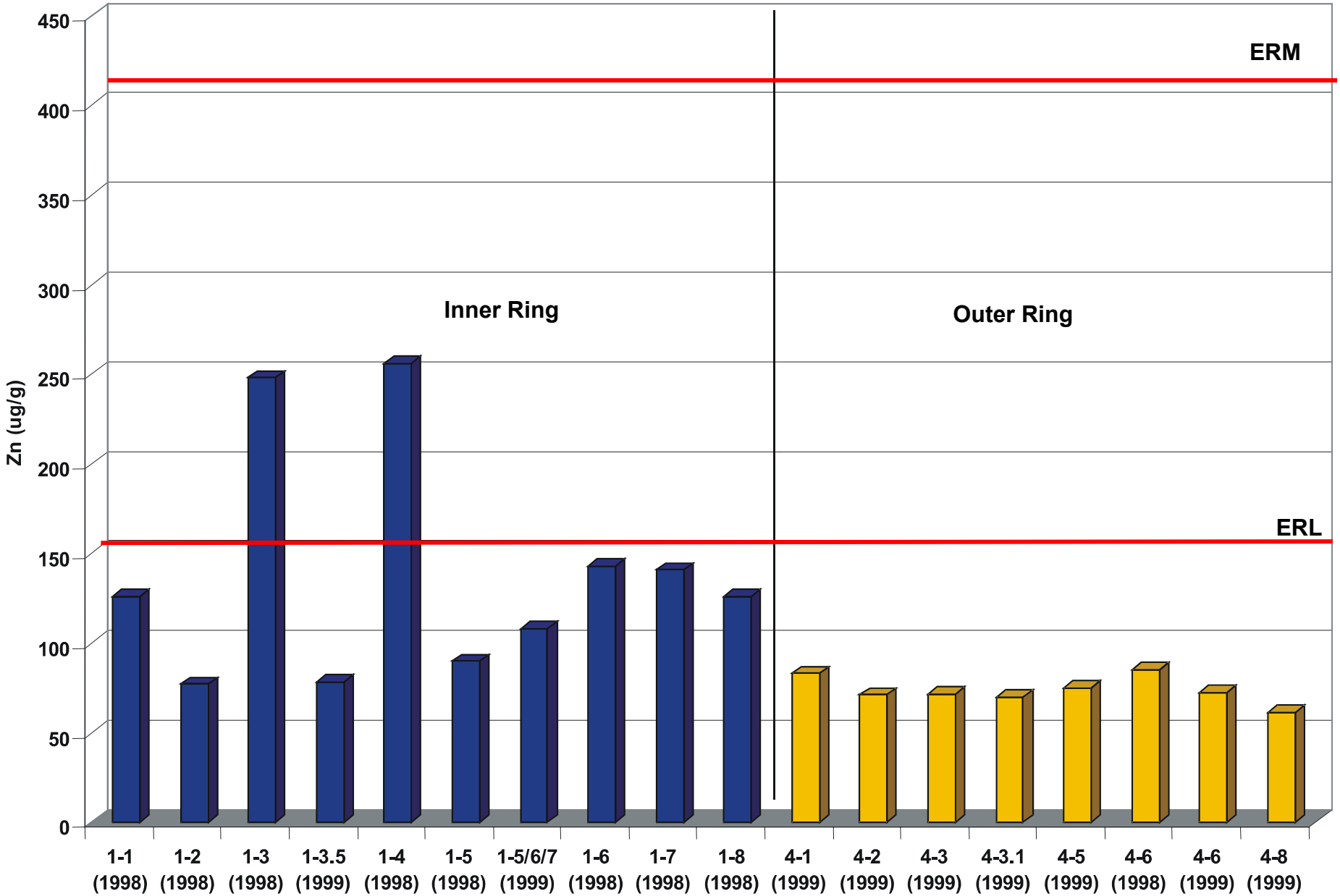
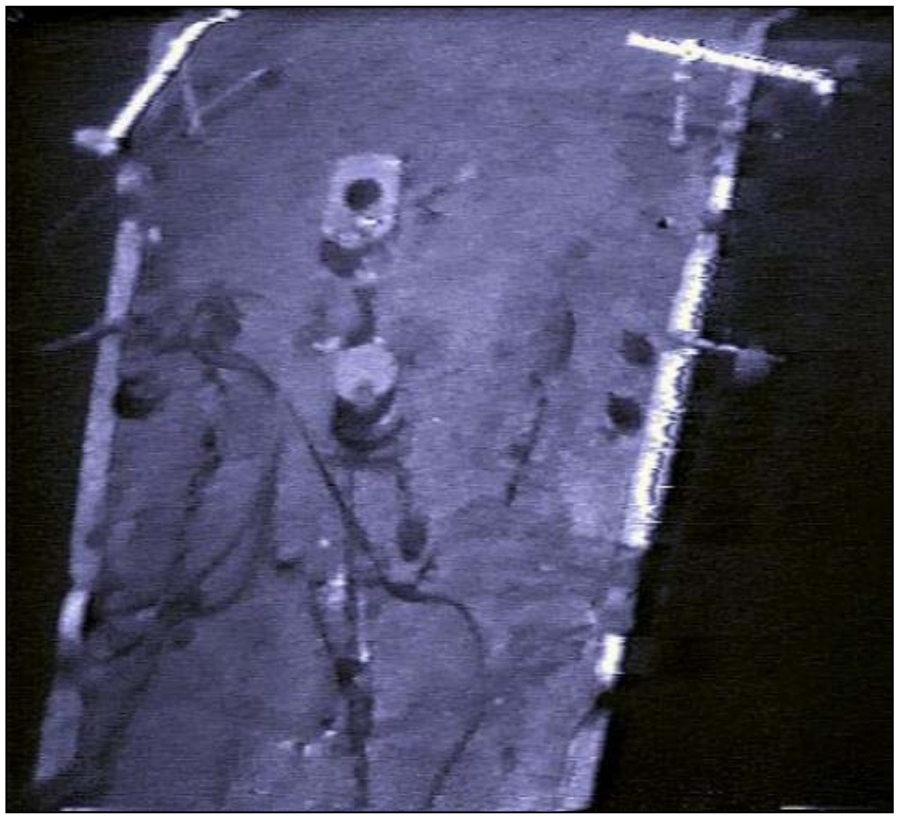


Figure 31. Graphical screening for zinc (Zn) concentrations measured in surface sediments collected in 1998 and 1999 from the SINKEX study site (from Gauthier et al. 2003).

What is Exposure Relative to Reference and Background?

Could Exposure be Harmful?	Less	Similar	Higher
Very Unlikely	*Negligible Exposure*	*Negligible Exposure PCB, PAH, Hg, Pb*	*Negligible Exposure*
Unlikely	*Negligible Exposure*	*Negligible Exposure*	*Low Exposure Ag, Hg*
Potential	*Negligible Exposure*	*Negligible Exposure Cr*	*Medium Exposure Cd, Cu*
Likely	*Negligible Exposure*	*Low Exposure*	*High Exposure*
Very Likely	*Negligible Exposure*	*Medium Exposure*	*Adverse Exposure Ni*

Figure 32. Summary of potential risk of exposure from the sediment pathway.



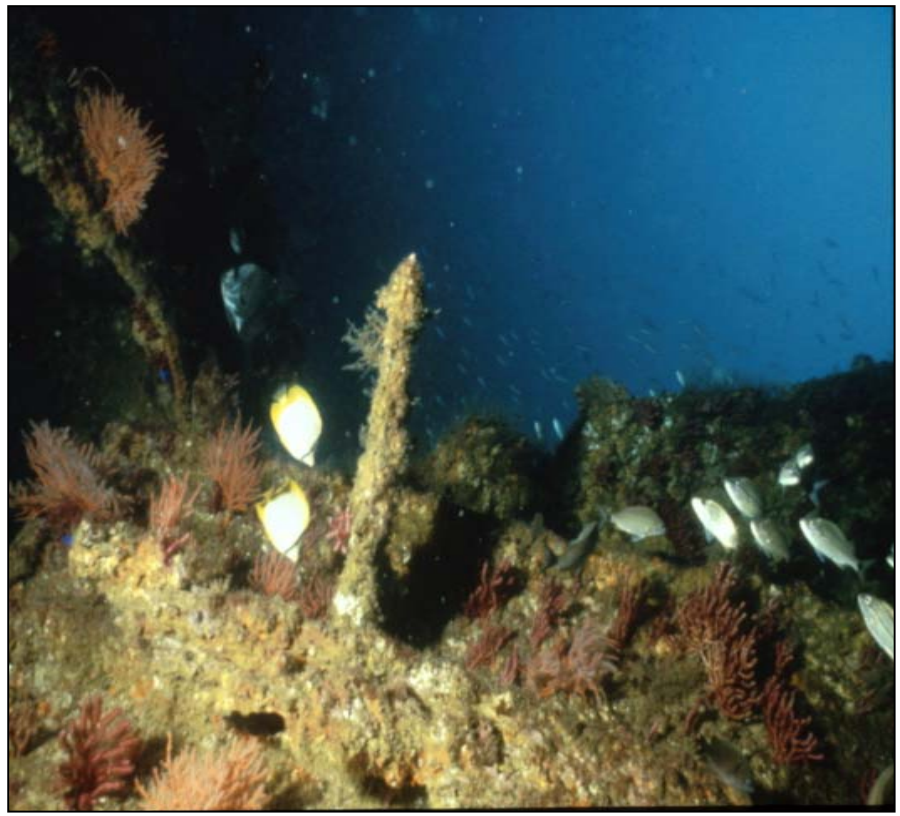


Figure 33. Differences in the reef community present on the ex-AGERHOLM (right) and the ex-VERMILION (left).

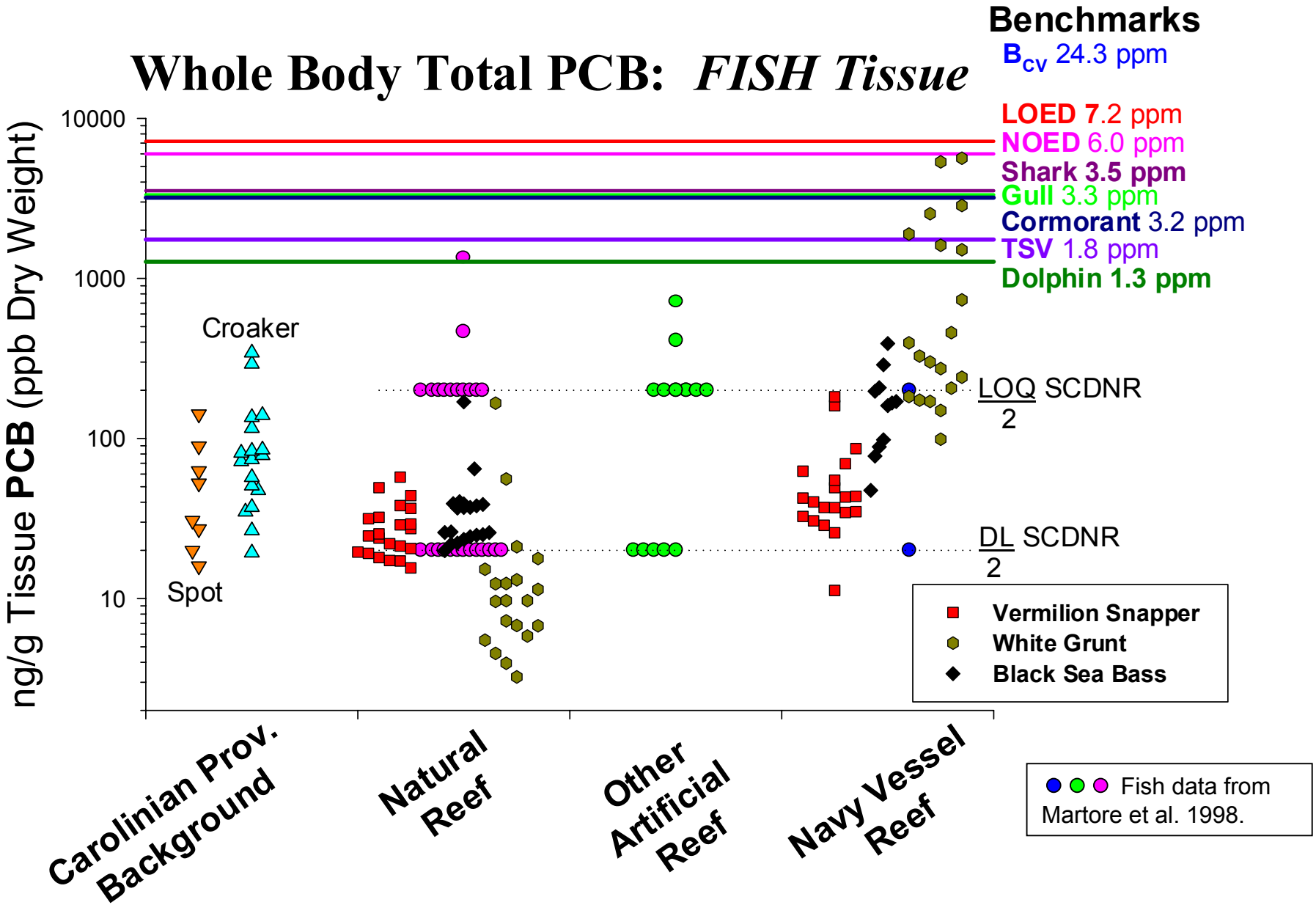


Figure 34. Graphical screening for total PCB in fish tissue residues. Fish residue data are compared to fish data (spot and croaker) from EMAP (Carolinian Prov. Background, Hyland et al. 1998) and to ecological effect benchmarks for fish tissue (see Table 3). Data from the SCDNR study that were reported below the limit of quantitation (LOQ) or detection limit (DL) were plotted as ½ the LOQ (LOQ/2) or DL (DL/2), respectively.

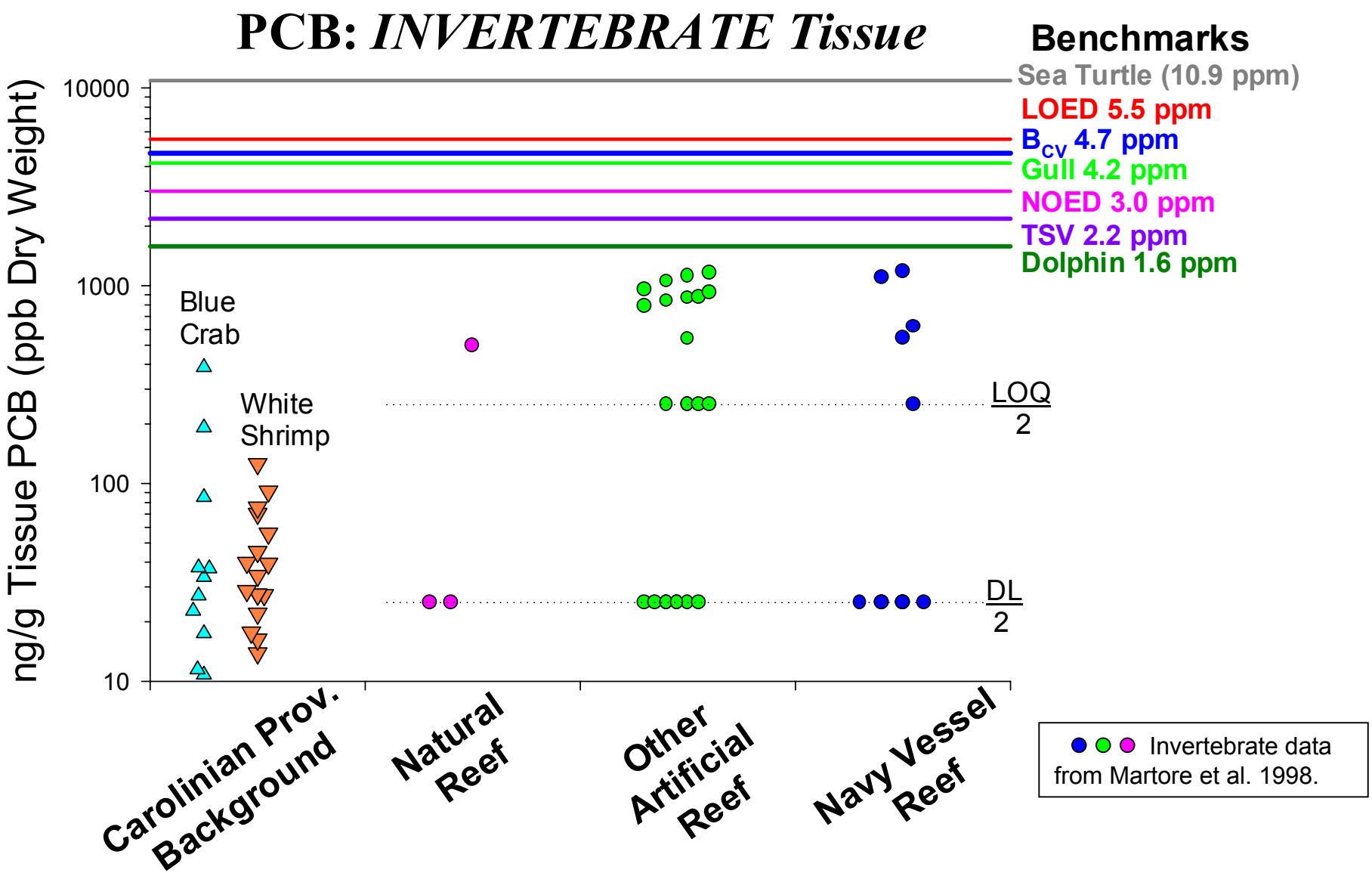


Figure 35. Graphical screening for total PCB in invertebrate tissue residues. Invertebrate residue data are compared to data (blue crab and white shrimp) from EMAP (Carolinian Prov. Background, Hyland et al. 1998) and to ecological effect benchmarks for invertebrate tissue (see Table 3). Data from the SCDNR study that were reported below the limit of quantitation (LOQ) or detection limit (DL) were plotted as ½ the LOQ (LOQ/2) or DL (DL/2), respectively.

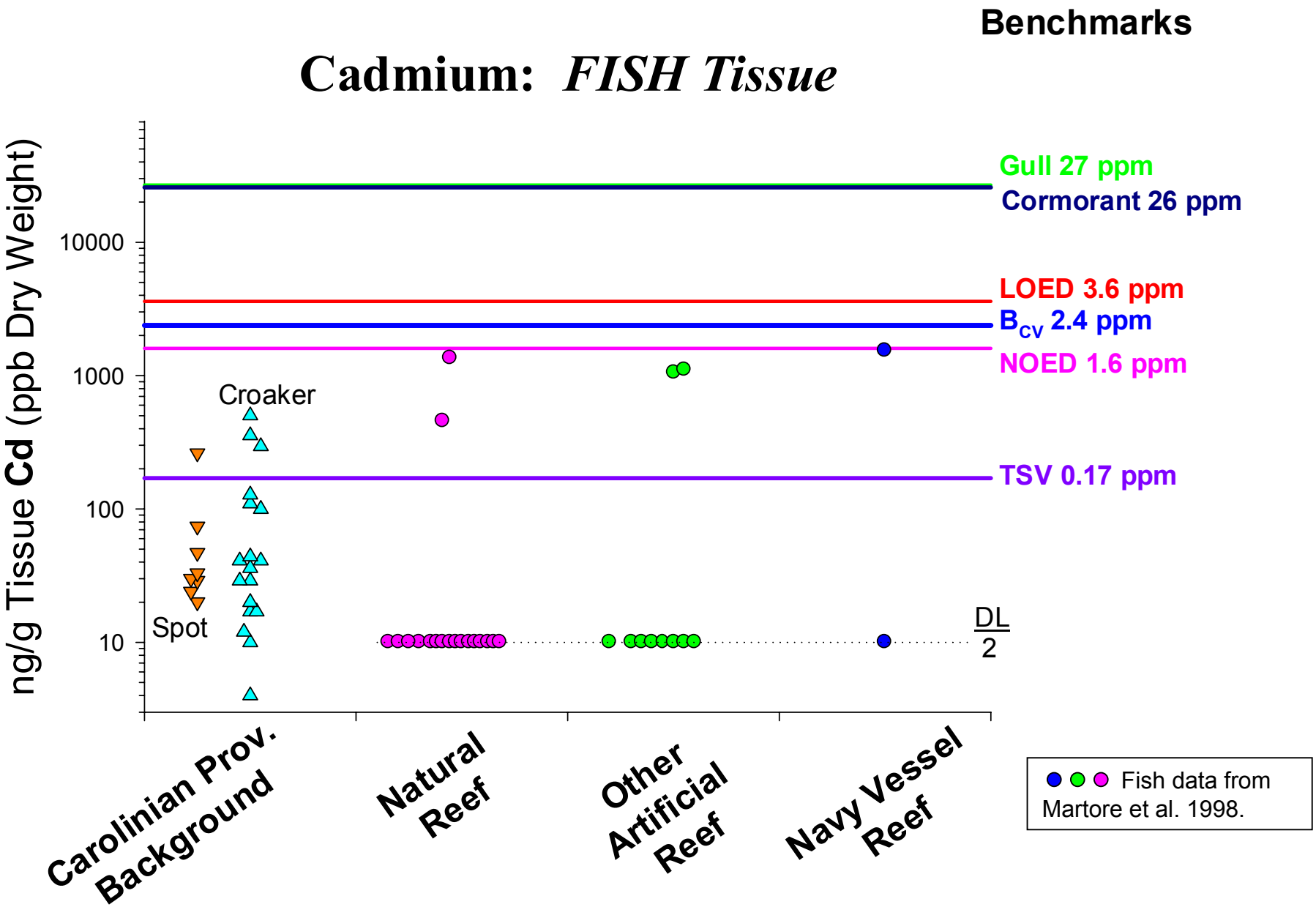


Figure 36. Graphical screening for Cd in fish tissue residues. Fish residue data are compared to fish data (spot and croaker) from EMAP (Carolinian Prov. Background, Hyland et al. 1998) and to ecological effect benchmarks for fish tissue (see Table 3). Data from the SCDNR study that were reported below the detection limit (DL) were plotted as ½ the DL (DL/2).

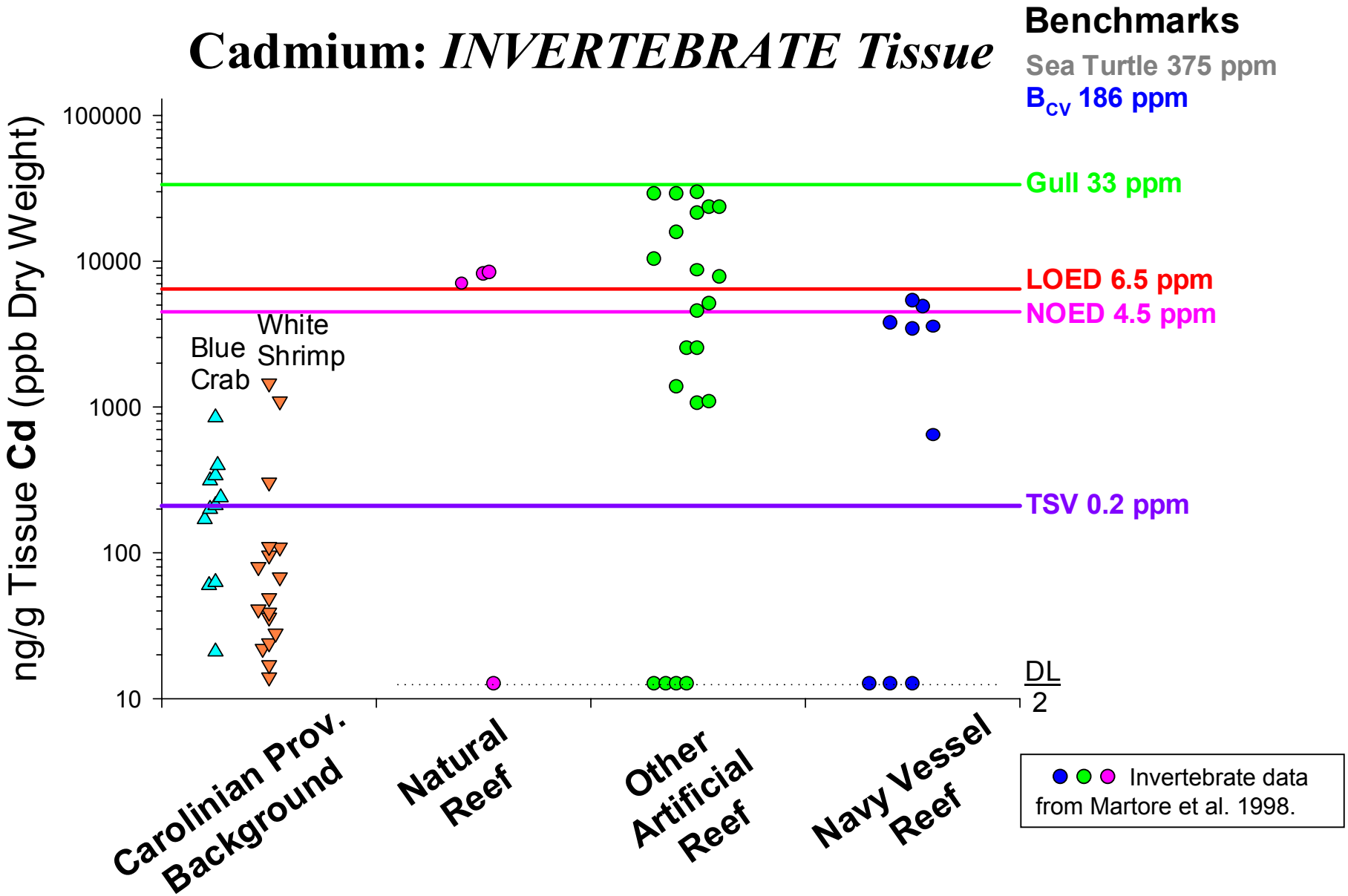


Figure 37. Graphical screening for total Cd in invertebrate tissue residues. Invertebrate residue data are compared to data (blue crab and white shrimp) from EMAP (Carolinian Prov. Background, Hyland et al. 1998) and to ecological effect benchmarks for invertebrate tissue (see Table 3). Data from the SCDNR study that were reported below the detection limit (DL) were plotted as ½ the DL (DL/2).

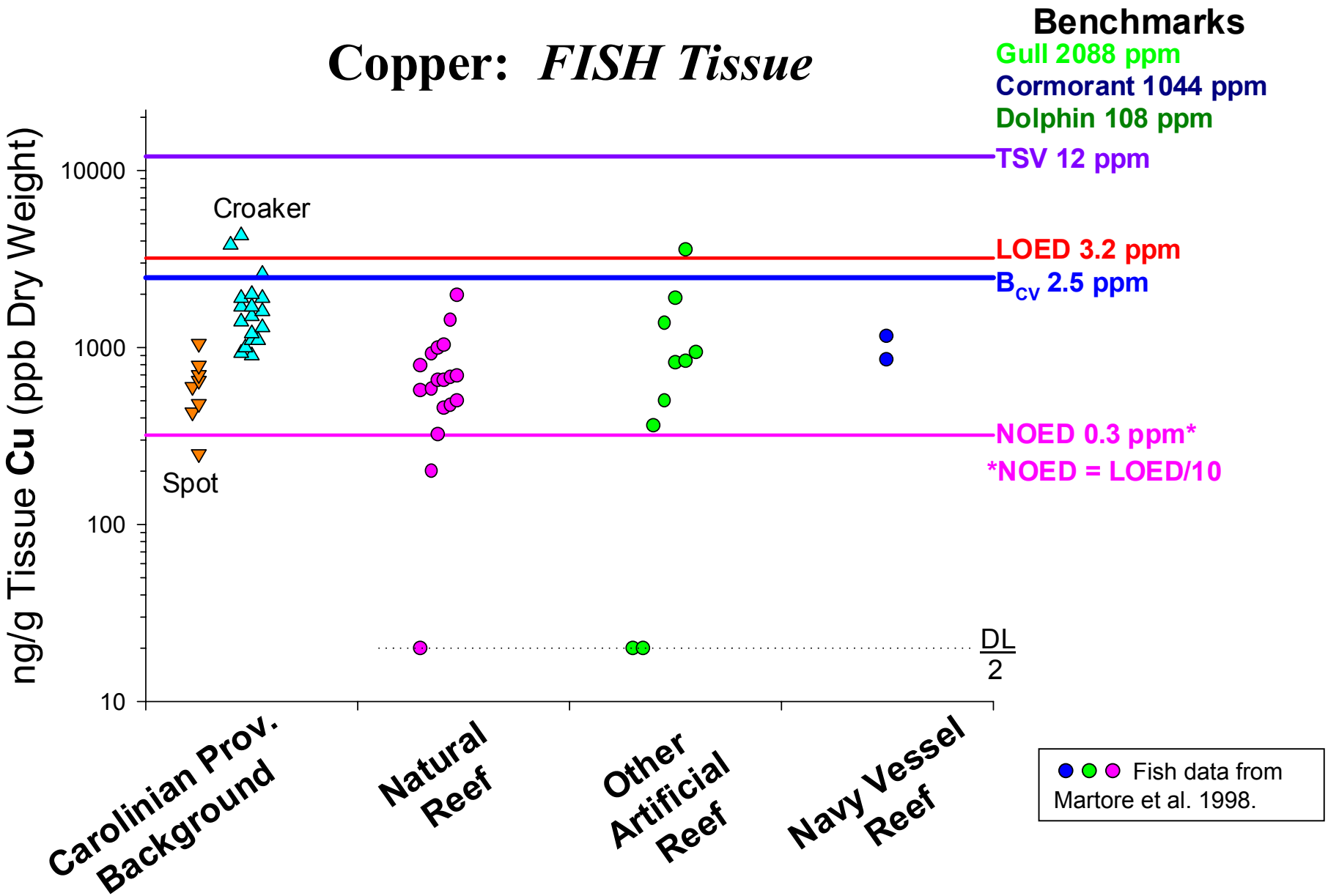


Figure 38. Graphical screening for Cu in fish tissue residues. Fish residue data are compared to fish data (spot and croaker) from EMAP (Carolinian Prov. Background, Hyland et al. 1998) and to ecological effect benchmarks for fish tissue (see Table 3). Data from the SCDNR study that were reported below the detection limit (DL) were plotted as ½ the DL (DL/2).

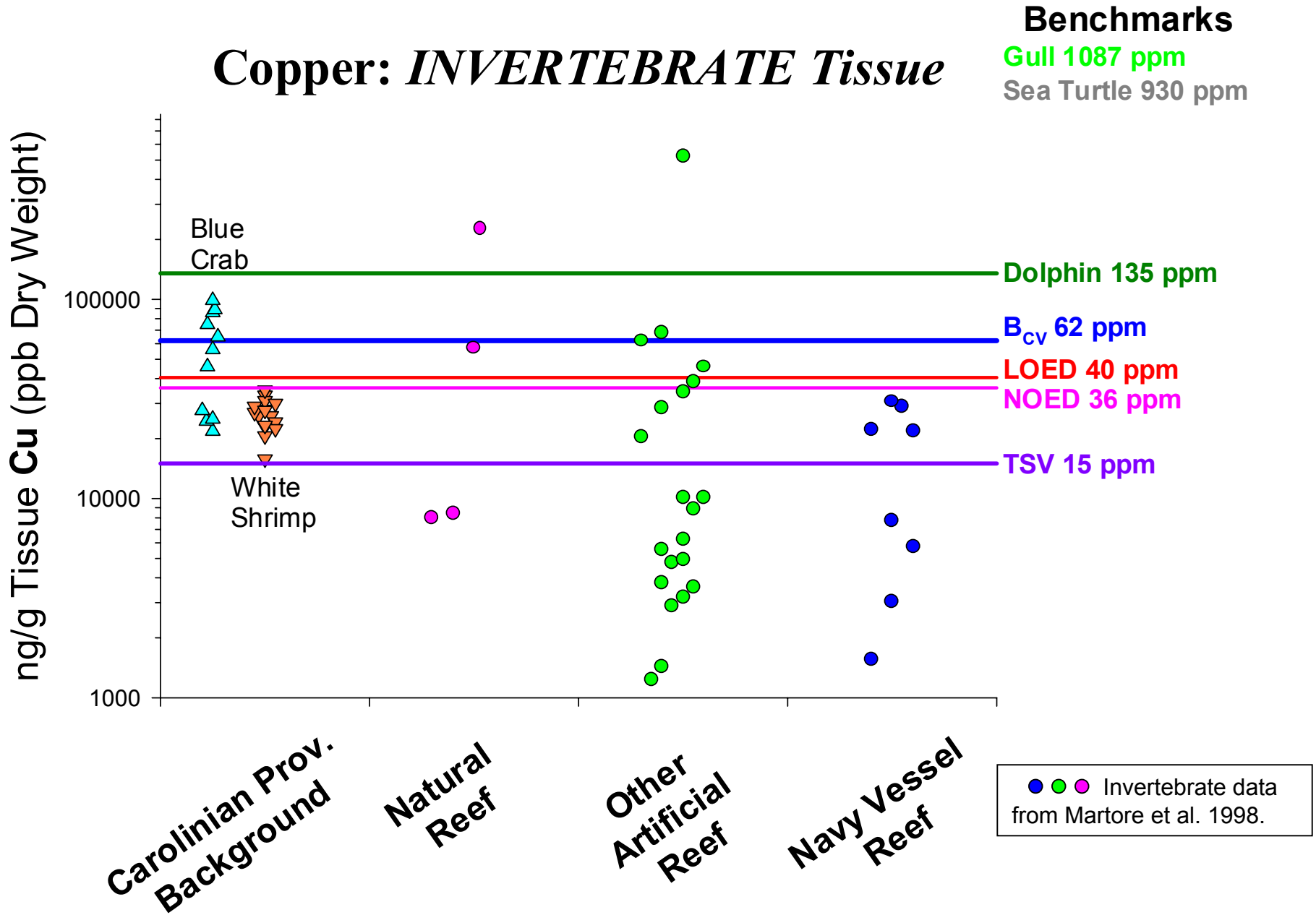


Figure 39. Graphical screening for Cu in invertebrate tissue residues. Invertebrate residue data are compared to data (blue crab and white shrimp) from EMAP (Carolinian Prov. Background, Hyland et al. 1998) and to ecological effect benchmarks for invertebrate tissue (see Table 3).

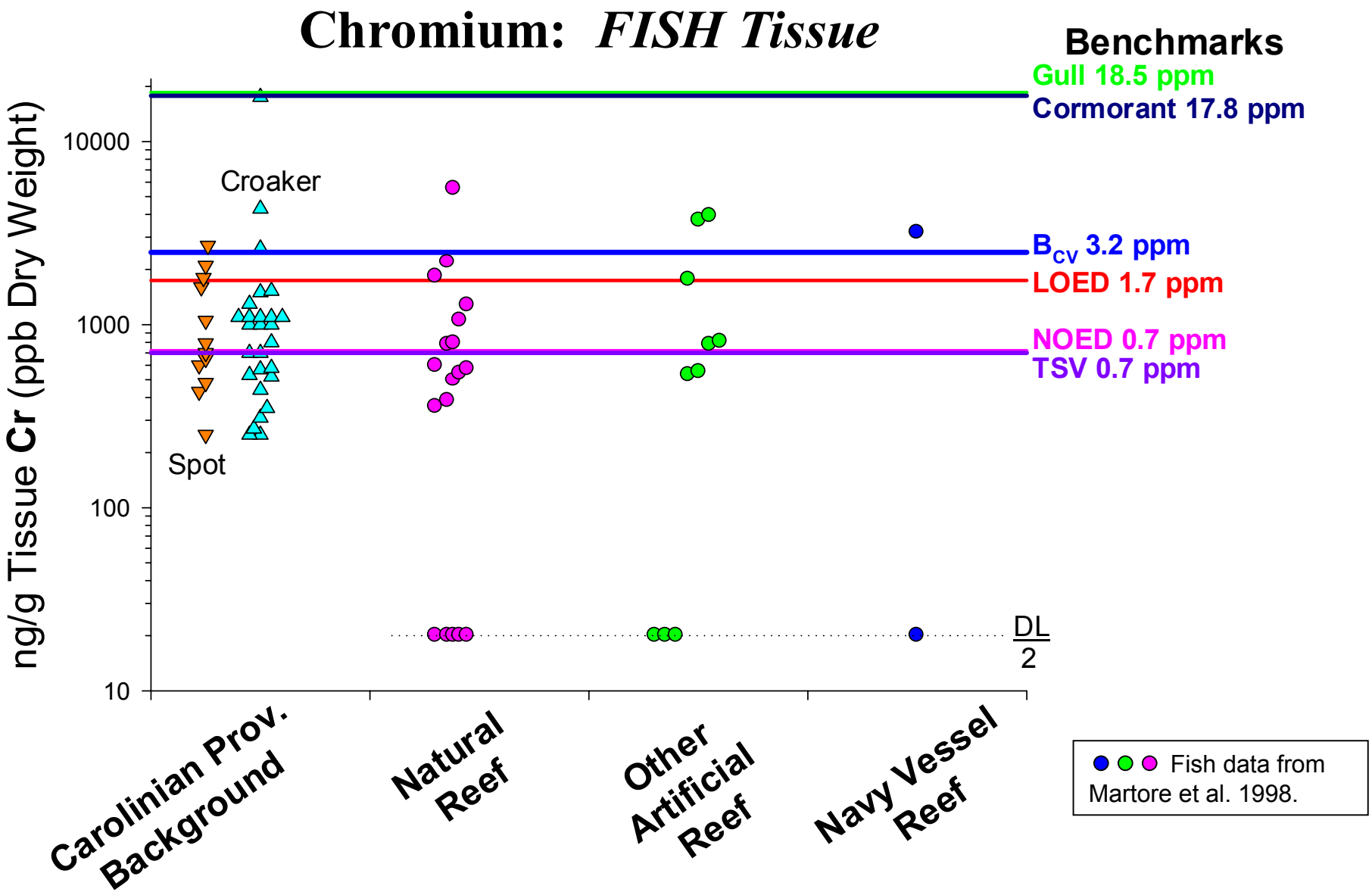


Figure 40. Graphical screening for Cd in fish tissue residues. Fish residue data are compared to fish data (spot and croaker) from EMAP (Carolinian Prov. Background, Hyland et al. 1998) and to ecological effect benchmarks for fish tissue (see Table 3). Data from the SCDNR study that were reported below the the detection limit (DL) were plotted as ½ the DL (DL/2).

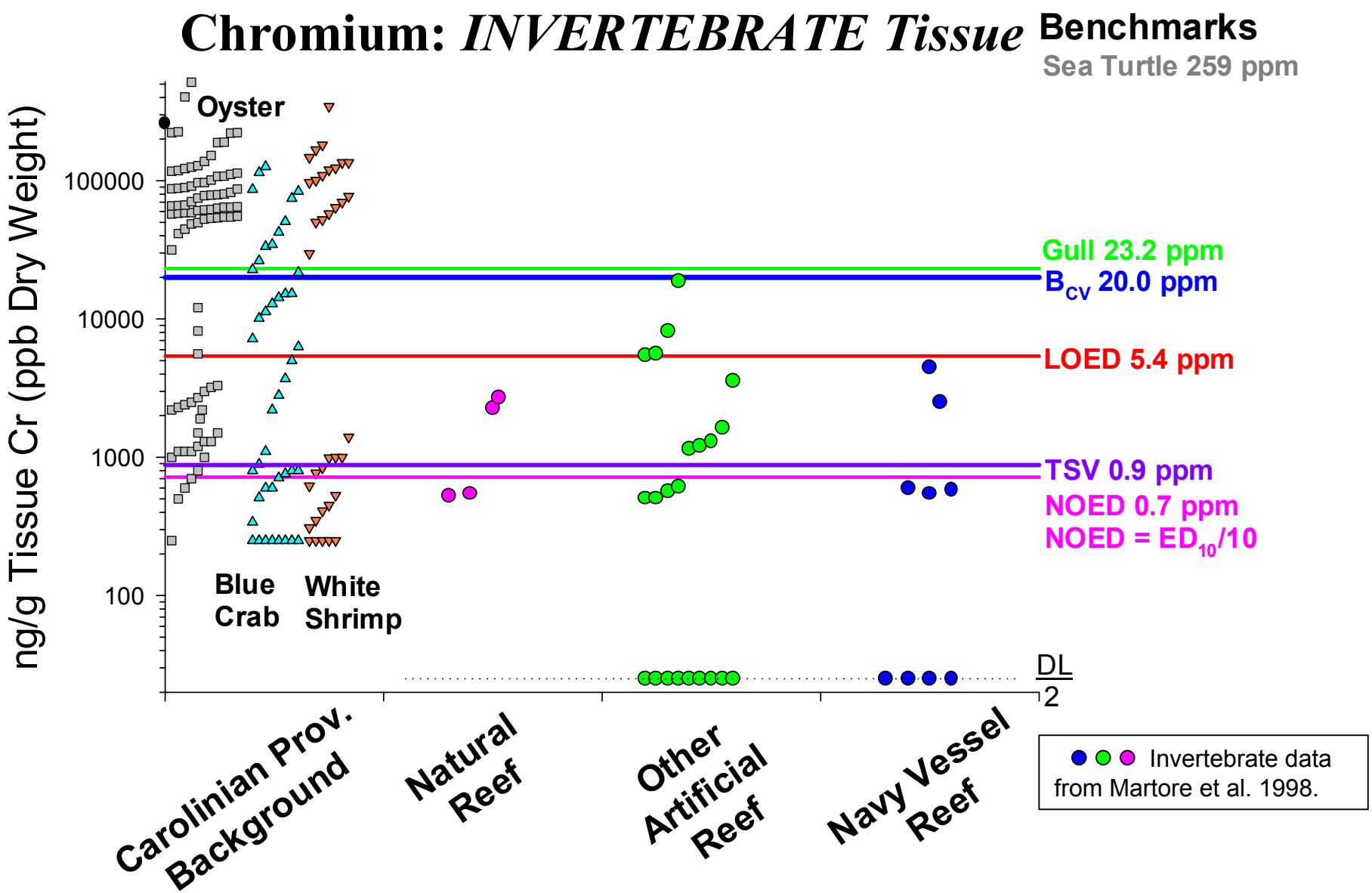


Figure 41. Graphical screening for Cr in invertebrate tissue residues. Invertebrate residue data are compared to data (blue crab and white shrimp) from EMAP (Carolinian Prov. Background, Hyland et al. 1998) and to ecological effect benchmarks for invertebrate tissue (see Table 3). Data from the SCDNR study that were reported below the the detection limit (DL) were plotted as ½ the DL (DL/2).

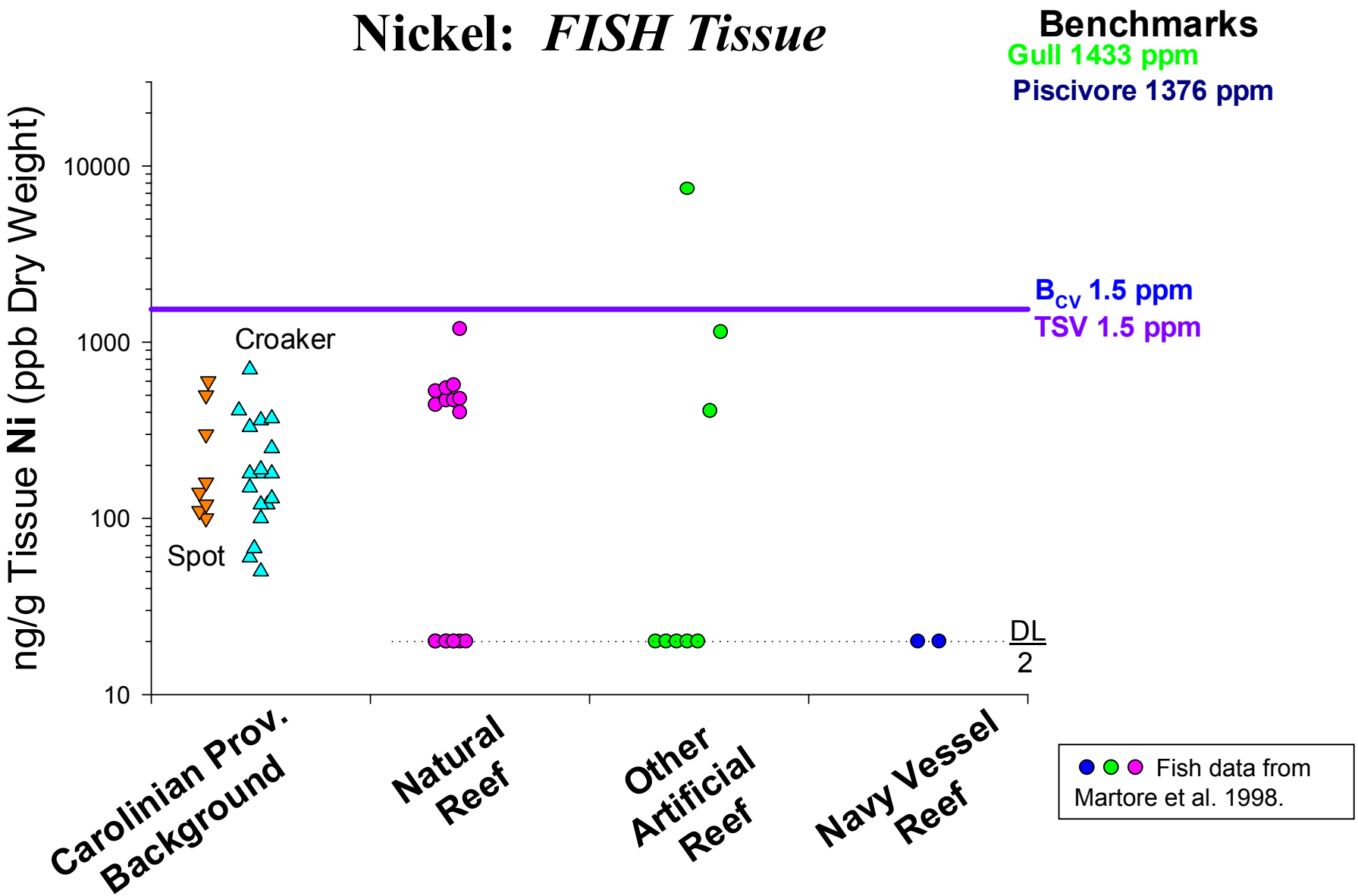


Figure 42. Graphical screening for Cd in fish tissue residues. Fish residue data are compared to fish data (spot and croaker) from EMAP (Carolinian Prov. Background, Hyland et al. 1998) and to ecological effect benchmarks for fish tissue (see Table 3). Data from the SCDNR study that were reported below the the detection limit (DL) were plotted as ½ the DL (DL/2).

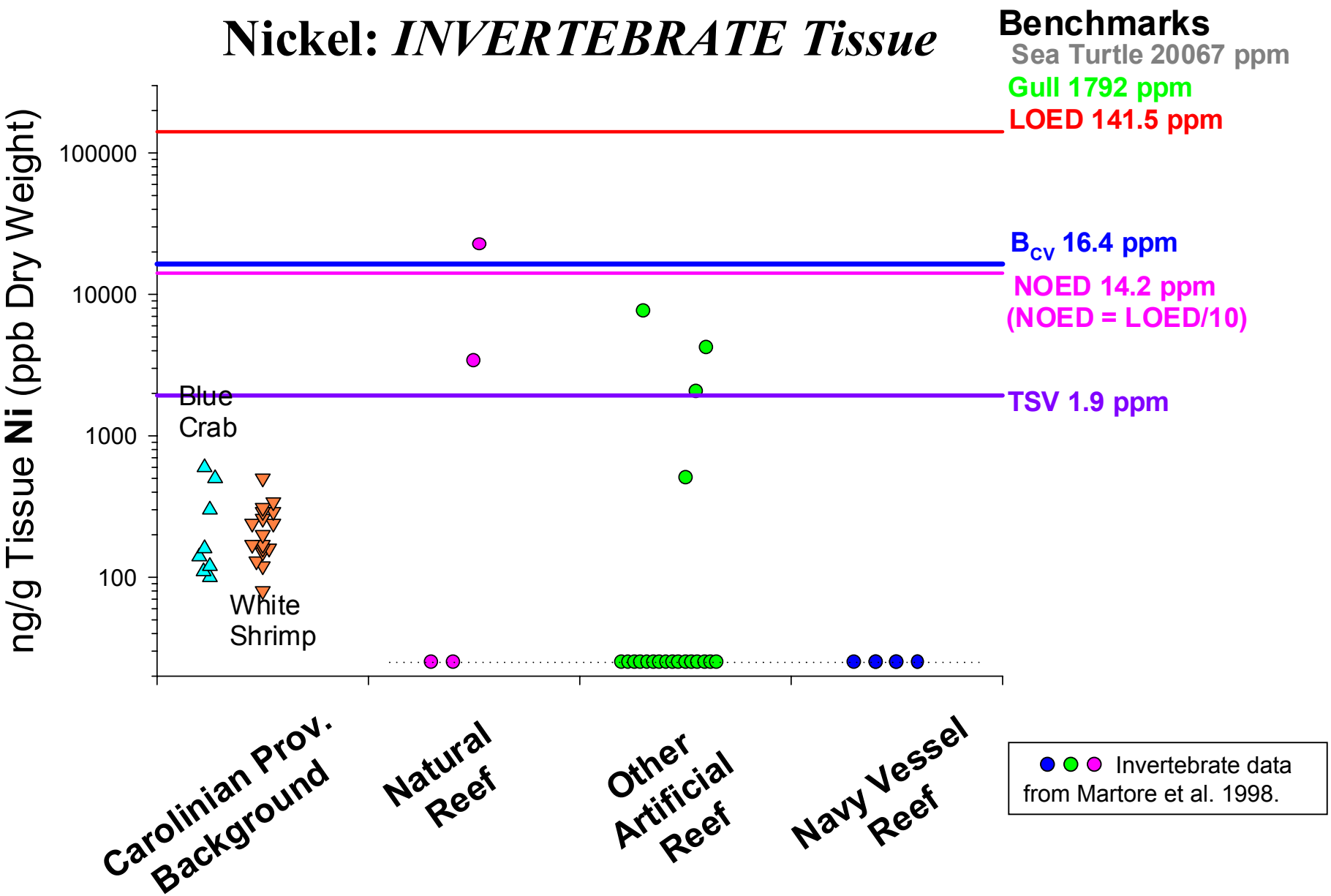


Figure 43. Graphical screening for Ni in invertebrate tissue residues. Invertebrate residue data are compared to data (blue crab and white shrimp) from EMAP (Carolinian Prov. Background, Hyland et al. 1998) and to ecological effect benchmarks for invertebrate tissue (see Table 3). Data from the SCDNR study that were reported below the detection limit (DL) were plotted as ½ the DL (DL/2).

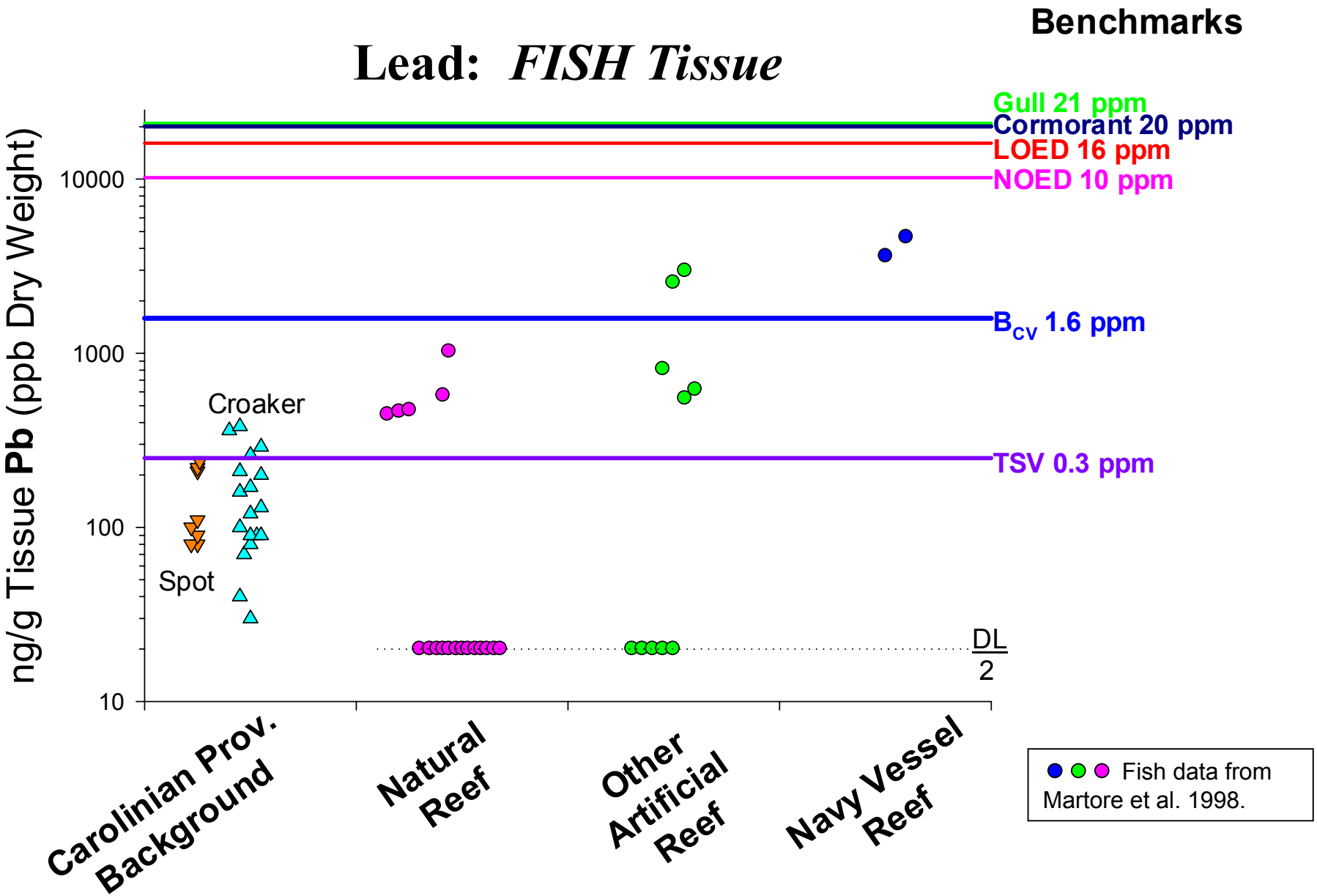


Figure 44. Graphical screening for Pb in fish tissue residues. Fish residue data are compared to fish data (spot and croaker) from EMAP (Carolinian Prov. Background, Hyland et al. 1998) and to ecological effect benchmarks for fish tissue (see Table 3). Data from the SCDNR study that were reported below the detection limit (DL) were plotted as ½ the DL (DL/2).

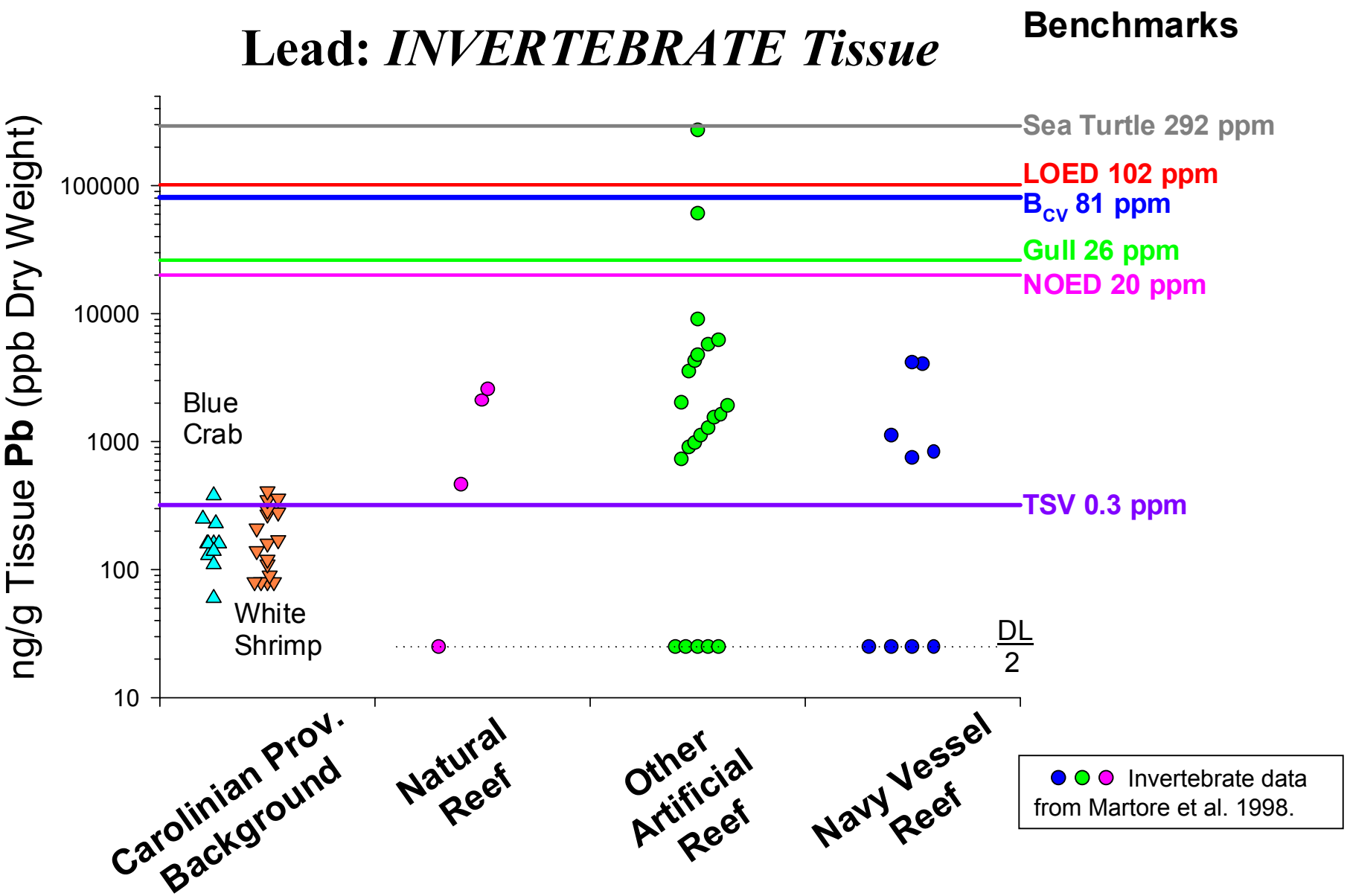
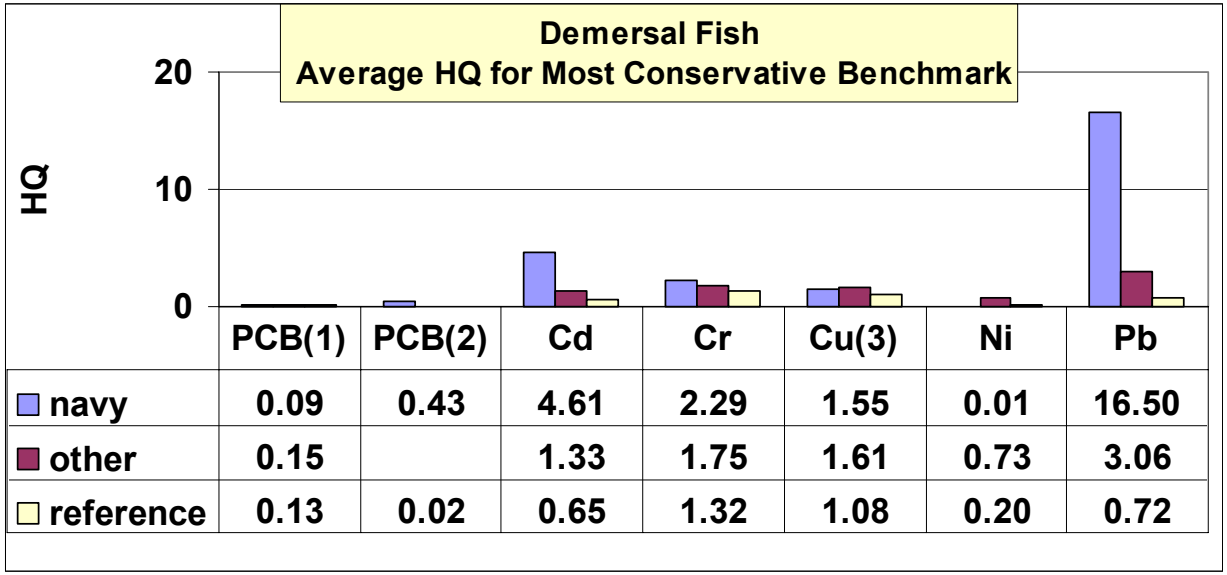


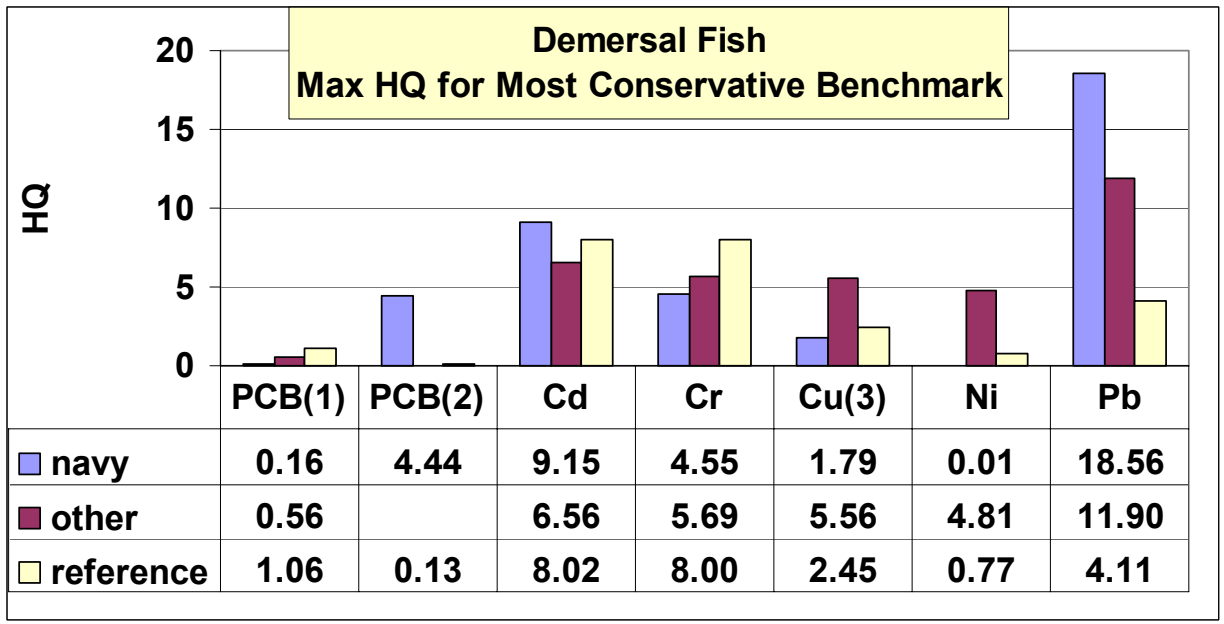
Figure 45. Graphical screening for Pb in invertebrate tissue residues. Invertebrate residue data are compared to data (blue crab and white shrimp) from EMAP (Carolinian Prov. Background, Hyland et al. 1998) and to ecological effect benchmarks for invertebrate tissue (see Table 3). Data from the SCDNR study that were reported below the detection limit (DL) were plotted as ½ the DL (DL/2).

A.



	PCB(1)	PCB(2)	Cd	Cr	Cu(3)	Ni	Pb
navy	0.09	0.43	4.61	2.29	1.55	0.01	16.50
other	0.15		1.33	1.75	1.61	0.73	3.06
reference	0.13	0.02	0.65	1.32	1.08	0.20	0.72

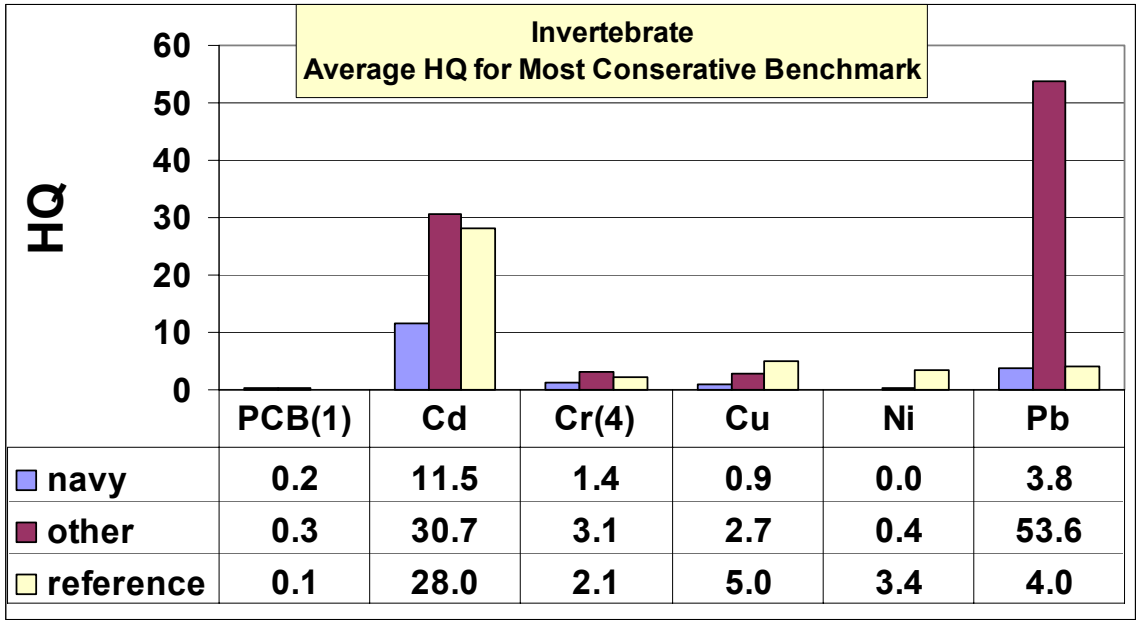
B.



	PCB(1)	PCB(2)	Cd	Cr	Cu(3)	Ni	Pb
navy	0.16	4.44	9.15	4.55	1.79	0.01	18.56
other	0.56		6.56	5.69	5.56	4.81	11.90
reference	1.06	0.13	8.02	8.00	2.45	0.77	4.11

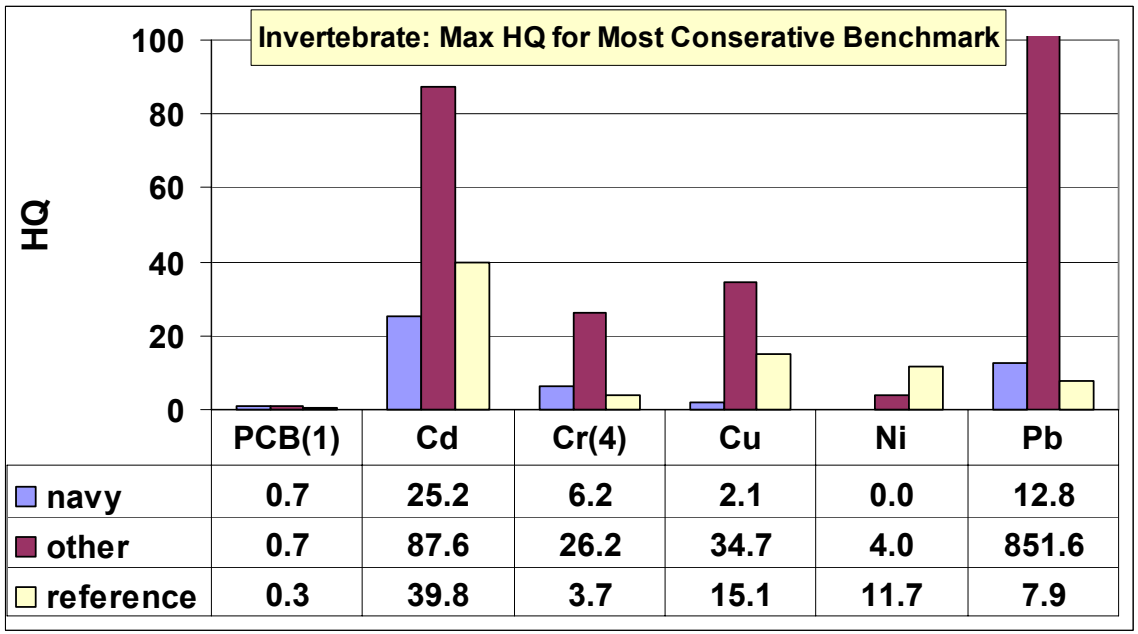
Figure 46. The average (A) and maximum (B) hazard quotients (HQ) obtained for the most conservative benchmark for Demersal Fish. Unless otherwise noted plots show the HQs for TSV and SCDNR data. PCB(1) = $D_{Dolphin}$ for SCDNR data; PCB(2) = $D_{Dolphin}$ for supplemental fish data; Cu(3) = NOED for SCDNR data.

A.



	PCB(1)	Cd	Cr(4)	Cu	Ni	Pb
navy	0.2	11.5	1.4	0.9	0.0	3.8
other	0.3	30.7	3.1	2.7	0.4	53.6
reference	0.1	28.0	2.1	5.0	3.4	4.0

B.



	PCB(1)	Cd	Cr(4)	Cu	Ni	Pb
navy	0.7	25.2	6.2	2.1	0.0	12.8
other	0.7	87.6	26.2	34.7	4.0	851.6
reference	0.3	39.8	3.7	15.1	11.7	7.9

Figure 47. The average (A) and maximum (B) hazard quotients (HQ) obtained for the most conservative benchmark for Invertebrates. Unless otherwise noted plots show the HQs for TSV and SCDNR data. PCB(1) = $D_{Dolphin}$ for SCDNR data; Cr(4) = NOED for SCDNR data.

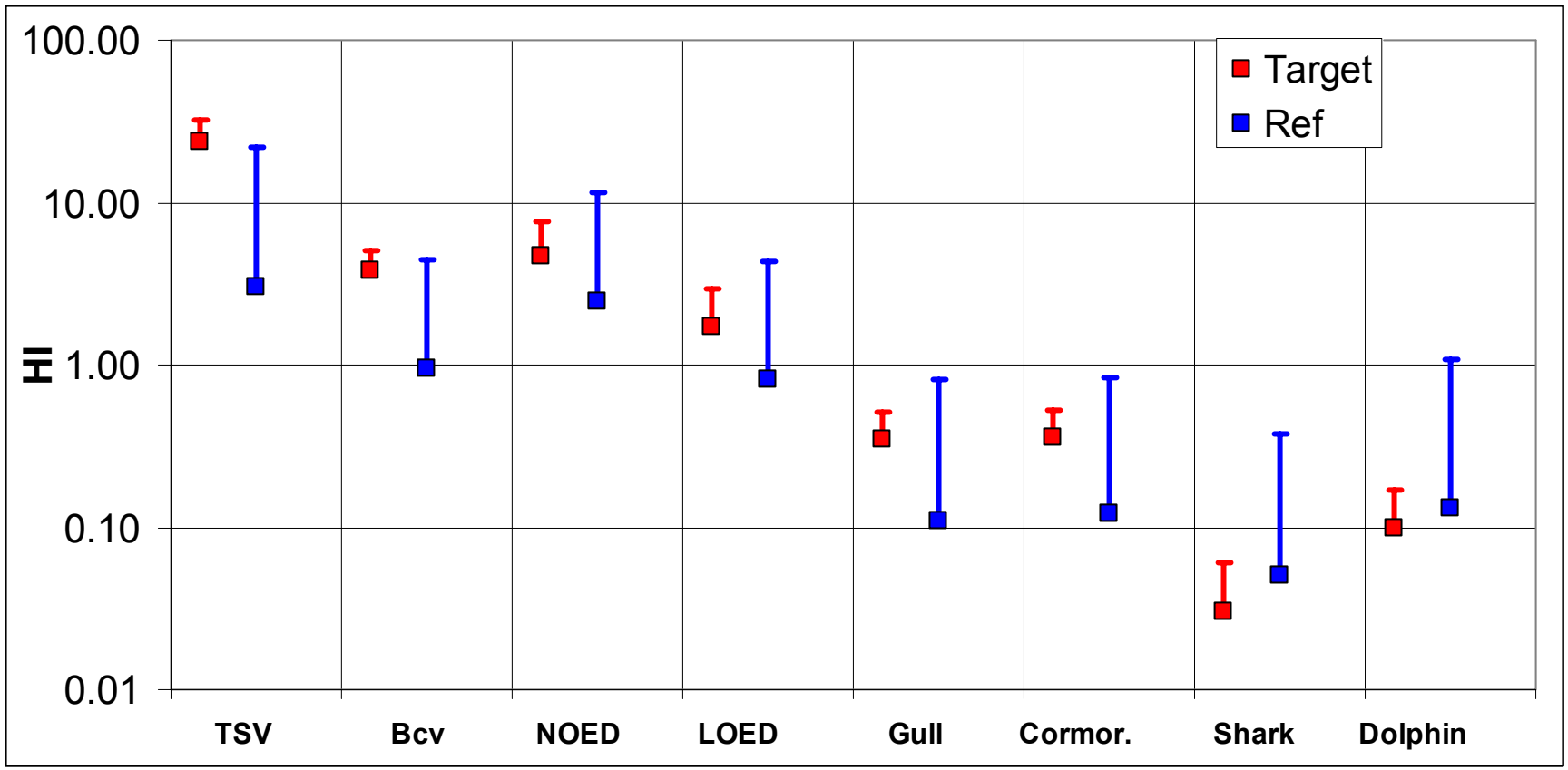


Figure 48. The range between the average (squares) and maximum hazard indices (HI) calculated for natural (Ref) and Navy vessel (Target) reefs based on fish tissue data from Martore et al. (1998).

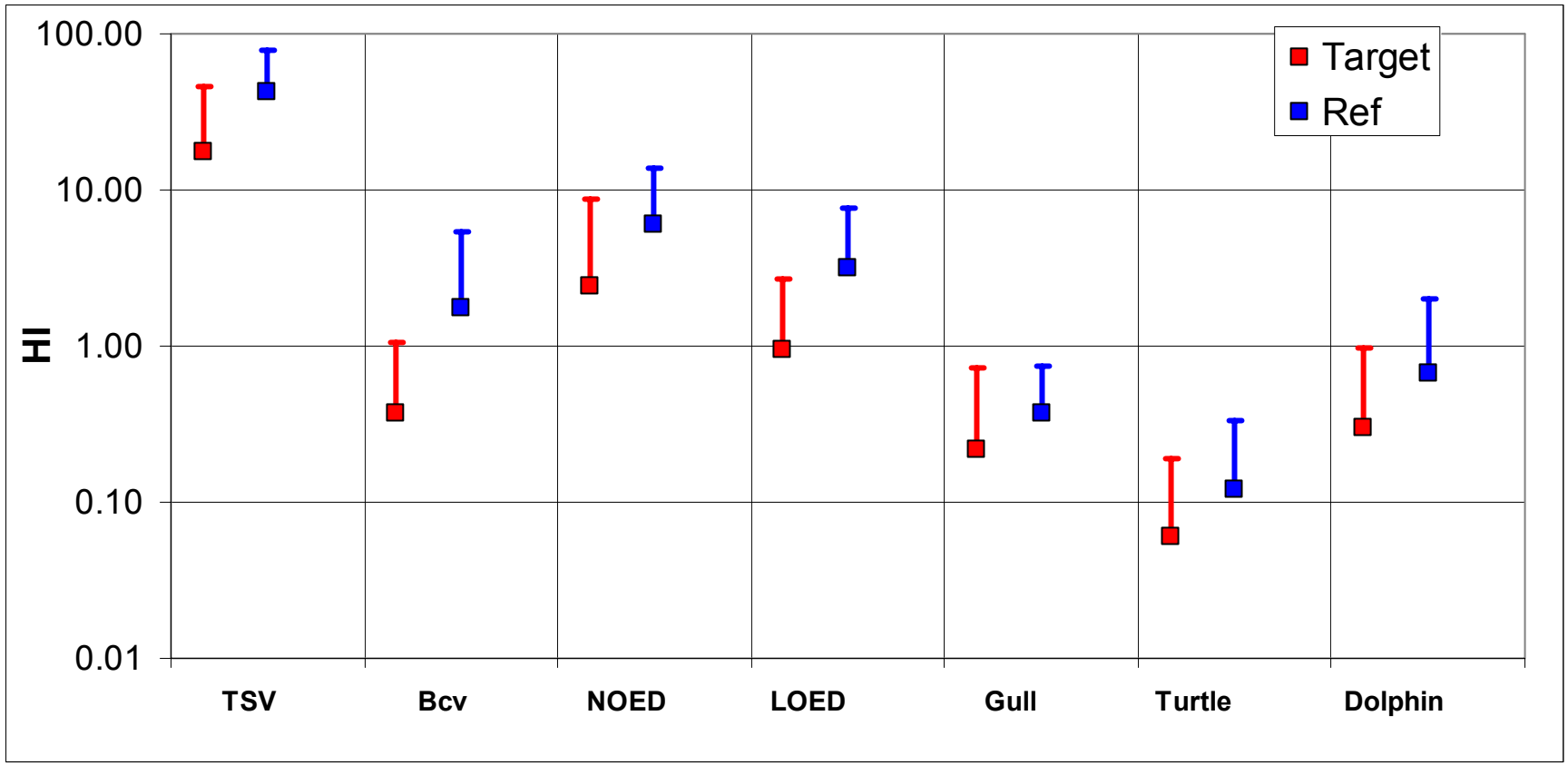


Figure 49. The range between the average (squares) and maximum hazard indices (HI) calculated for natural (Ref) and Navy vessel (Target) reefs based on invertebrate tissue data from Martore et al. (1998).

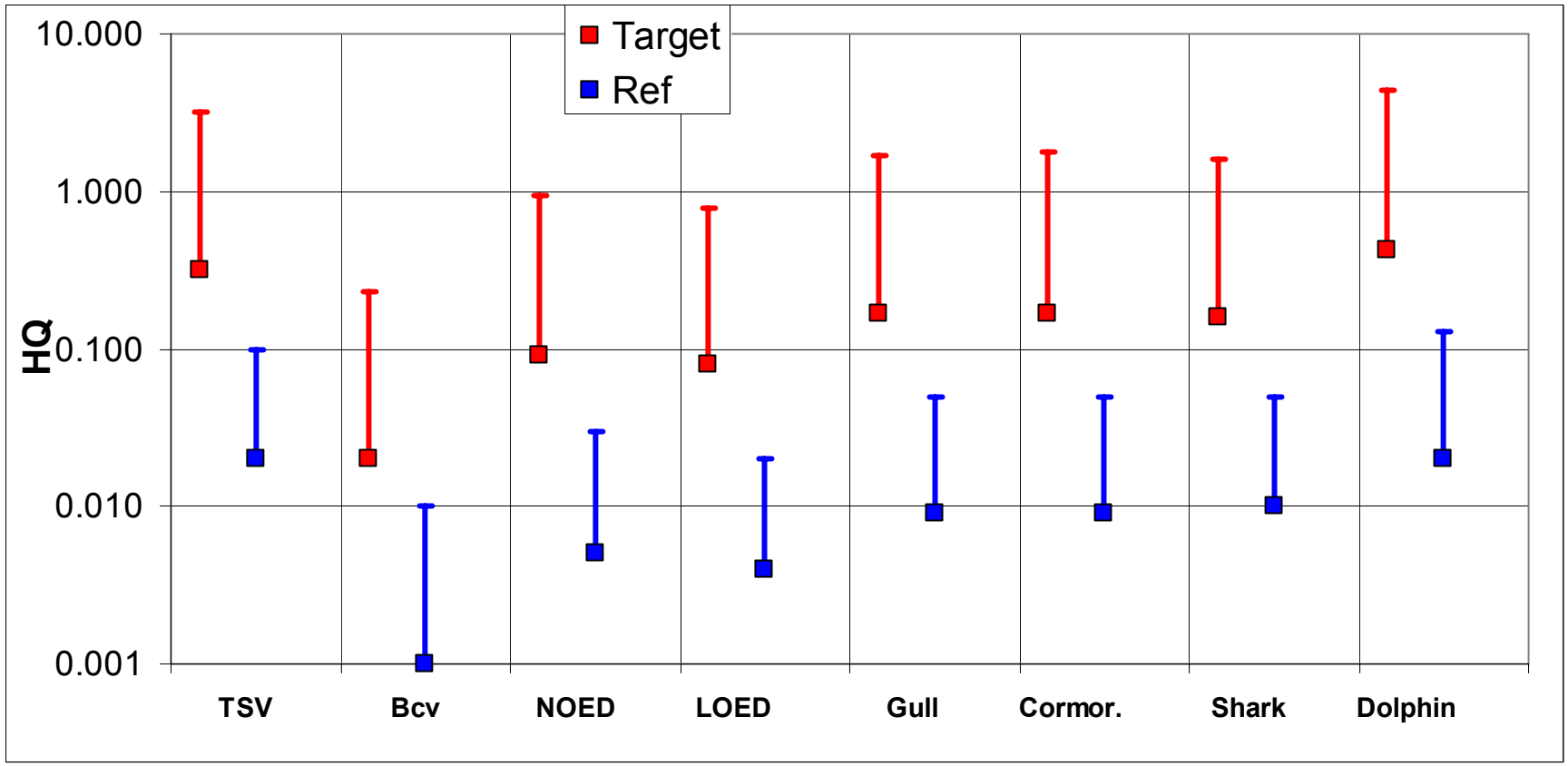


Figure 50. The range between the average (squares) and maximum hazard quotients (HQ) calculated for reference (Ref) and Navy vessel (Target) reefs based on supplemental fish tissue data.

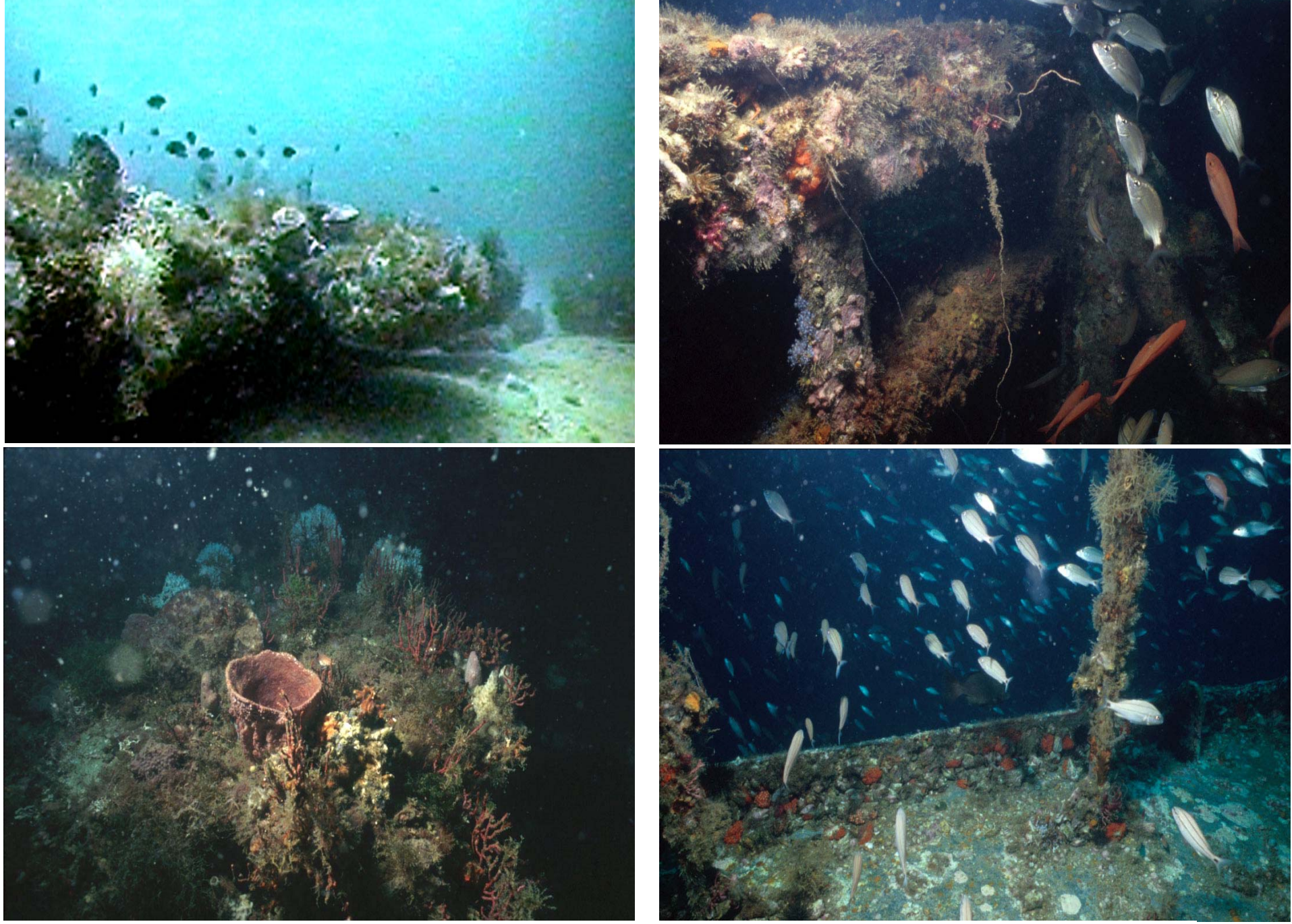


Figure 51. Differences between natural hard bottom reef (left photos) and the ex-Vermilion Reef (right photos).

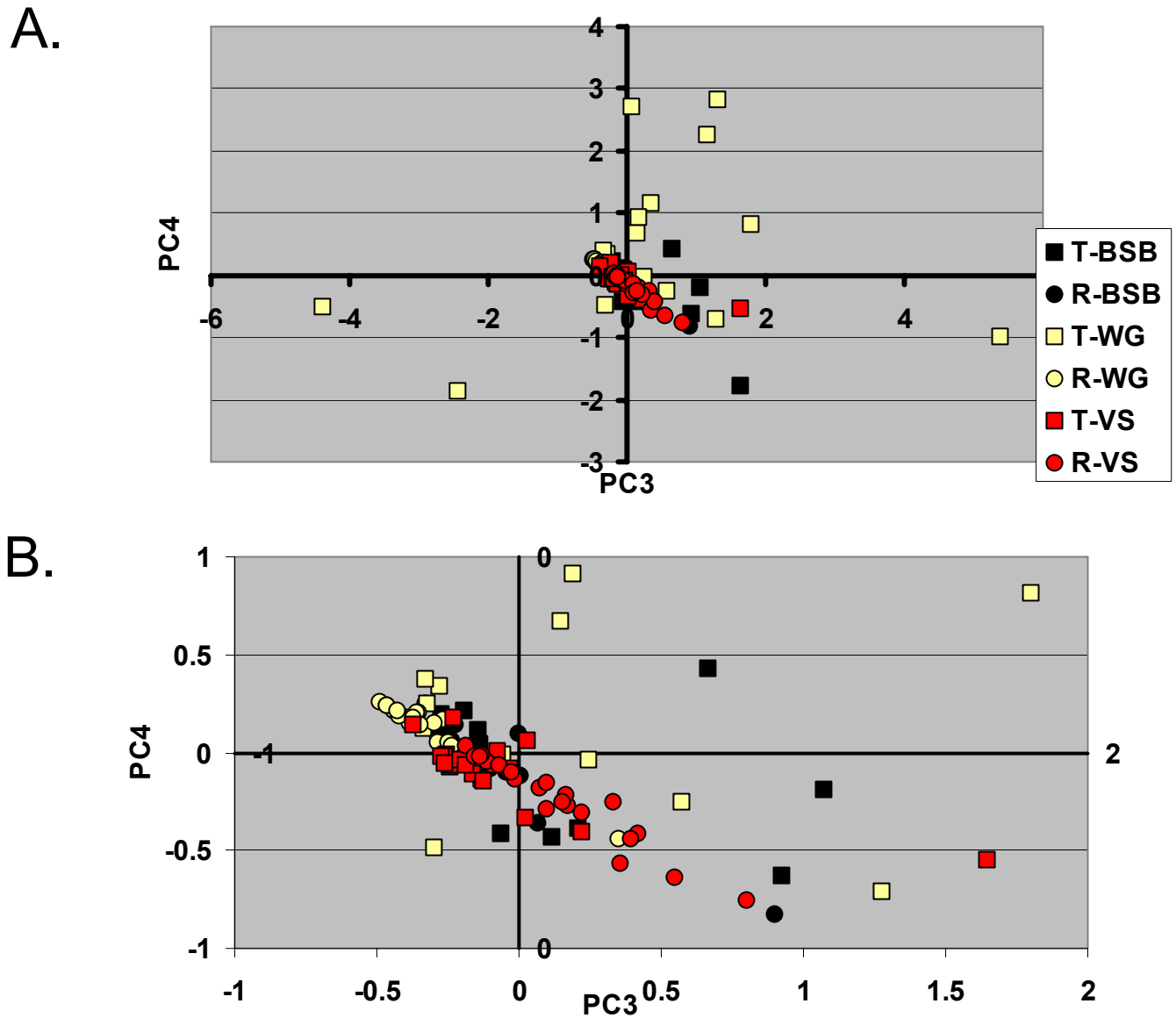


Figure 52. (A) Plot of principal component vector loading factors for PC3 vs PC4 showing the target (squares) and reference (circles) fish for black sea bass (BSB), white grunt (WG), and vermilion snapper (VS). (B) Expanded axis.

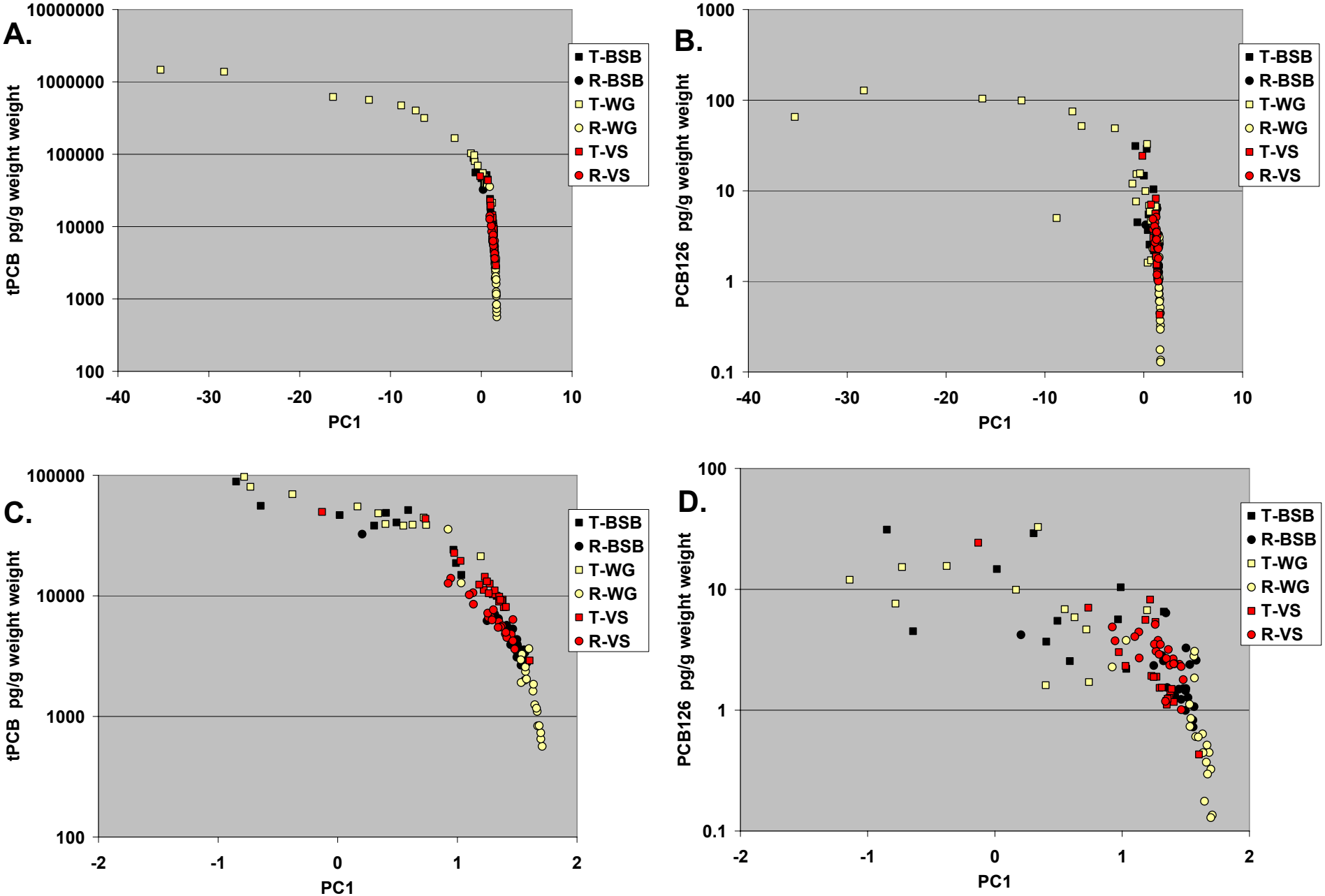


Figure 53. Plot of PC1 vs tPCB (A) and PCB126 (B) showing the target (squares) and reference (circles) fish for black sea bass (BSB), white grunt (WG), and vermilion snapper (VS). Expanded axis for tPCB (C) and PCB126 (D).

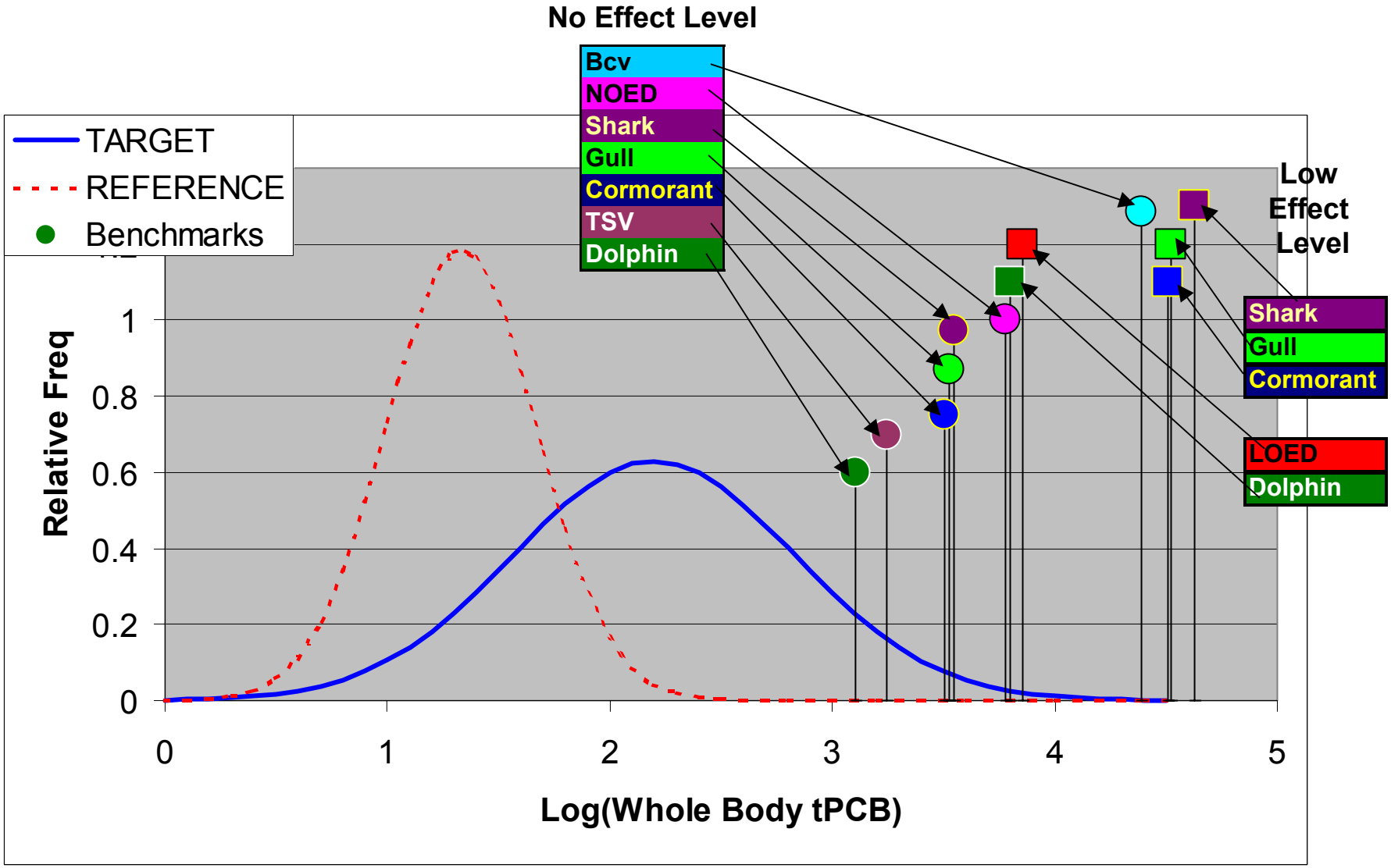
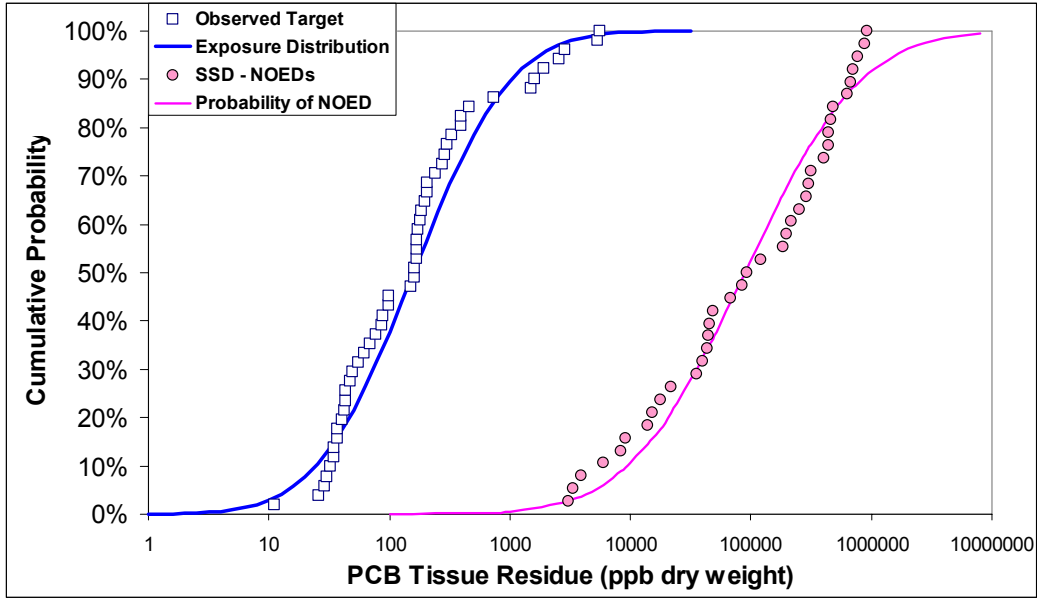


Figure 54. A graphical presentation of the probability of whole body tPCB residues measured in supplemental fish collected from the target and reference reefs to exceed benchmarks for no and low effects. The probability of exceeding a benchmark is shown by the area under the curve to the right of the benchmark.

A.



B.

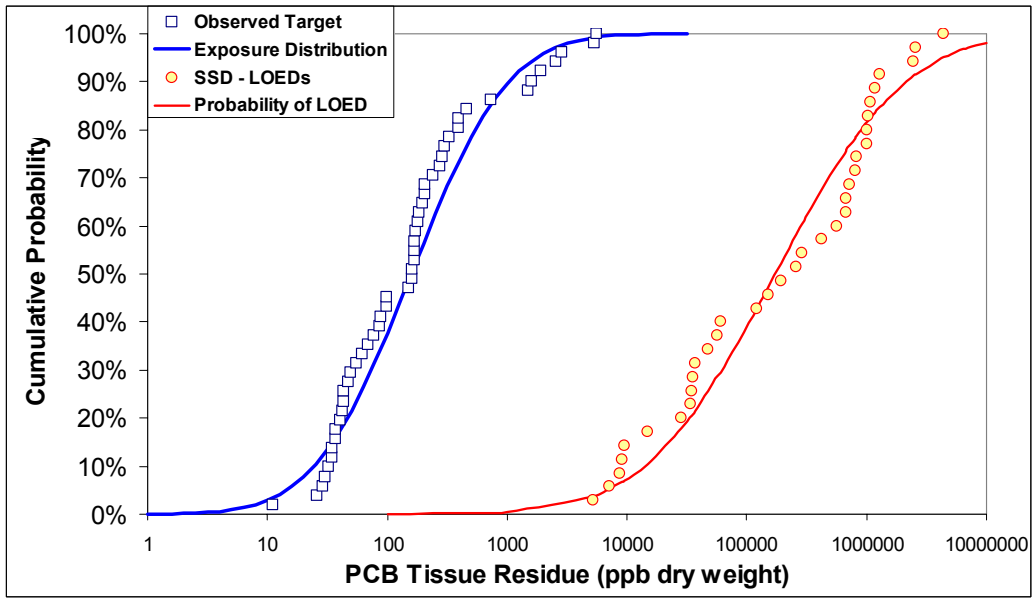


Figure 55. The cumulative probability of exposure (blue curve) based on data from the target reef (squares) compared to the species sensitivity distribution for the NOED (A) and LOED (B) effects of PCB residues in fish species (circles).

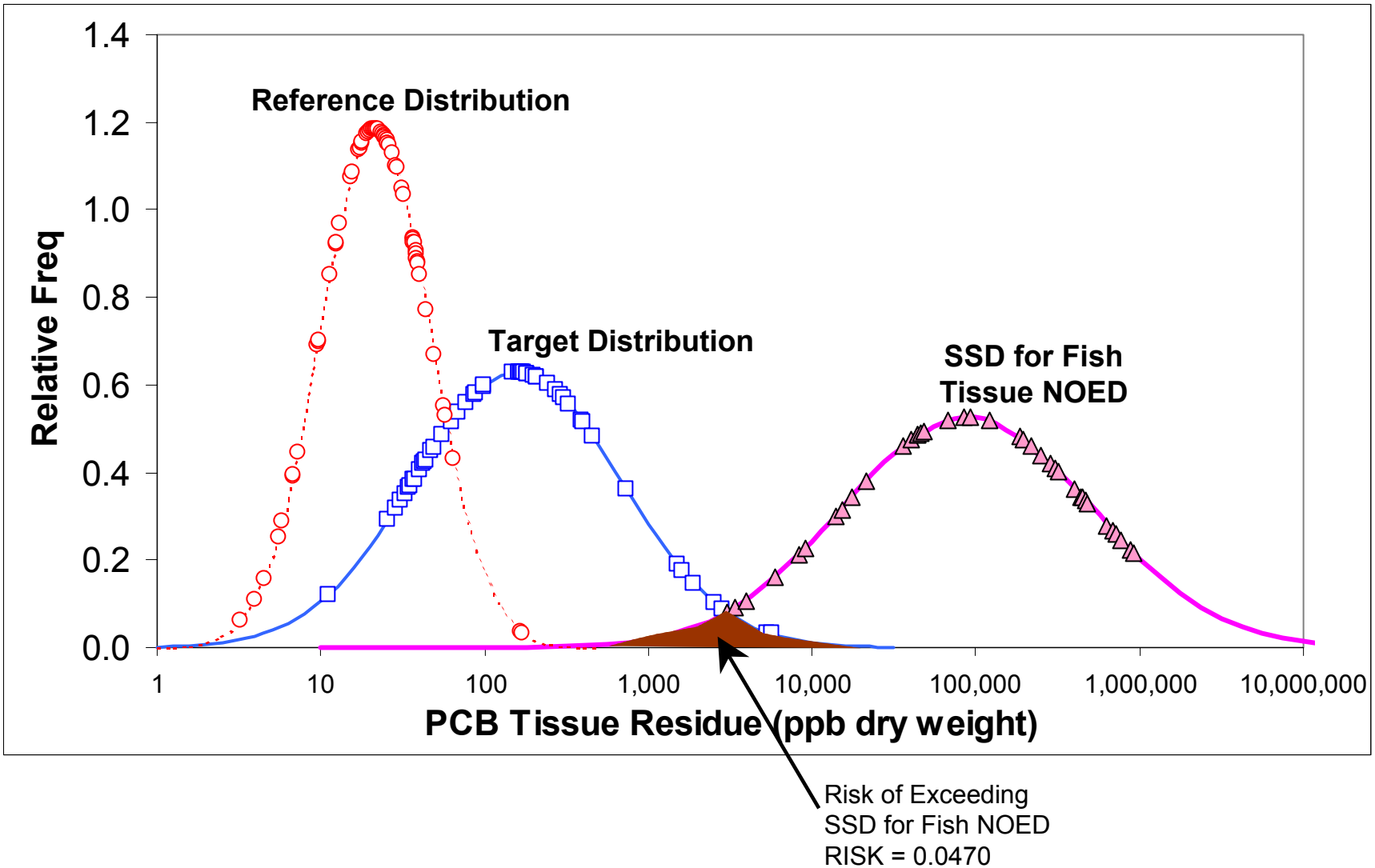


Figure 56. The probability of exceeding the SSD for for fish tissue NOEDs (triangles) given the probability of exposure for fish from the target (squares) and reference (circles) reefs.

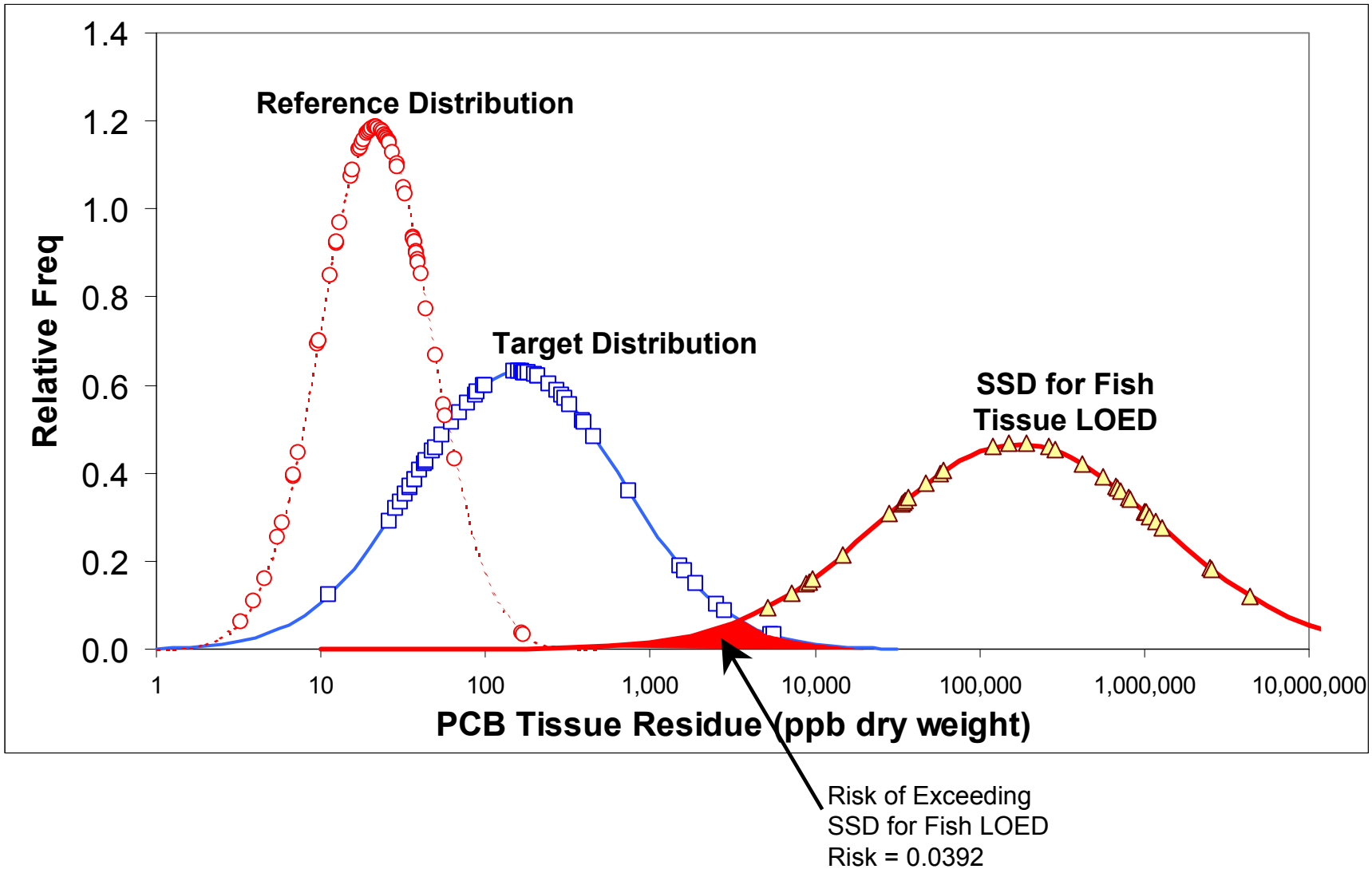


Figure 57. The probability of exceeding the SSD for for fish tissue LOEDs (triangles) given the probability of exposure for fish from the target (squares) and reference (circles) reefs.

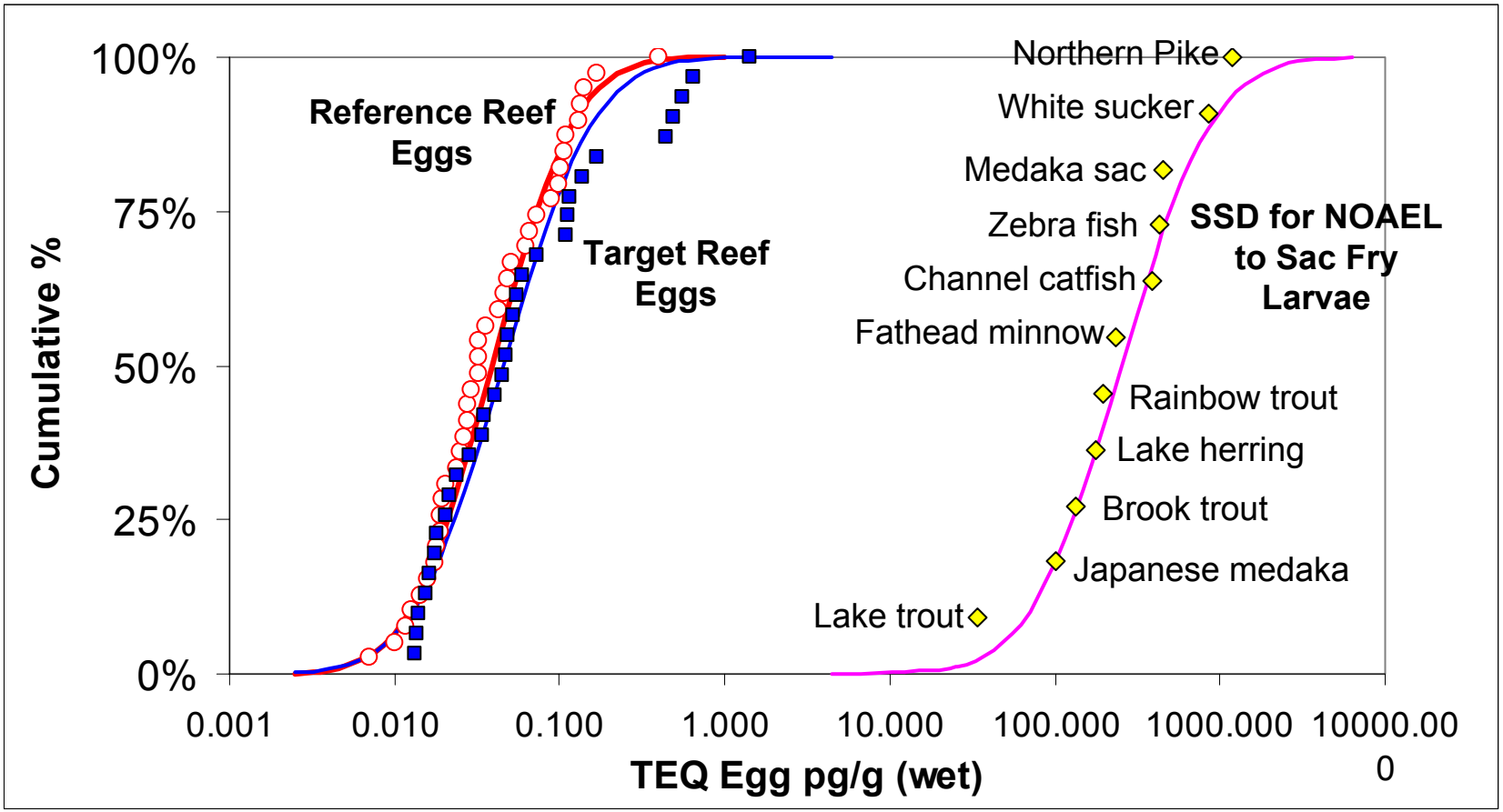


Figure 58. The cumulative probability of TEQ exposure in eggs for the reference (circles) and target (squares) reefs and the SSD for TEQ NOED to sac-fry larvae (diamonds).

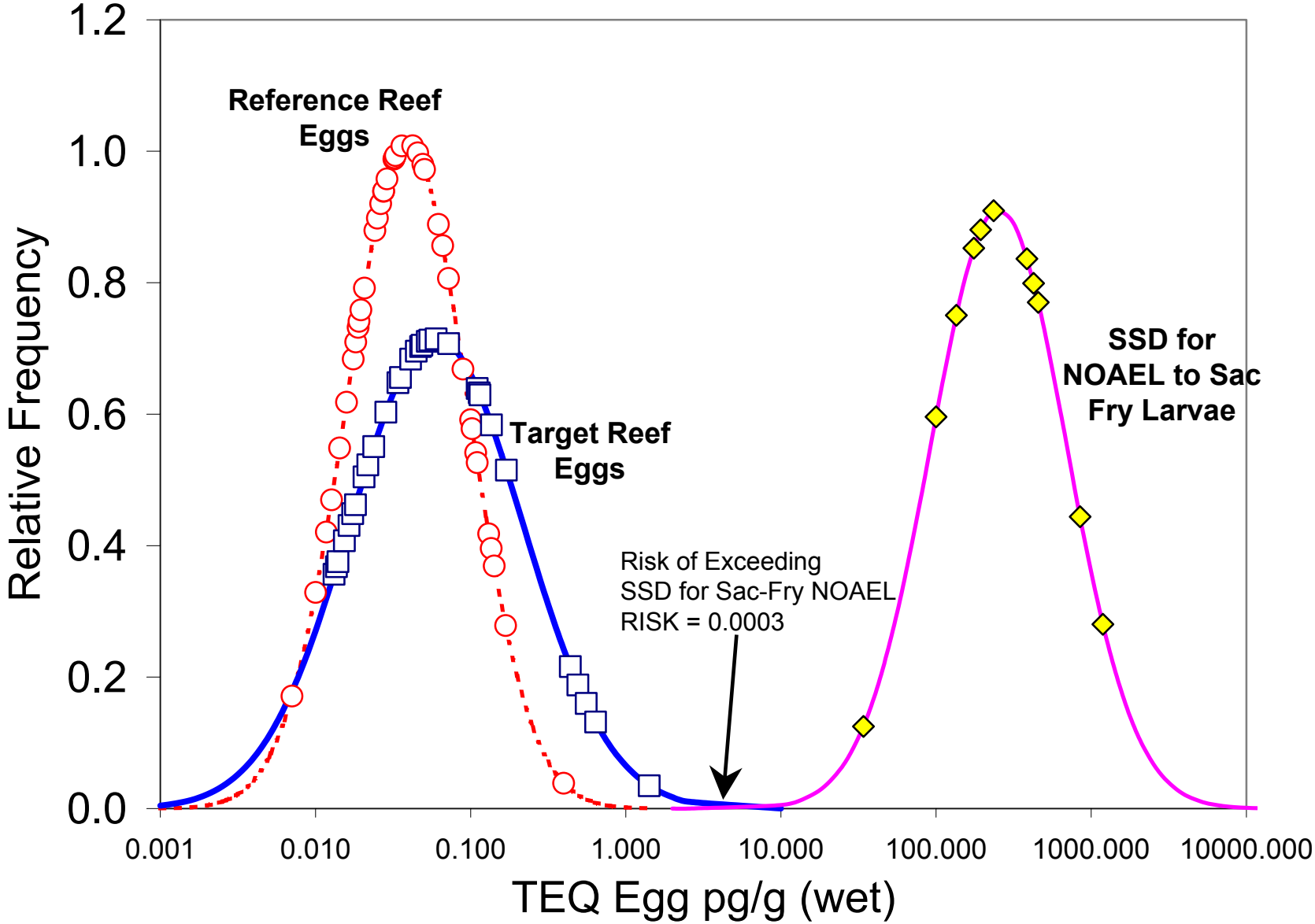


Figure 59. The probability of exceeding a SSD NOAEL for sac-fry mortality (diamonds) given the probability of exposure to eggs from the reference (circles) and target (squares) reef.

Appendix 1. Response to Comments

A1.A. Response to comment on An Ecorisk Screening-Level Assessment for Using Former Navy Vessels to Construct Artificial Reefs on the Continental Shelf of the United States (SCREENEX-ECO) - Draft Work Plan of 23 March 2000

Response to Comments on An Ecorisk Screening-Level Assessment for Using Former Navy Vessels to Construct Artificial Reefs on the Continental Shelf of the United States (SCREENEX-ECO) - Draft Work Plan of 23 March 2000

Comments from Laura Casey, USEPA, Fibers and Organics Branch Letter of May 15, 2000

#	Comment	Response
1	1. Section 1.2, Background - The citation for the disposal of PCB Bulk Product waste is incorrect. The cite should be - 63 FR 35384, June 29, 1998. The citation used here is for the Technical Corrections to the PCB Disposal Amendments of June 29, 1998.	Sentence has been revised to read: "EPA has the authority to approve risk-based disposal of PCB bulk product waste (63 FR 35384, June 29, 1998), if a finding of no unreasonable risk of injury to human health and the environment can be made."
2	2. Section 1.3, Problem Formulation and section 4.2, Study Area - Please go into more detail on what types of substrates would make up regional background conditions (Background). Is "background" assumed to be soft substrates such as sandy areas or sand bars?	Sandy, non-hard bottom is the predominant bottom type off the coast of South Carolina. Other bottom types are hard bottom (reefs) with low relief (< 0.5m), medium relief (0.5 - 0.2m), or high relief (>2m) and artificial reefs (Van Dolah et al. 1994). Many species of fish tend to congregate in the hard bottom areas, but they are also highly mobile and can move around within and out of the study area. In SCREENEX-ECO "background" refers to areas that are not directly related to reef habitat, and can be most likely characterized as sandy soft bottom substrate. The following footnote has been added to the text: "Background" refers to areas that are not directly related to reef habitat. Background areas can be most likely characterized as sandy, soft bottom substrate.
3	3. Page 3-2, Discussion of the PCB Disposal Amendments – The ability to do risk based disposal approvals for bulk product waste (761.62(c)) was in the original published rule of June 29, 1998. Section 761.62(c) was not added in 1999. The citation in this paragraph refers to the Technical Corrections not the PCB Disposal Amendments.	The sentence has been revised to read: "The ability to perform risk based disposal approvals for bulk product waste (40 CFR 761.62(c)) was authorized by the rule published in June 29, 1998 (63 FR 35384)".
	Comments from Linda Phillips and Ann Cyrus, Versar Inc. received May 15, 2000:	
4	p.2-1. Section 2: The current EPA guidance (1998) is cited here. It may be helpful to also state that the screening ecological risk assessment will be conducted in accordance with the current EPA guidance and any other applicable guidance (e.g., Department of Defense, Navy, regional EPA guidance, etc.) for this project.	The following text has been added to Section 2, paragraph 3 "Screening level risk assessments are recommended as an important step in developing a defensible approach for evaluating ecological risks (Wentsel et al. 1994, Wentsel et al. 1996, U.S. EPA 1998c, U.S. EPA 1998d, U.S. Navy 1999, U.S. EPA Region IV 2000). Based on the outcome of the screening level assessment, the risk assessment approach can be refined and focused on critical aspects of risk."
5	p.4-1. Section 4.1. The first paragraph mentions studies of four sunken military vessels, but the next paragraph mentions only two – the ex-	All the data reported in the SCDNR will be evaluated in SCREENEX. The text has been revised to clairify:

	Vermilion and the ex-Betsy Ross. What are the other two vessels and why are they not being evaluated.	"Although data are limited, field studies of four artificial reefs composed of sunken military vessels (two reefs are composed of ex-Navy vessels, one reef is an ex-Army liquid tanker, and the other reef is composed of an ex-Army landing craft and an ex-Army tug boat)…"
6	p.4-1. Section 4.1, third paragraph. Mentions that the ex-AGERHOLM will be used to estimate potential sediment contamination from a sunken vessel. Because the environment of the ex-AGERHOLM (at 2,700 ft.depth) is likely to be very different from the environment of the proposed project, the expected differences in physical, chemical and biological conditions should be discussed relative to the fate and transport of the contaminants of potential concern (COPCs). For example, differences in the reduction-oxidation potential at the ex-AGERHOLM site and the proposed project site may have a significant effect on the bioavailability of the COPCs at the different locations. Also, the text states that chemical concentrations were measured in the inner ring. What is the size of the inner ring?	A thorough description of the differences in the geochemical environment around the ex-AGERHOLM and the study area and a detailed discussion on the uncertainties associated with the comparison will be provided in the SCREENEX report. In addition, the Marine Environmental Support Office has recently received preliminary data generated by the Ocean Disposal Division of Environment Canada, on sampling and analysis of sediments and biota collected in the vicinity of artificial reef created from the sinking of a former Canadian warship (ex-Saskatchewan) at a depth of 100 ft in coastal waters off the coast of Vancouver Island, British Columbia (Lee 2000). These data will also be reviewed and evaluated as another line of evidence of potential release from sunken vessels in the SCREENEX report. The inner ring was defined as a set of sample stations that were located within 3 m of the hull of the ex-AGERHOLM (the positioning error was ±3 m). The following clarifications were made to the SCREENEX-ECO workplan: "In addition, a study is currently being conducted by the by the Ocean Disposal Division of Environment Canada, to evaluate PCB contamination levels in the vicinity of an artificial reef created from the sinking of a former Canadian warship (ex-Saskatchewan) at a depth of 100 ft in coastal waters off the coast of Vancouver Island, British Columbia (Lee 2000). If available, these data will also be reviewed and evaluated as another line of evidence of potential release from sunken vessels in the SCREENEX report. "Data from studies of other sunken vessels reported in the literature will also be reviewed to identify pertinent data and evaluate their applicability to SCREENEX-ECO. Although most the literature studies reported in the literature were not specifically conducted to evaluate PCB levels and potential releases from former Navy vessels, the data from these studies can be evaluated qualitatively and used to develop a weight of evidence of potential risk from contaminant releases from sunken ships. A thorough description of the differences in the geochemical environment around the ex-AGERHOLM, the ex-Saskatchewan, and other study areas reported in the literature and the SCREENEX study area and a detailed discussion on the uncertainties associated with the comparisons will be provided in the SCREENEX report."
7	p.4-3. Section 4.3, general. Mentions that contaminants can enter the system from releases	The route of contaminant release from coastal waters will be evaluated in SCREENEX-ECO, that is why data from reference reefs and background

	from sunken vessels or inputs from coastal waters. It should be noted in the text that the scope of the assessment is, however, limited to the analysis of contaminants from sunken vessels. Also, Figure 2 should be modified so that coastal runoff as a primary source is removed since this exposure pathway is not evaluated in the ecological risk assessment.	areas are needed for the analysis. Because the sunken vessels are not isolated from coastal contamination sources, contamination levels present at the sunken ship reef could be from other sources besides the sunken vessel itself. The reference and background data can be used, to the extent possible, to evaluate whether contamination levels present at the site are higher than what would be expected if the sunken vessels were not present. The uncertainty in the analysis will be discussed in the report. The following clarification has been added to the SCREENEX workplan: "Because the sunken vessels are not isolated from coastal contamination sources, contamination levels present at the sunken ship reef could be from other sources besides the sunken vessel itself."
8	p.4-4. Section 4.5, general. Although the different groups of marine organisms were described fairly well it is not clear what the receptor species and the assessment endpoints were, this should be included in the text.	The following information has been added to Section 4.5 For the ecological system under consideration for this study, primary exposure can occur to the reef community, which is composed of demersal fishes, epibenthic and benthic invertebrates, and primary producers, and indirect exposure through bioaccumulation in the food chain (food chain receptors) can occur to avian omnivores, avian piscivores, and marine mammals.
9	p.4-4. Section 4.5; first paragraph, last sentence. Although it is implied here, it may be helpful to add that receptor species evaluated here are part of the food web and as a result help to measure the potential for bioaccumulation of the COPCs.	The follow phase has been added to the last sentence: "…that it is an important component of the food web, …"
10	p.4-5. Section 4.5.4, 4.5.5 and 4.5.6. The higher trophic level species included in the analysis (avian omnivore, avian piscivore and marine mammals) are likely to have very large home ranges compared to the proposed study area. As a result there would be a lot of uncertainty regarding the levels of contamination that these species would be exposed to directly and indirectly at the artificial reef. Are there any other ecologically or commercially important species, such as higher trophic level fish (especially those that may have relatively small home range areas) that could also be included in the analysis?	The following sentence will be added to the section: "Carnivorous fish that are known to be long time residents of the reef will be evaluated to assess ecological effects of contamination. Example receptors species for demersal fishes include such fish as back sea bass (Centropristis striatia), gag grouper (Mycteroperca microlepis), and leopard toadfish (Opsanus pardus)"
11	p.5-1. Section 5, general. There is a good description here of the different benchmark values and background sources to be used in the screening ecological assessment. However, it may help to define the actual screening process more clearly.	The following sentence will be added to step 4 of the screening procedure: "Chemicals that exceed the most conservative benchmarks of each media (sediment, water, and biota) will be retained as contaminants of concern (COC) for evaluation in the risk assessment."

12	For example, in Section 5.1.2 the sediment benchmark values are described. Then, in Section 5.3, third paragraph, it states that sediment data from the inner ring of the ex-AGERHOLM will be compared to the outer reference ring and to sediment benchmarks in Table 2. How will the sediment data be compared? If contaminants detected in inner ring sediments exceed the ER-L or ER-M values would these contaminants then be retained for further analysis? Similarly, if certain contaminants detected in inner ring sediments were less than ER-L or ER-M values would these contaminants then be screened out? Would the inner-ring sediments also be compared to the background (outer ring) sediments in order to screen out contaminants?	For an example of how sediment data from the inner ring of the ex-AGERHOLM will be compared to the outer reference ring and to sediment benchmarks please see Figure 6 in the Draft SCREENEX-ECO Workplan. The chemicals that exceed both the ERL and the outer ring reference concentration will be retained as COCs for the risk assessment. Chemicals that did not exceed the screening level and reference concentration will not be retained. The following clairification has been added to the SCREENEX-ECO Workplan. "The chemicals that exceed both the ERL and the outer ring reference concentration will be retained as COCs for the risk assessment."
13	This process needs to be more clearly defined for each media evaluated. And in cases where there is more than one benchmark available for a media, like the B_{cv}, TSV, NOED/LOED and D_{bd} values for fish tissue, the single value that is actually used for screening needs to be identified. The selected value is generally the most conservative of the benchmarks for the screening assessment.	The following text has been added to Section 5.3 "The chemicals that exceed the most conservative benchmark for each exposure pathway in the food chain will be retained as COCs for the risk assessment."
14	p.5-1, Section 5.1.1. The text states that water exposure will be evaluated by comparing tissue residues to bioaccumulation critical values. Because B_{cv} values may vary based on the mass fraction of dry to wet tissue, on which B_{cv} would the estimated water concentration be based? Will the estimated water concentration(s) for each contaminant then be compared to the saltwater ambient water quality criteria in Table 2? If water concentrations are to be estimated from B_{cv} values, the uncertainties inherent in this process should be defined.	The estimated water concentration is set to salt water criteria continuous concentration (ambient chronic) and the screening level concentration is calculated for both fish and shellfish. The difference in the mass fraction of dry weight between fish and shellfish results in a different B_{CV} for fish and shellfish. The uncertainties associated with this assumption will be discussed in the SCREENEX-ECO report. The following footnotes have been added to Table 3. "1 Assumes that shellfish contain 80% moisture resulting in a dry : wet ratio of 0.2." "2 Assumes that fish contain 75% moisture resulting in a dry : wet ratio of 0.25."
15	p.5-2, Section 5.1.3.1. The Bcv would be the tissue concentration if the water exposure levels were at the chronic or lowest available benchmark. The units for the input parameters for the Bcv equation should be more clearly presented. It appears that a units conversion factor is needed. Also, what is meant by "5 for fish (80% moisture)" and "8 for shellfish and other invertebrates (87.5% moisture)." If 80% and 87.5% are the respective moisture contents for fish and shellfish, shouldn't these factors be	The value for the mass fraction of dry to wet weight was mislabed: the ratio of dry : wet is 0.125 (dw) and the ratio of wet : dry is 8 (dw^{-1}) for fish (87% moisture) and the ratio of dry : wet is 0.2 (dw) and the ratio of wet : dry is 5 (dw^{-1}) for shellfish (80% moisture). The BCV equation with the units identified and the correct values for dw has been provided in section 5.1.3.1. $B_{CV} = W_B \frac{\mu g}{L} \times BCF \frac{L}{kg(wet)} \times \frac{g\ wet}{dw\ g\ dry} = \frac{\mu g}{g}$ (dry weight) dw = 0.25 for fish (75% moisture) dw = 0.20 for shellfish and other invertebrates (80% moisture)

	0.2 and 0.125 if they are used in the denominator of the equation?	
16	Please explain the lipid normalizing factor of 0.395. Table 4 states that the BCF was normalized to 3% lipid.	The following footnote has been added to Section 3.1.4.1 "The BCF for PCBs (log BCF = (0.85 x logKow) – 0.70) was determined from experiments conducted with using fat head minnows (*Pimpephales promelas*) that had an average lipid content of 7.6 % (US EPA 1980, URS 1996). Freshwater and marine organisms that are commonly consumed in the US have a weighted average of about 3% lipid content (US EPA 1980, URS 1996). Therefore to make the BCF for PCB more applicable to water quality criteria the US EPA adjusted the BCF value by 3%/7.6% = 0.395 (URS 1996)."
17	p.5-3, Section 5.1.3.2. The need for and use of a lipid adjustment is not clear. Again the equation appears to lack a unit conversion factor. Please explain the difference between Bcv's and TSVs and the rationale for calculating both values. It appears that the only difference between the two values is that TSVs use the freshwater chronic aquatic life criteria value and a lower BCF than the Bcv, and the Bcv's use saltwater criteria values and a higher BCF. The rationale for this is not clear.	Please see the explanation for the lipid adjustment in the response provided for comment 16. The TSVs are more conservative than the BCVs for some chemicals because the freshwater criteria was more conservative than the criteria continuous concentration CCC currently proposed for salt water. The TSVs were calculated for use as conservative screening criteria in ecological risk assessments at Navy sites (URS 1996) and the B_{CV}'s were calculated using more recent screening criteria (Buchman 1999). Both are provided for comparison purposes and to include the most conservative benchmarks available.
18	p.5-3. Section 5.1.3.4, general. The use of food chain benchmarks for screening purposes may not be sufficiently conservative. The development of dietary benchmarks for the omnivorous black duck appears to be based solely on ingestion of prey. However, direct ingestion of surface water and sediment may also occur which would increase the black duck's total intake of contaminants. As a result, the duck may be adversely affected at levels that are less than the estimated dietary benchmarks.	Because birds and mammals do not have gills, it is assumed that exposure from incidental demurral contact to birds and mammals is negligible. Note that incidental consumption of sediment could be included in the model, but was not, because it is assumed that the hard bottom reef sites would not result in appreciable consumption of sediment during feeding.
19	p.5-3. Section 5.1.3.4, last paragraph. The wording of the first three sentences is not clear. The first sentence is fragmented. Also, if no observed adverse effect levels (NOAELs) are to be used as Toxicity Reference Values (TRVs), then the description of the TRV should be reworded to "the TRV represents a chemical concentration below which significant effects to the receptor are not anticipated."	The paragraph has been revised as follows: "The food chain benchmark was set to correspond to the dose that is equivalent to the no observed adverse effect level (NOAEL) for the receptor species (avian omnivores, avian piscivores, and marine mammals). Toxicity Reference Values (TRVs) can be used to determine potential adverse exposure to predators. When the NOEAL is used to calculate the TRV, the TRV represents a chemical concentration below which significant effects to the receptor are not anticipated."
20	p.5-4, Section 5.1.3.4. It is unclear why a surface water benchmark value (B) would need to be calculated if there are no surface water data	The calculation of surface water benchmarks based on TRVs is not needed and has been deleted. The dietary benchmarks for selected predators (receptor species) were developed to evaluate food chain

	available for comparison to these benchmarks. It would be more useful to simply calculate the prey benchmark concentration using the effect level of the predator species and the dietary uptake factor, and then comparing the prey benchmark concentration to the measured tissue concentrations.	exposure. The text has been revised to clearly indicated TRV-based benchmarks will be developed for black ducks, osprey, and dolphins.
21	p.5-5, Section 5.2. Please explain the equation for calculating tPCB. What do the constants 2.19 represent and why is this value multiplied by and added to the sum of PCBs.	The following footnote has been added to Section 5.2: "[1] The equation for total PCB (tPCB = 2.19sumPCB + 2.19) was obtained by NOAA's Status and Trends Program from a regression of empirical data from samples that were analyzed for both individual congeners (sumPCB) and total aroclors (tPCB) (NOAA 1991)."
22	p.5-6, Section 5.3 and Figure 5. The terms used for the benchmark doses should be the same as those used in the previous discussion to avoid confusion.	Bioacummulation critical values (B_{CV}), tissue screening value (TSV), critical body residues corresponding to the no observed effect dose (NOED) and the lowest observed effect dose (LOED) for the receptor species, and the dietary consumption of tissue by black ducks (D_{BD}), osprey (D_O), black sea bass (D_{SB}) and dolphins (D_D) will be used in the text, tables and figures.
23	p.10-3, Table 2. The acronyms used for the PAHs should be defined. "TSC" in the title should read "TSV.	The table heading was corrected and the chemical names have been defined
24	p.10-4, Table 3. Footnote "a" is missing	"a" has been deleted, no footnote is needed.
25	p.10-5, Table 4. Shouldn't the units for BCF be reported as L/kg?	Yes table has been corrected.
26	p.10-6, Table 5. The meaning of footnote "a" is unclear.	The following explanation was added to the footnote: "Obtained from Dyer et al 2000; values adjusted to account for bioavailability"
27	The type of analysis described in this document has numerous uncertainties that must be acknowledged. Extrapolation from one trophic level to another and from biotic to abiotic media is inherently uncertain, and the relative biases associated with this type of analysis needs to be described in detail. Even if the tissue levels observed at sunken Navy vessels are below the estimated benchmarks, it may not be possible to say, with certainty that there are no adverse impacts to the aquatic life around the reef because of the uncertainty that would be introduced by such extrapolations. Uncertainty factors may need to be applied to counter these extrapolations and to ensure that biases are adequately accounted for.	The uncertainty section of the SCREENEX report will summarize the sources of uncertainty, identify procedures and precautions taken to reduce uncertainty to the extent possible, and discuss the ramifications of uncertainty in the conclusions drawn from the risk characterization.

A1B. Response to Comments on Ecorisk Assessment Summary Presentation

Response to Comments
FROM: Ann L. Cyrus
DATE: March 14, 2001
SUBJECT: Review of REEFEX Ecorisk Screening Draft Report presentation dated 12/13/00.

Comment	Response
1. Page 10, Sediment Screening. The location of the Ex-Agerholm is not provided in the presentation. The location of this site relative to the location for the proposed sunken vessel(s) should be discussed. Specifically, any physical and chemical differences between the Ex-Agerholm site and the proposed site(s) and how these differences may affect fate and transport of the chemicals of potential concern should be addressed.	The location of the ex-ARGERHOLM is provide in Section 6.2 and Figure 21; The uncertainties associated with extrapolating results from the deep-water ex-AGERHOLM SINKEX Study to REEFEX are provided in Section 6.2.2.
2. Page 21-24, Bioaccumulation Critical Values and Tissue Screening Values. These tissue concentration benchmarks were estimated based on chronic water quality values. Because the water quality criteria are typically based on effects to lower order organisms, it may not be appropriate to assume that higher trophic-level aquatic organisms are sufficiently protected when water criteria are met, particularly in the case of bioaccumulative compounds such as PCBs.	Comment noted. That is why benchmarks of critical body residues were developed for demersal fish and reef invertebrates. Dietary benchmarks for food chain receptors (dolphins, osprey, and black ducks) were also used in the assessment.
3. Page 22, Bioaccumulation Critical Values Table. The BCF values in the table appeared to be adjusted for shellfish moisture content (QA/QC of the fish bioaccumulation critical values required adjusting the BCFs by the difference in moisture content between fish and shellfish). In the report, it would be helpful to show the adjusted dry weight BCFs for both fish and shellfish.	The equation used to calculate B_{CV}s is shown in EQU [11] and the values are reported in Table 5. The adjusted dry weight Bcv are shown for both fish and invertebrates.
4. Page 22, Bioaccumulation Critical Values Table. The BCF for total PCBs in the table appears to be based on wet weight, not dry weight as indicated in the table. This should be clarified in the report. If the BCF given is actually in dry weight then the bioaccumulation critical values should be adjusted down accordingly.	Calculation of the BCF for total PCB is shown in Table 6. The BCF is based on wet weight of the organism and converted to dry weight to obtain the Bcv for fish and shellfish.
5. Page 22, Bioaccumulation Critical Values Table. Noted that the metal BCFs were based on bivalves and the BCF for total PCBs was based on fish sampled during the SINKEX. It may be helpful to use metal BCFs that are specific for fish when evaluating fish and a total PCB BCF specific for shellfish when evaluating these organisms since fish and shellfish may concentrate these compounds differently (in addition to the difference in moisture content between the two types of organisms which has been accounted for in the report).	The Bcv values have been updated. The Bcv for fish and invertebrates and are based on BCFs for fish and invertebrates, respectively (see Section 5.1.3.2). The BCF for tPCB was calculated using the fraction of tPCB (f_{PCB}) present for each homolog group measured in a subset of vermilion snapper samples collected from the ex-VERMILION and reference site.
6. Page 23, Tissue Screening Values. The equation on page 23 does not include the conversion factor of 0.001. This value should be included in the equation for the report.	The conversion factor of 0.001 has been included in the calculation for TSVs [EQU 10].

should be included in the equation for the report.	
7. Page 24, Tissue Screening Values Table. For ambient water quality criteria (AWQC), Versar noted that the lower of the marine and freshwater values was used in the table. This is not consistent with the bioaccumulation critical value table where only marine values were used. If the site is expected to be in marine habitat then marine AWQC should be used whenever available.	The TSV values were developed by URS and are assumed to be protective of all aquatic life (see Shepard 1998 and Dyer, S.D., C.E. White-Hull, and B.K. Shephard, 2000). Marine water quality criteria were used in the development of the Bcv values.
8. Page 30, Dietary Benchmarks table. In checking the dietary calculations using the data provided on page 29 and the reference doses provided in Sample et al. (1996), it appears that the results differ from the benchmarks in the table by a factor of 0.9. I was unable to account for this factor, based on information provided in the presentation.	The dietary benchmarks were calculated assuming an assimilation factor of 0.9 (*a* in [EQU 20]). This factor was applied to the dietary benchmarks developed for black ducks, osprey, and dolphins (Tables 9, 10, and 11, respectively).
9. Page 30, Dietary Benchmarks table. It appears as though the benchmarks provided in the table were based on the associated no adverse effects level (NOAEL) for the surrogate species. For the black duck and dolphin which are assumed to have more than one component to their diet (e.g., fish and invertebrates), it seems as though the benchmark values for fish and shellfish should be adjusted down based on the fraction of this part of the diet vs. the total diet.	The benchmarks for the food chain receptors are based on each prey item consisting of 100% of the predator's diet (*d* in (EQU 20]). Reducing the fraction of diet from a particular prey would increase the dietary benchmark proportionally.
10. Page 30, Dietary Benchmarks table. The development of dietary benchmarks seems to be based solely on ingestion of prey. However, direct ingestion of surface water and sediment may also occur which would increase the receptor species total intake of contaminants. As a result, these species may be adversely affected at levels that are less than the estimated dietary benchmarks.	The dietary benchmarks are based on prey consumption and direct ingestion of surface water and sediment were not included. This was because data on sediment and surface water concentrations were not available. Exposure from incidental contact with sediment would be negligible for predators in the reef environment. Estimates of water concentrations based on steady state leaching showed that water exposure levels were very very low indicated negligible exposure from incidental contact with surface water at the reef.
11. Page 33, Screening Evaluation Criteria. For tissue screening, noted that the data reliability was described as low for fish (with two samples) and passable for invertebrates (with one study). The limited amount of data used in the screening evaluation should be addressed as a source of uncertainty for the results in the final report.	Comment noted. There was high confidence of negligible to low exposure to PCBs because supplemental fish sampling and analysis for PCBs was conducted for the assessment. Owing to limited data available for screening, the confidence in the conclusions for the other chemicals of concern was low.
12. Page 35, PCB: Invertebrate Tissue. If the dolphin benchmark concentration for invertebrate tissue is adjusted down to reflect the fraction of invertebrates in the dolphin's total diet, the resulting value may be equal to or less than some of the actual invertebrate tissue concentrations collected from navy vessel reefs.	The benchmark for dolphin consumption of prey is based on each prey item consisting of 100% of the dolphin's diet (*d* in (EQU 20]). Reducing the fraction of diet from a particular prey would increase the dietary benchmark proportionally.

A1C. Response to Comments on Ecorisk Draft Report

Response to Comments on: A Screening Level Ecorisk Assessment for Using Former Navy Vessels to Construct Artificial Reefs - Draft Final Report, December 26, 2002

1) Response to comments from Laura Casey, USEPA, OPPT/NPCD March 6, 2003

Comment	Response
OPPT/NPCD is pleased to comment on the above referenced document. When compiling the final report, please keep in mind that it will be reviewed and assessed by people who are not familiar with all the details of this project. Please include such things as details of decisions made and why, methods chosen and why and also include a detailed discussion of the cleanup that the Ex- Vermilion may have received and any proposed cleanup plan or level for future artificial reefs. OPPT has also asked that the same level of detail be included in both the HHRA and the Leach Rate Study.	Thank you very much for your helpful comments. Additional details on the REEEFEX Working Group decisions, methods chosen, and rationale have been included in the problem formulation and methods section of the report. A section describing the cleanup conducted for the Ex-Vermilion has been added (4.1.1 Artificial Reef Creation). See comment 6 below.
1. There are many uses of acronyms and abbreviations and at times, it is difficult to keep track of them all, please add a list or table of all acronyms and abbreviations for quick reference.	A Glossary of Terms, Acronyms, and Abbreviations have been added to the report.
2. Please check the spelling of the name "Betsy", it should not be "Bestsy" or "Besty"	The spelling has been corrected.
3. Chapter 7, Literature Review discusses the sinking of Canadian ships and the approval granted by California to sink the Yukon. It is my understanding that the Canadian vessel preparations are very rigid and demanding and it also appears that the approval issued by California was also very rigid with regards to PCBs. Please explain how you can compare ships that were sunk or may be sunk with little or no PCB removal to ships that have undergone an extensive cleanup.	The following discussion has been added to Chapter 7: "The experience from the ex-YUKON and other reefs created from ex-warships shows that ex-warships can be successfully reused to create artificial reefs that provide ecological and socioeconomic benefits (Jones and Welsford 1997, Francis 2001, Phillips and Gamble 2001, San Diego Oceans Foundation 2002a, b). According to Environment Canada's clean-up standard for ocean disposal of vessels, any equipment or components suspected of containing PCBs must either be removed or certified that the "equipment or component does not contain PCBs" (Environment Canada 2001b). However, Environment Canada's standard is not based on risk and the cost and practicability of removing everything irregardless of risk may preclude realizing the benefits of creating artificial reefs with ex-warships."
4. Chapter 9, Conclusions and Recommendations - 4th paragraph down, please provide more detail as to what is meant by "relatively small quantities", remove a percentage or a certain weight?	The paragraph has been revised as follows: "Empirical estimates of PCB leaching rates were to simulate the leaching of PCBs from the ex-VERMILION and estimate the instantaneous steady state concentration of total PCB around the ship. The model showed that residual oils & greases and bulkhead insulation were the most important sources of PCB loading. The lack of empirical data on PCB leaching in oils

	& greases was identified as a major source of uncertainty in the analysis. The estimated concentrations were compared to the PCB water benchmarks and multiplied by bioconcentration factors to project the resulting PCB concentration in fish and shellfish. The results showed that there was negligible risk of exceeding water column or tissue benchmarks for any of the loading scenarios evaluated. The results from the empirical leaching studies and hypothetical steady state model were used to evaluate the consequences of removing materials from the ship to reduce PCB loading. In general, removing the materials with the highest leachrates would result in the greatest reduction in PCB loading per unit material removed. Based on the empirical upper bound of the leachrate obtained from the solids tested (George and In 2002a, 2002b, LEACHRATE SSC-SD 2003b) removing 0.001 kg (1 g) of pure Aroclor 1254 would reduce leaching by the same amount as removing 0.004 kg of pure Aroclor 1268, 0.143 kg of bulkhead insulation, 1.855 kg of foam insulation, 3.8 kg of felt gaskets, 5.3 kg of rubber products, 56.5 kg of paint, or 80 kg of electrical cable (Appendix 8). For the solid materials tested in the laboratory leaching experiments, the effect of decreasing PCB loading by reducing the amount of solid materials containing PCBs was evaluated using the steady state model. The steady state model takes into account both the quantity and concentration of PCBs in the materials estimated to be on the ship when it was sunk. Based on the average loading scenario, removing about 150 g of bulkhead insulation would result in about the same reduction in PCB loading as removing about 4 kg of felt gaskets, 30 kg of foam insulation, 200 kg of electrical cable, 300 kg of rubber products, or 500 kg of paint (Appendix 8). Because considerably more effort is required to remove certain types of materials than others, removing relatively small quantities of bulkhead insulation and using extra care to clean up oils & greases in areas where they may of come into contact with PCBs would greatly reduce the amount of PCBs leached and therefore further reduce the potential risk of exposure to PCBs." In addition, a section on "Reducing PCB Loading" has been added to Appendix 8 (see attached).
5. Please check the citation for 761.62(c) in the Response to Comments (Appendix 4), a copyright symbol was inserted instead of (c).	Typo has been corrected.
6. Appendix 3-1 - Vermilion Background - were any solid materials suspected of containing PCBs removed from the vessel? You may want to include a detailed description of the cleanup procedure used on the Vermilion since people who are not entirely familiar with this project may be reviewing the final submission.	The following has been added to Section 4.1 and Appendix 8: "In the late 1980s the South Carolina Department of Natural Resources (SCDNR) created artificial reefs consisting of sunken ex-U.S. Navy and Army ship hulls. The reefs were constructed as part of SCDNR Marine Artificial Reef Program (Bell 2001, SCDNR 2002). One such reef was created about 30 miles off the coast of South Carolinia in 110 ft of water by sinking the ex-VERMILION (amphibious cargo ship LKA 107) (Appendix 3.D). The ex-Vermilion was obtained by the State of South Carolina in 1987 from the U.S. Maritime Administration's (MARAD) inactive reserve fleet in the James River near Ft. Eustis, Virginia. The 460 foot-long (139 m) ship was towed to Wilmington, North Carolina where it was cleaned, stripped and prepared for its new role as reef material by a

	private marine contractor and ship breaker. The goal of the artificial reef program was to enhance recreational fishing opportunities by developing carefully designed, permitted, and monitored artificial reefs (SCDNR 1987). The vessel was prepared to acceptable standards for artificial reef construction activity in the U.S. at that time (Stone, 1985). A letter application to the Department of Transportation from SCDNR documented the procedures used to prepare the ship (SCDNR 1987, Appendix 3.d). All commonly encountered potential shipboard pollutants such as fuels, oils, solid or liquid chemicals, liquid PCBs (electrical transformers and switchboards) and floatable materials such as plastics or wood were removed and properly disposed of by the contractor. To facilitate use of the ship in 110 feet of water and minimize its risk as a possible hazard to navigation, the overall height of the vessel was reduced to no greater than 55 feet (17 m) above the keel. All structure above the O-1 level was removed. Large holes were cut in the sides of the ship and between watertight bulkheads. Removing or welding internal doors and hatches open further breached internal watertight integrity. After final inspection by U.S. Coast Guard Marine Safety Office Wilmington, the vessel was towed to its final destination and sunk by the use of explosive charges set by U.S. Navy Explosive Ordnance Disposal personnel (EOD Mobile Unit Six). The Vermilion sank quickly, and settled in an upright position on barren flat sand bottom 110 feet (33 m) deep, approximately 32 miles southeast of the port of Georgetown, SC. When the Vermilion and other similar ships were prepared for sinking in the 1980's, SCDNR was not aware that solid materials containing PCBs were present onboard the vessel. Therefore, no effort was made to remove specific materials for this reason. When all materials above the O-1 level (superstructure) were removed, some materials that likely contained PCBs were also removed. No effort was made to remove gaskets, cable runs, or other solid materials that may of contained PCBs in other parts of the ship. In the case where hatches or watertight doors were removed, they were often just thrown inside the ship, unless they were deemed to be of value to the contractor, then they were retained for scrap (some gaskets were left behind, others were removed).”

2) Response to Comments Received from Versar, Inc., 11 March 2003

Comment	Response
General Comment: It was noted in the previous round of comments from Versar that the water quality criteria (WQC) used to calculate B_{cv} were all marine values while those used to calculate TSVs were both freshwater and marine. It was stated in the response to comments that the TSV values were developed by URS and are assumed to be protective of all aquatic life. Versar still recommends using marine WQC (when available) if the site is expected to be in marine habitat	Thank you very much for your helpful comments. The following discussion was added to Section 5.1.3.1: "The TSV is based on water quality criteria that were derived to be protective of 95% of aquatic organisms (US EPA 1986, URS 1996, Shepard 1995). Because the TSV is equal to the no effect tissue concentration, a single TSV applies to both freshwater and marine organisms (URS 1996, 2000). This assumes that the difference between freshwater and marine criteria are due to differences in chemical uptake in freshwater and marine organisms and not differences in tissue concentrations that would cause adverse effects." The following discussion was also added to the discussion of the uncertainty associated with tissue screening (section 6.3.3): "The TSV represents a conservative initial screening value capable of eliminating chemicals that do not pose significant risks to aquatic biota. If a TSV is exceeded it does not necessarily mean that an observed tissue concentrations poses an adverse risk to biota, rather it indicates that the chemical requires a more detailed evaluation in later phases of the ecological risk assessment (Shepard 1995)."
1. Page 1-3, Section 1-5. The screening methodology listed here is slightly different from the screening methodology listed in Section 5 (Page 5-1) of the document.	The description of the screening methodology provided in the Executive Summary was revised to be consistent with the description provided in the body of the report.
2. Page 4-7, Section 4.3, first paragraph. The phrase "Exposure to contaminants present in the water column could occur to marine organisms through contact and uptake (e.g., gill tissues) and to higher-level predators by incidental contact." Should be modified to read "Exposure to contaminants present in the water column could occur to marine organisms through contact and uptake (e.g., gill tissues) and to higher-level predators by incidental contact *and ingestion of contaminated prey.*"	Missing phrase was added to paragraph.
3. Page 5-3, B_{cv} equation [11]: there needs to be a conversion factor added (0.001 kg/g) and the dry:wet ratio should be divided not multiplied in the equation.	Equation was revised as suggested.
4. Page 6-11, Section 6.3.1.4, Invertebrates. The second sentence incorrectly mentions concentrations of Cr in fish, should be changed to invertebrates.	The typo was corrected.
5. Figure 2 - Exposure pathways and assessment endpoints evaluated for the ecorisk screening. Figure 2	The figure caption was annotated as follows:

should be modified to remove 'recreational fisher', since the food chain receptors should be limited to ecological receptors.	"Note that exposure to recreational fishers was evaluated by the human health risk assessment (NEHC 2002)."
6. Table 3, Benchmark concentrations: Total PCB B_{cv} does not match the value provided in Table 5 (Table 5 values were verified).	The Total PCB B_{CV} value Table 3 was corrected to 24.3 ug/g. All figures and calculations using the value were corrected.
7. Table 3, Tissue Screening Values (TSV): TSC in the table should be changed to TSV in order to be consistent.	Table caption was corrected.
8. Table 6, Calculation of BCF_{tPCB}, We calculated 202452 rather than 202542 which was reported in Table 6. Could the 202542 value in Table 6 be a typo?	The calculations in Table 6 were verified the correct value is 202542.
9. Table 8, LOEDs: For invertebrates, the reference values for Cr and tPCB is an ED_{10} which is given a UF of 1.00. Should these UFs be adjusted down since the reference values are not actually lowest observed effect dose (LOED)s?	Upon further review of the results from ERED database an invertebrate LOED for tPCBs was identified as 5.5 ug/g for grass shrimp (URS102: Hansen, Parrish, and Forester 1974) This is lower than the previous invertebrate LOED of 20 ug/g and NOED of 7 ug/g, therefore a lower NOED of 3.0 ug/g for the mussel *Mytilus edulis*. (URS223 Velduizen-Tsoerkan, Holwerda, Zandee) was also selected. For Cr the invertebrate ED_{10} was multiplied by an UF of 0.75 to obtain the LOED. All figures and calculations using the above values were corrected.

A1D. Response to Comments on Final Draft SERA Report of July 1993 Comments received from Dr. Wayne R. Munns of U.S. EPA Office of Research and Development, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division of 3 SEP 2004.

Responses 10 DEC 2004

Wayne R. Munns, Jr., September 3, 2004: Technical Review of *A Screening Level Ecorisk Assessment for Using Former Navy Vessels to Construct Artificial Reefs*, Final Report, dated July 17, 2003

FROM: Wayne R. Munns, Jr.
Associate Director for Science

TO: Maria Doa
Director, OPPT NPCD

Craig Brown
Research Ecologist, Region 4

I have completed a technical review of the subject document at your request. This document (hereafter referenced as "REEFEX SERA") was prepared by Johnston et al. of the Marine Environmental Support Office (MESO), Space and Naval Warfare Systems Center (SPAWAR), U.S. Navy, to support future decisions regarding the use of decommissioned Navy vessels for reef building projects. In its specific application, the REEFEX SERA is being used to support decisions regarding the sinking of the ex-ORISKANY, a decommissioned aircraft carrier, as an artificial reef off the coast of Pensacola, FL. An electronic copy of the REEFEX SERA was provided to me by Dr. Robert K. Johnston, lead author.

In preparing this review, I also considered past meeting minutes of the REEFEX Technical Work Group (TWG) spanning 7 July 1999 through 31 July 2002, provided to me by Laura Casey of EPA's OPPTS on 30 August 2004. These minutes were useful for understanding the approaches taken in the REEFEX SERA and the consensus opinions of the REEFEX TWG.

Organized by section (beginning with Section 4), this review evaluates key assumptions, addresses the strengths and limitations of assessment approaches, identifies concerns about the confidence of conclusions, and highlights specific issues that may require additional evaluation prior to final concurrence on the decision to sink the ex-ORISKANY and other vessels. In a few instances, I also offer editorial suggestions to enhance the clarity of the meaning and intent of the assessment. I apologize in advance for my verbosity.

Please contact me if you have questions.

Attachment (1)

cc:
Laura Casey, OPPTS
Beverly Banister, R4
Ken Mitchell, R4
Kevin Koporec, R4
Mark Fite, R4
Roland Ferry, R4
Solomon Pollard, R4
John Ackermann, R4
Laura Johnson, OW
Dave Redford, OW
Jim Pendergast, OW
Marjorie Wellman, OW
Linda Phillips, OW
Jim Carleton, OW
Russell Kinerson, OW
Craig Barber, ORD
Jonathan Garber, ORD
Steve Hedtke, ORD

#	Comment	Response
	General Comments	
1	My understanding is that the results of the REEFEX SERA are intended to be applicable to all future reefing exercises using ex-Navy vessels, and perhaps would support decisions involving other vessels as well. As a screening level assessment, it is therefore appropriate to use generic assessment endpoints, site-neutral analysis approaches, and benchmark comparisons involving national (or at least regional) criteria to elucidate ecological risks broadly. At the same time, use of existing data that are necessarily specific to particular situations (e.g., data from the ex-VERMILION) may be required to add realism to estimates of exposure and so on. But, use of those data creates an interesting quandary with respect to interpreting assessment results generally – how much do the conclusions of the assessment depend upon the specifics of the situation from which data were obtained? I don't know the answer to this, but I recommend that this consideration be factored into future decisions regarding specific reefing exercises as well as those concerning general ("blanket") permits for sinking ex-Navy vessels to create reefs.	The REEFEX SERA was prepared to address ecorisk issues associated with sinking ex-Navy vessels to create artificial reefs. The objectives for the ecorisk assessment were to formulate the problem, conceptual model, and exposure pathways to assess risks from sunken ships, develop the methods, benchmarks, and decision criteria for the ecorisk screening, and evaluate the results and discuss the uncertainties associated with the assessment. The data used to conduct the risk assessment were mostly site specific (e.g. data from the ex-VERMILION), therefore there are limitations to the extent that the results obtained can be extrapolated to future sinkings. However, the ecorisk assessment provides a process to evaluate ecological risks from sunken ships that can be used to support the decision making process.
2	An issue has been raised about the sufficiency of the REEFEX SERA for understanding toxicological risks that may result from the sinking of multiple vessels within a defined region. The REEFEX SERA conceptual model assumes that a single vessel is the sole additional (above background) source of PCBs and other contaminants of concern (COCs) to the reef community. However, I think it is reasonable to assume that placement of other vessels as reefs nearby will contribute to elevated background levels of contaminants, and could add to a matrix of multiple point-sources of exposure to organisms that move among reefs. Understanding the incremental human health risks of multiple reefs may be as simple as increasing the percentage of contaminated fish eaten by recreational fishers (assuming fishers visit multiple reefs), but assessment of ecological risks likely would require modeling scenarios of multiple reefs to understand their potential impact. The REEFEX SERA contributes to the understanding of, but does not assess, the ecological risks of multiple reefs.	To the extent data were available, the SERA did evaluate regional exposure present along the coast of South Carolina, which included numerous artificial reefs. However, data were only available for two Navy ship reefs and these were about 120 miles (104 nautical miles) apart (ex-VERMILION and ex-BETSY ROSS).

3	I am concerned that the presentation of screening approaches, results and interpretations obfuscates the ecological risks associated with using ex-Navy vessels as artificial reefs. As reflected in the Specific Comments below, there are several instances in the document where methods are not described clearly or completely, where the enumeration of possible explanations for assessment results emphasizes the potential benefits of reefing projects and downplays possible linkages between reefed ex-Navy ships and possible effects, and where discussion of uncertainties is incomplete or irrelevant. I understand and appreciate the limitations of resources and information available to the SERA effort and the urgency with which it was completed. However, I think we all would benefit from a more neutral and transparent presentation of methods and results, and of the strengths and limitations of what was done.	The SERA has been revised, as suggested by the specific comments, to more clearly communicate the strengths and limitations of the assessment. Any imprecise or confusing presentation of methods, results, and uncertainties was unintentional and such errors or omissions have been corrected as noted below.
	Specific Comments	
1	Section 4. Problem Formulation I was unable to find a statement in Section 4.2.2 (or elsewhere) that affirmed that whole fish from the supplemental fish sampling effort were analyzed for COCs. According to members of the REEFEX TWG, data from fish fillets were actually used in this assessment. This fact calls into question the relevance of all the supplemental fish tissue chemistry data as used in the REEFEX SERA. Unlike humans, piscivores typically consume whole fish, or when they can't, they are not selective about what tissues they do consume. Because bioaccumulative organic chemicals (like PCBs) partition selectively to lipid-rich tissues (such as liver), data derived solely from fish fillets can dramatically underestimate both the exposure experienced by fish and the dietary exposure to consumers of those fish. Additionally, fillet muscle often is not the site of toxic action for such contaminants. Thus, analyses in the REEFEX SERA that relied on residue data from the supplemental fish sampling are not appropriately conservative for a screening-level (or other) ecological risk assessment.	The raw data from the supplemental fish sampling are from fillets with "skin on" and this has been made clear in section 4.2.2. (and elsewhere) in the report. A procedure to estimate whole body PCB residues has been developed and applied to calculate whole body concentrations for the supplemental fish data. The calculations for whole body tissue residues are higher than the estimates derived solely from analysis of fillets. 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 will be included in the revised report. A spreadsheet with the assumptions, equations, and calculations for the supplemental fish data is available for review as well (see Appendix_4C_.xls). The following text has been added to section 4.2.2 "The supplemental fish were collected by the SCDNR at the reference and target sites between May 1 and June 15, 2004 using fish traps, hook-and-line, and diver spearfishing (NEHC 2004). Specimens were measured for length and weight, sexed, and aged using total length to otolith relationships developed by SCDNR. Livers were excised and weighed and the fillets with skin-on were removed for chemical analysis." The whole-body calculations and resulting comparisons to benchmarks will be included in the revised report see Appendix_4C_.xls Figs 10a, 10b, and 10c).

	That said, there are reasonable approaches that can be used to salvage the supplemental fish sampling chemistry data. With some quantifiable level of additional uncertainty, relationships between fillet residues and whole body burdens could be developed for each of the three species from data sets existing in the literature. Such relationships may even be reported in the literature currently. I recommend that this or a similar approach be taken to generate reasonable estimates of whole body burdens, with quantified uncertainty, and that all analyses involving the supplemental fish sampling data be redone and reinterpreted.	
2	The REEFEX SERA uses data from the leach rate study to estimate instantaneous steady state concentrations of total PCBs in a well-mixed volume of water as a source of exposure to reef organisms. Unlike calculations used in the Supplemental Human Health Risk Assessment (SHHRA), however, the actual dimensions of the ex-VERMILION were used to estimate this volume (p. 4-6). Thus, assumptions concerning "zone of influence" and the degree of initial dilution of PCBs appear not to be issues in the REEFEX SERA.	No response required.
3	The conceptual model (p. 4-8, Figure 2) appears reasonably comprehensive and realistic as a set of working hypotheses to guide the assessment, with two noteworthy exceptions. First, I would add a completed pathway leading from water directly to food chain receptors (Figure 2 shows an arrow from water leading to nothing), since such exposure would be expected to occur. Second, it is likely that higher trophic level fish (e.g., black see bass, grouper, various shark species) would be exposed to PCBs and other contaminants associated with ex-Navy ships through food chain pathways. I recommend that the conceptual model be modified accordingly, and that analyses be included in the REEFEX SERA that explicitly address risks to higher trophic level fish. These modifications aside, I endorse the regional approach first described on p. 4-1 as a reasonable one for isolating the incremental risks of reefed Navy vessels, as almost all reefing projects undertaken in the U.S. will occur in areas influenced by coastal sources of contamination. Thus, it is appropriate to include a "coastal runoff" source term in the conceptual model as a means to isolate the incremental risks of reefed Navy vessels.	The conceptual model has been revised as suggested. Assessment endpoints for PRIMARY PRODUCERS (phytoplankton and encrusting algae), PRIMARY CONSUMERS (zooplankton, epifauna, infauna, and grazing fish), SECONDARY CONSUMERS (grunt, snapper, sea bass, lobster, and crab), TERTIARY CONSUMERS (marine mammal, reef shark, barracuda, and sea turtle), and AVIAN PISCIVORES (cormorant and herring gull) have been defined. Additional dietary benchmarks for sea turtle (loggerhead), double-crested cormorant and herring gull (rather than black duck and osprey), reef shark (short-finned mako shark), and barracuda (great barracuda) have been developed and will be included in the revised report. (See updated conceptual model.)

4	Assessment endpoints for the REEFEX SERA are defined (beginning on p. 4-9) rather loosely. Per EPA guidance (USEPA 1998), assessment endpoints should be defined operationally in terms of a valued ecological entity and one or more of its attributes or characteristics. It is insufficient to simply identify "demersal fishes" or "avian omnivores" as assessment endpoints. Rather, attributes of these entities need to be articulated that reflect management goals. This may seem overly pedantic, but in fact, fully defined assessment endpoints are required to focus assessment activities and to relate results back to management goals. The default taken by the REEFEX SERA presumably reflects concerns about the toxicological risks of PCBs and other COCs to individual organisms; the implication being that survival, individual growth and development, and reproduction are the unspecified attributes. With these as the sole assessment endpoints, application of the REEFEX SERA is limited with respect to its ability to address other valued ecological entities, such as species diversity, primary productivity or aquatic populations. Thus, claims made at various places in the document about being able to use the results of the assessment to determine impacts on the ecology of the reef community (e.g., pp. 4-11–4-12) are overstated.	Section 4.5 has been revised to reflect the changes in the conceptual model and address comments noted. The following text has been added; "To assess ecological effects to the assessment endpoints, receptor species were selected to evaluate contaminant exposure to species that comprise the reef community. The receptor species used in this risk assessment were selected to be representative of species found at the reef that would be sensitive to contaminant exposure and for which exposure and effects data would be available or could be inferred. Because this risk assessment was primarily concerned with evaluating toxicological risks associated with exposure to contaminants (especially PCBs migrating through the food chain), the primary ecological effects to the assessment endpoints to be evaluated were individual survival, reproduction, and growth and development. Evaluating ecological effects to other valued ecological attributes, such as species diversity, primary productivity or aquatic populations was possible only to the extent that the benchmarks (see Section 5) were also protective of those attributes. This risk assessment only evaluated the potential effects of contaminant exposure and did not address the presence and physical structure of the artificial reef, which greatly influences the ecological processes present at site."
5	As reflected in meeting minutes of the REEFEX TWG and in comments on earlier drafts of the REEFEX SERA, there appears to be some concern about the receptors selected to represent assessment endpoints as indicator species. While accurately reiterating considerations important to selection of receptors as surrogates for assessment endpoints (p. 4-9), the problem formulation section provides little analysis of the options available or explanation of the choices made (although some relevant information is provided later in Section 5). Without that analysis, I question whether black duck is a reasonable surrogate for avian omnivores, and osprey for avian piscivores, potentially utilizing artificial reef habitats. Are they appropriately sensitive to PCBs and other REEFEX-related COCs? Are the toxicological data available for these species sufficient to interpret exposure concentrations? Is their ecology representative of birds that utilize reef habitats with regard to use patterns, prey utilization, etc.? Because little attempt was made to extrapolate susceptibility to REEFEX COCs quantitatively from chosen receptors to actual site receptors (with the possible exception of the mink-to-	More reef-centric receptor species including sea turtle (loggerhead), birds of prey (cormorant and herring gull rather than black duck and osprey), barracuda (great barracuda), and reef shark (short-finned mako shark) have been added to the assessment. Discussion and documentation of the receptors susceptibility to COCs and limitations and uncertainty of the approach have been added to the report. A more detailed analysis of the assessment endpoints has been added to the revised report: "Based on existing toxicological data receptor species were selected that would most likely be sensitive to PCBs and other REEFEX-related COPCs. Toxicological data were reviewed to identify available toxicological benchmarks that could be used to interpret whether exposure concentrations to

	bottlenose dolphin extrapolation), the degree of bias towards conservatism (as appropriate for a screening-level ecological risk assessment) claimed in the assessment is largely undocumented.	the receptor species could be harmful. To the extent possible, receptor species were selected that were representative of mammals, birds, reptiles, fishes, and invertebrates that utilize reef habitats. In many cases, toxicological data were not available for reef organisms and the susceptibility of the receptor species to the COPCs had to inferred or extrapolated from species used in toxicological tests and studies (mainly freshwater and estuarine species). As is appropriate for screening level assessments, conservative assumptions and uncertainty factors (UFs) were used to help assure that that the assessment did not underestimate potential risk."
6	I generally like the articulation of working hypotheses found on pp. 4-11–4-12, as they serve to explain the analysis design, and set the stage for interpretation of results. That said, I think the wording should be more precise to clarify the limits of the assessment. Specifically, for hypothesis 1 on p. 4-11, there are many ways in which contaminants from sunken ships could adversely impact "the ecology of the reef." To be consistent with the (presumed) fully-specified assessment endpoints, better language might be "affecting survival, growth and reproduction of reef organisms." Similarly, for hypothesis 1 on p. 4-12, the hypothesis itself might be stated better as "no difference in indicators of exposure and toxicity between artificial reefs constructed...", and the subsequent question be rephrased to address toxicity (as opposed to "perturbed ecosystems"); for hypothesis 2 on p. 4-12, "no difference in indicators of exposure and toxicity between artificial reefs constructed..."; and for hypothesis 3 on p. 4-12, "no difference in indicators of exposure and toxicity between artificial reefs constructed...".	Suggested revisions have been made.
7	For clarity, replace "degree of risk" with "degree of incremental risk" in the last full sentence on p. 4-11, and replace "degree of risk" with "degree of background risk" in the first line on p. 4-12.	Suggested revisions have been made.
	Section 5. Screening Methodology	
8	The REEFEX SERA uses EPA's chronic ambient water quality criteria (WQC) as benchmarks for water exposures (pp. 5-1–5-2). While this approach is reasonable and has been vetted in past risk assessments, the document should be clear on how results should be interpreted. The REEFEX SERA states (on p. 5-1 and elsewhere) that "[WQC] have been developed to be protective of 95% of the most	Sentence has been revised to read: "Benchmarks for water exposure were set to saltwater ambient water quality criteria, which have been developed to be protective of 95% of the species tested (or more precisely, of the genera tested) (U.S. EPA 1991, 1994)."

	sensitive species...” (italics mine). This statement is not strictly correct, and can lead to inappropriate interpretation of assessment results (see, for example, 2nd paragraph of Section 5.4.3). EPA’s Aquatic Life Criteria Guidelines Committee, responsible for developing the technical basis for national WQC, considers the criteria to be protective of 95% of the species tested (or more precisely, of the genera tested). The standard WQC calculation results in a number that is designed to protect 95% of the species sensitivity distribution represented by the data set available. The assumption here is that the data set available is representative of the species sensitivity distrubution of the potentially exposed aquatic community. To the degree that this assumption is true, WQC protect 95% of the species exposed. The data set is biased in two ways: 1) the species tested generally are among the more sensitive species that can be tested; and 2) only species that can be tested are tested – species that are more difficult to maintain in the laboratory could be more sensitive than those actually tested. By implication, a sensitive species of particular value, or of particular importance to community and ecosystems dynamics (a "keystone" species), for which no toxicity test data exist, could be adversely affected at exposure concentrations lower than the WQC. In addition to national criteria, it may be instructive to evaluate water exposures against any existing state-specific standards, particularly if these have been developed to protect valued species.	Other instances of this unclear usage have also been corrected. Further discussion of this issue has been added to the uncertainty section. Section 5.4.3 has also been revised to read: “Since the denominators of the bioaccumulation HQs (TSV and B_{CV}) are based on chronic water quality criteria, they are similar lines of evidence and the resulting hazard index (HI_{Bcv}) was used to evaluate water column exposure of multiple chemicals to reef organisms. Water quality criteria were developed to be protective of 95% of the species tested including plants, invertebrates, and fish, therefore the HI_{Bcv} provides an indication, based on observed tissue concentrations, as to what extent exposures may reach or exceed levels in the water column that could be potentially harmful to reef organisms.” The report has been revised to note: “The benchmarks selected based on national WQC were less than or equal to the water quality standards promulgated by the State of South Carolina (South Carolina 2001).” South Carolina 2001 Water Classifications & Standards Regulations (R.61-68) - http://www.epa.gov/waterscience/standards/wqslibrary/sc/sc_4_wqs.pdf
9	Generally, I endorse the creative use of existing information to establish residue-based benchmarks of safe exposure levels. However, the definitions provided for tissue screening values (TSV), bioaccumulation critical values (BCV) and critical body residues (CBR), used as benchmarks for screening tissues residues (pp. 5-2–5-	Suggested revisions have been made.

	4), are imprecise. Conceptually, each is a chemical residue threshold at or below which adverse toxicological effects would not be expected, but the given definitions obscure this and potentially confound interpretation of results. Simple word smithing would correct this problem: · - replace "that would not be expected to cause adverse effects" with "at or below which adverse effects would not be expected to occur" in the definition of TSV (p.5-2) - replace "exceeded" with "equaled" in the definition of BCV (p. 5-3) · - replace "the concentration of a contaminant in the tissue of an organism that can cause adverse effects to the organisms when exceeded" with "the threshold concentration of a contaminant in the tissue of an organism above which adverse effects could occur" in the definition of CBR (p.5-4)	
10	The relationships between TSV and BCV are confusing. From eqs. 10 and 11-13, they look to be fairly similar, with the sole differences appearing to be application of an unexplained adjustment factor of 0.001 (which I assume to be a kg to g conversion factor) and division by a dry-to-wet weight ratio in the calculation of TSV, versus no adjustment factor and multiplication by a dry-to-wet weight ratio in calculation of BCV. Further, there appears to be a units accounting problem in eq. 11. Am I missing something? Are the BCVs intended simply to be a case-specific application of the TSV approach? My confusion suggests that additional explanation of these benchmarks is needed to aid in understanding of their use, in interpretation of results, and to avoid promoting a false sense of confidence in risk conclusions (if, in fact, they are identical lines of evidence). Specifically, I recommend that the evidence provided uniquely by the two benchmarks be described explicitly, that the differential adjustment by dry-to-wet weight ratio be explained, and that the rationale for use of the 0.001 adjustment factor in calculation of TSV be described.	The following text has been added: "Similar in concept to the TSV, the B_{CV} was calculated using the most recent salt water quality criteria (U.S. EPA 1998b, Buchman 1999) and bioconcentration factors applicable to marine fish and invertebrates." The typos in the equations have been corrected as noted below:

$$\text{TSV} = \text{WQC}\,\frac{\mu g}{L} \times \text{BCF}\,\frac{L}{kg(wet)} \times \frac{1\ g\ wet}{dw\ g\ dry} \times 0.001\,\frac{kg}{g}\ (\mu g/g\ \text{dry weight}) \qquad [10]$$

Where

BCF_{LIPID} = bioconcentration factor (L/kg wet weight) normalized to the average (3%) lipid content of aquatic organisms (URS 1996)

dw = Dry weight:wet weight ratio for fish or invertebrates

WQC = was selected as the lowest value reported for marine or fresh water quality criteria (µg/L) that was in effect at the time the TSVs were calculated (URS 1996)

$$B_{CV} = W_B \frac{\mu g}{L} \times BCF \frac{L}{kg(wet)} \times \frac{1\ g\ wet}{dw\ g\ dry} \times 0.001 \frac{kg}{g} \quad (\mu g/g\ dry\ weight) \qquad [11]$$

where W_B = Most recent salt water chronic criteria (EPA 1998, Buchman 1999, see Table 3)

BCF = bioconcentration factor specific to marine fish or invertebrates (L/kg wet weight, see Table 5)

dw = mass fraction of dry to wet tissue g dry/g wet weight

and dw = 0.25 for fish (75% moisture)

dw = 0.2 for shellfish and other invertebrates (80% moisture)

11	Uncertainty factors (UF) were used in calculation of the CBRs for fish and invertebrates (p. 5-4, eqs. 14 and 15). Clearly, the choice of UFs influences the estimate of CBR, and although their values are specified, I could not find the rationale for those values. I recommend that the rationale justifying the use of these specific values for UF be provided.	The following description has been added: "If NOED or LOED were not available for the contaminant-receptor being evaluated, UFs were used to make other endpoints comparable to the NOED or LOED. In the absence of a NOED, laboratory derived LOEDs were converted into a NOED by reducing the LOED by up to a factor of 10, depending on how severe the effect was (U.S. EPA 1995, Sample et la. 1996). If only data on an effective dose (ED_x.) were available for a COPC, then the ED_x was reduced by up to a factor of 10, depending on how severe the effect was, to obtain the LOED. For example, the lowest toxicity endpoint obtained from ERED for Cu in whole fish tissue was 6.4 ug/g, which caused 100% mortality in non-metallothionein induced rainbow trout (*Oncorhynchus mykiss*, Dixon and Sprague 1981). This value was multiplied by an UF of 0.5 to obtain the LOED benchmark of 3.2 ug/g, and an UF of 0.05 to obtain the NOED benchmark of 0.32 ug/g. For Cr, the lowest endpoint reported for whole fish tissue was an ED50 of 3.48 ug/g for rainbow trout (*Oncorhynchus mykiss*, Buhler et al. 1974) so the LOED of 1.75 ug/g was obtained by applying an UF of 0.5. The lowest endpoint for Cr invertebrate residues was an ED10 of 7.2 ug/g for stonefly (*Clioperla clio*, Poulton et al. 1989), which was multiplied by an UF of 0.75 to obtain the LOED benchmark of 5.4 ug/g and an UF of 0.1 to obtain the NOED benchmark of 0.72 ug/g. For Ni, the lowest invertebrate endpoint reported in

		ERED was an ED50 of 283 ug/g in clams (*Cerastoderma edule*, Wilson 1983) and UFs of 0.5 and 0.05 were applied to obtain the invertebrate LOED (141.5 ug/g) and NOED (14.5 ug/g), respectively. A UF of 0.5 was used to convert the LC50 of 203.5 ug/g reported for Pb in copepods (*Calanus hyperboreus*, Ritterhoff and Zauke 1997) to obtain the LOED of 101.8." See Tables 7 and 8, Appendix 5
12	As indicated in Specific Comment 3 above, the conceptualization of exposure pathways leading to food chain receptors may be incomplete. The lack of direct exposure to water as a pathway is also reflected in the simple food chain model described on pp. 5-4–5-6. Whether water is an important source of exposure is unknown, but some discussion of its potential importance (and therefore why it wasn't included in the model of food chain exposure) is warranted here.	Section 5.1.3.4 has been revised. The simple food chain model has been deleted because it was misleading. The following is the revised introduction to Section 5.1.3.4 "The potential for bioaccumulative contaminants to affect higher trophic levels was evaluated by assessing contaminant concentrations in tissues of representative prey. The exposure to an upper trophic level predator (e.g. birds of prey, dolphin, etc.) is related to the exposure from eating prey species (clam, fish, worm, etc.) that have bioaccumulated contaminants from exposure pathways present within the reef community (Figure 2). The food chain benchmarks were set to correspond to the dose that is equivalent to the no observed adverse effect level (NOAEL) for the receptor species (birds of prey, sea turtles, marine dolphin, and reef shark). If available, Toxicity Reference Values (TRVs) were used to determine potential adverse exposure to predators. When the NOAEL is used to calculate the TRV, the TRV represents a chemical concentration below which significant effects to the receptor are not anticipated. Water exposure was not evaluated for birds, mammals, and sea turtles. None of these species have gills, which is the main route of uptake from water exposure for marine fish and invertebrates. For birds, incidental contact with the water would occur when foraging at the reef (diving and swimming) and it was assumed that this exposure would not be significant. Although dolphins and sea turtles could also be attracted to forage at the reef for intermittent periods, they are not considered to be reef residents and it was assumed that uptake of contaminants from the water would be negligible and could be ignored. Water exposure for the reef shark was evaluated by assuming that potentially harmful tissue concentrations (NOED) could arise by accumulating contaminants from water and food. Incidental contact with sediment by upper level predators was not considered an important pathway and sediment exposure to birds of prey, sea turtles, dolphins, and reef sharks was not included in the analysis."

13	The initial description of food chain benchmarks (second sentence of Section 5.1.3.4) does not conform with the conceptual model for the REEFEX SERA (Figure 2) in suggesting that prey only take up contaminants through the water exposure pathway. The conceptual model indicates that prey also accumulate contaminants through sediments and "surface of ship" pathways. I don't believe this misstatement affects the analyses performed, but it does add confusion (as does implying that black ducks and dolphins are "bird[s] of prey"). Simple word smithing would correct this.	Sentence has been revised to read: "The exposure to an upper trophic level predator (bird of prey, dolphin etc.) is related to the exposure from eating prey species (clam, fish, worm, etc.) that have bioaccumulated contaminants from exposure pathways present within the reef community (Figure 2)."
14.	I'm curious about the veracity of the first part of the sentence on p. 5-5 that reads "Based on the similarity of toxicity values reported among avian species, the NOAELs reported for the test species (NOAELT) were assumed to be equivalent to the NOAEL for black ducks and ospreys (ELBlackDuck = ELOsprey = NOAELT, Sample et al. 1996)." I could not find an evaluation of literature-derived avian toxicity data (nor the data themselves, actually) in the REEFEX SERA that supports an assumption of similarities among birds in their toxicological susceptibilities. The uncertainties introduced by this assumption therefore cannot be evaluated directly. Because values for a given toxicity endpoint (e.g., the LC50) can vary among species by one or more orders of magnitude, however, these uncertainties are potentially large.	The following clarification has been provided: "Sample et al. (1996) reported that a scaling factor, other than one, is not appropriate for avian species because an analysis of existing data showed that the scaling factor which ranged from 0.63 to 1.55 with a mean of 1.15, was not significantly different than 1. This assumes that toxicity effects to receptor species (birds of prey) would be similar to the species tested (ring-necked pheasant for PCBs) after adjusting for differences in food consumption rate and body weight of the receptor species." Sample, B.E., D.M. Opresko, and G.W Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 227 pp, ES/ER/TM-86/R3 (PDF file, tm86r3.pdf; self-extracting WP file, tm86r3.exe).
15	Although limited in-and-of-themselves, hazard quotients (HQs) and hazard indices (HIs) are appropriate for use in screening-level ecological risk assessments. The hazard index approach utilized in the REEFEX SERA assumes toxicity from multiple contaminants to be additive – this is the basic toxic unit approach – not synergistic as stated on p. 5-8. An assumption of additivity appears to be appropriately conservative for a screening-level assessment.	Sentence revised as to read: "…to evaluate the potential additive effect of exposure to many chemicals."
16.	The logic offered in selection of Bcv as the basis for hazard index calculations for water exposure is unclear. But, given Specific Comment 10, I'm not certain that it matters.	The Bcv hazard index is similar to the TSV hazard index, except that the Bcv is more specific to marine organisms. See response to comment #10.

17	I strongly endorse the use of predetermined evaluation criteria in the screening analysis (Section 5.4). Because the REEFEX SERA indicates these criteria to reflect the consensus of the REEFEX TWG, this comment should be taken primarily as a question for my edification. Why would HIs as high as (or rather, just less than) 10 be interpreted as "moderate likelihood [that] exposure is harmful"? Assuming HIs to represent the sum of toxic units (Specific Comment 15, above), anything greater than 1 should be cause for concern. Is it that some "redundancy" in the toxicity of individual contaminants is expected?	There was a consensus among the REEFEX TWG members on how to apply the evaluation criteria used in the SERA. The evaluation was based on the interpretation that "Moderate likelihood that exposure is harmful" was cause for concern, and would result in a higher conclusion of risk.
18	I recommend striking the words "most sensitive" from the TSV and Bcv HI interpretations on p. 5-10 based on Specific Comment 8 above.	Suggested revision has been made.
19	With reference to decision criteria (Section 5.4.5), Table 12 seems to be incomplete in my copy. To what do the column headings (less, similar, greater) refer? Reference levels?	Column heading of "Is exposure greater than Reference and Background?" has been added to Table 12.
	Section 6. Results and Discussion	
20	Supplemental Fish Sampling – Even with the issue raised in Specific Comment 1 as a backdrop, suggestive findings associated with the supplemental fish sampling are the differences in fish sizes (length, weight), liver weights, hepatosomatic index (HSI), lipid content, total PCBs and lipid-normalized total PCBs between target and reference reefs (pp. 6-2–6-4). The REEFEX SERA reports findings of: - significantly larger vermilion snapper from the target reef, but no differences between reefs for black sea bass or white grunt - significantly heavier livers for all three species from the target reef· - significantly higher percent lipid contents for target reef black sea bass and white grunt, but not vermilion snapper - significantly higher total PCBs in all three species from the target	The Section 6.1.2 has been revised to include the following result: "For the supplemental fish samples, there was a statistically significant correlation ($p \leq 0.05$) between HSI and total PCB measured in white grunt ($r=0.47$) and black sea bass samples ($r=0.63$) but not for vermilion snapper. For all fish data HSI was significantly correlated ($p \leq 0.05$) to log(tPCB) ($r = 0.57$), lipid content ($r = 0.54$) and total length ($r = 0.21$). Liver weight was significantly ($p \leq 0.05$) correlated to age ($r = 0.67$), length ($r = 0.65$), PCB levels ($r = 0.64$), and lipid content ($r = 0.44$)."

	reef· - significantly higher lipid-normalized total PCBs for target reef vermilion snapper and white grunt, but not for black sea bass (note: after log-transformation, lipid-normalized total PCBs in black sea bass were actually significantly lower at the reference reef) · - significantly higher HSI for all three species from the target reef - "little" correlation between HSI and total PCBs in all three species	
20a	In sum, there was evidence that fish at the target reef were different from fish at the reference reef. The REEFEX SERA offers a number of potential explanations for these differences, including that: differences in lipid content are suggested to be caused by "significant differences in the diets of the fish or availability of food on the two reefs" (p. 6-3); some of the differences in total PCB concentrations "could be caused by...higher lipid levels [of target reef fish]" (p. 6-3); "PCBs accumulated through different routes of exposure" for target and reference fish, because "lipid content did not correlate very well with total PCB concentrations" (p. 6-3); elevated HSIs may have been due to exposure to contaminants other than PCBs, or may reflect reproductive differences among females; and elevated HSIs were not caused by PCB accumulation because HSI and total PCBs were not well correlated (or rather, were "little correlated"). All of this is summarized on p. 6-4 as:	The following analysis was conducted and added to the report. "Correlation and regression analysis of the supplemental fish data were conducted to evaluate the relationships between body weight, age, liver weight, %lipid content, tPCB concentrations, and HSI. Bivariate regressions with whole fish body weight, lipid content and HSI as the dependent variables were conducted for all fish, each species (VS, WG, and BSB), and each species-site group (target and reference). The regression coefficient (r^2) and regression equation ($y = mx + b$) were reported for each regression equation with a slope significantly different than zero ($p \leq 0.05$). A step-wise multivariate regression of all fish data was also performed to identify the variables, including "dummy variables" for site, species, and sex, that contributed to explaining the variance in HSI." The results of this analysis are provided for review (see Appendix_4C_.xls)

20b	"The differences in PCBs [sic] levels may be related to the physical differences...in fish sampled from the two sites." Although I think most of the explanations offered are plausible (if somewhat ad hoc), I also think the existing (fillet) data can tell us more about the story. I've taken the liberty of analyzing portions of the data set for white grunt (only) further, using the information provided in Appendices 4.1 and 4.2 (AYXS data). Notably (combining both target and reference reef fish; all reported correlations are significant at $p \leq 0.05$): · white grunt % lipid (dry) correlated ($r = 0.591$) with fish dry weight (g) · white grunt lipid weight (g) calculated from the percent lipids of dry total fish weight (g) correlated strongly ($r = 0.901$) with fish dry weight · white grunt HSI correlated ($r = 0.459$) with total PCBs · white grunt HSI correlated ($r = 0.547$) with log(lipid-normalized total PCBs) · white grunt total PCBs correlated strongly ($r = 0.730$) with lipid weight (g) calculated from the percent lipids of dry total fish weight (g), and white grunt total PCBs correlated ($r = 0.609$) with % lipid wet weight	A similar analysis was conducted for vermilion snapper (VS) and black seabasss (BSB) and will be included in the revised report. (see Appendix_4C_.xls)
20c	Thus, bigger fish have higher concentrations of lipids than do smaller fish, and because total PCBs correlated with lipid weight, bigger fish likely have higher concentrations of total PCBs than do smaller fish. This last relationship is shown in Fig. 1 (attached), which distinguishes between target reef (open squares) and reference reef (closed circles) fish. For each reef, log(total PCBs) increases in apparent linear fashion, indicating that bigger fish have higher concentrations of total PCBs than do smaller fish. To be clear, this means that for a gram of fish tissue, bigger fish have more PCBs than do smaller fish. Although this is not an unexpected phenomenon for bioaccumulative organic chemicals (like PCBs), I did not see this last relationship evaluated in the REEFEX SERA.	A similar relationship was also found for VS and BSB, although the separation between reference and target reef was not as strong as that observed for WG. (see Appendix_4C_.xls). "There was a significant increase ($p<0.05$) in whole body Log(tPCB) as a function of body weight for the combined reefs for white grunt, vermilion snapper, and black sea bass with a regression coefficient (r^2) of 0.16, 0.23, and 0.32, respectively (see Appendix_4C_.xls Table 1, Figs 5a, 5b, and 5c). For all fish from the combined reefs, Log(tPCB) increased in a linear fashion, indicating that bigger fish had higher concentrations of total PCBs than did smaller fish. The vermilion snapper from the target reef were significantly larger than the reference reef and they had significantly higher PCBs as well (Figure 13, Table 13). The white grunt and black sea bass from the target reef were also larger than the reference reef (Figure 13, Table 14 and Table 15) and the largest fishes with the highest PCB levels were caught from the target reef."
20d	More telling in this figure is that for a given size of white grunt, target reef fish have higher concentrations of PCBs than do reference reef fish (I did not bother to test for differences in slope and intercept).	A similar analysis was conducted for VS and BSB (see Appendix_4C_.xls). "A significant positive regression ($p<0.05$) with an r^2 of 0.16 was obtained for all fish from both reefs between body weight and Log(tPCB/Lipid) (see Appendix_4C_.xls Table 1). The regression of data for white grunt from both

	This was reported indirectly in the REEFEX SERA (SERA Finding d, above) as differences in mean concentration. However, in contrast to that reported in the REEFEX SERA for all fish, there is a significant correlation between (combined reef) white grunt total PCBs and lipid content (r = 0.609 on a % lipid wet weight basis), and the relationships appear to differ between the two reefs (Fig. 2, attached), such that for a given fish size, target reef white grunt generally have higher total PCB concentrations per gram of lipid than do reference fish.	reefs showed a significant positive slope with an r^2 of 0.15 for increasing PCB levels in larger white grunt and the relationship appeared to differ between the two reefs (see Appendix_4C_.xls Fig. 6b), such that for a given fish size, target reef white grunt generally had higher total PCB concentrations per gram of lipid than did reference white grunt. A significant positive slope ($p < 0.05$) was also detected for vermilion snapper from the combined reefs (r^2=0.23) and target reef (r^2=0.22), which was probably due to the fact that smaller fish with less PCB were sampled from the reference reef (see Appendix_4C_.xls Fig. 6a). The black sea bass data did not show the same trend, instead Log(tPCB/Lipid) levels in black sea bass were independent of body weight (see Appendix_4C Fig. 6c)"
20e	The REEFEX SERA acknowledges elevated HSI to be an indicator of pollution-related stress (pp. 6-3–6.4). Because (combined reef) white grunt HSI correlated positively (r = 0.547) with log(lipid-normalized total PCBs) (shown graphically in Fig. 3, attached), and target reef fish have higher concentrations of total PCBs (lipid-normalized or not), PCBs cannot be dismissed as a potential cause for the difference in HSI between reefs (SERA Finding f, above).	"The HSI measured in fish from the target reef was significantly higher than fish from the reference reef for all three species (Figure 20). A linear regression between whole body Log(tPCB/Lipid) and HSI for all fish from the combined reefs showed a significant positive slope, but with a very low regression coefficient (r^2=0.05) (see Appendix_4C Table 1). For white grunt from the combined reefs the regression showed a significant positive slope, an r^2 of 0.29, and the relationship appeared to differ between the two reefs (see Appendix_4C Fig. 9b). The opposite relationship was observed for black sea bass, which had a significant negative slope and an r^2 of 0.23 indicating that HSI decreased in black sea bass with higher PCB per unit lipid (see Appendix 4C Fig. 9c). The relationship between whole body Log(tPCB/Lipid) and HSI was not significant for vermilion snapper, however there was a clear separation between reference and target reef fish, the vermilion snapper from the target reef had higher HSI than reference vermilion snapper for the same PCB per unit lipid (see Appendix 4C Fig. 9a)." "A step-wise multivariate regression of all fish data was performed to identify the variables that contributed to explaining the variance in HSI. The model assumed that the independent variables were equally weighted, including dummy variables for site, species, and sex. The stepwise multivariate regression of all fish data for HSI resulted in the equation: HSI = 0.01214 + 0.0066(***SITEVAR***) + 0.01785(***W_LPCB***) - 0.10508(***F_LPCBL***) + 0.08696(***W_LPCBL***) + 0.00053(***AGE***) The result of stepwise multiple regressions indicated that site was the most important variable for explaining the variance in HSI for all fish data combined (r^2 = 0.48). The regression also indicated that there was a positive relationship between HSI and whole body Log(tPCB), whole body Log(tPCB/lipid), and age and a negative relationship between HSI and fillet Log(tPCB/Lipid). While this analysis does not demonstrate a cause-and-effect relationship between PCB exposure and elevated HSI, it does suggest that PCB exposure may contribute to

		elevated HSI." (see Reg_Analysis.xls)

Name	VARIABLE	COEF.	STD ERROR	T	P	r^2*
	CONSTANT	0.01214	0.00299	4.06	0.00010	
Site	SITEVAR	0.00660	0.00123	5.37	0.00000	0.4778
Whole body Log(tPCB)	W_LPCB	0.01785	0.00229	7.78	0.00000	0.0652
Fillet Log(tPCB/lipid)	F_LPCBL	-0.10508	0.01464	-7.18	0.00000	0.0595
Whole Body Log(tPCB/lipid)	W_LPCBL	0.08696	0.01259	6.91	0.00000	0.0177
Age	AGE	0.00053	0.00026	2.01	0.04660	0.0121

* Variance in HSI explained when variable first entered into the regression

20f	Section 6.1.2 (and elsewhere) offers that "...the differences in contaminant levels and physiology of the fish populations sampled at the reefs may have more to do with the availability of food and foraging behavior on the reefs than on uptake of chemicals" (p. 6-4). Very little evidence is offered in the REEFEX SERA to support this speculation. Regardless, it is difficult for me to see how an increase in food availability or differences in foraging behavior would alter interpretation of the fact that fish associated with the ex-VERMILION had higher concentrations of PCBs. Further, wouldn't it be logical to assume that any food availability-modifying aspects of the ex-VERMILION would also be associated with other reefed Navy vessels?	The sentence noted has been deleted. The conclusions for the supplemental fish section will be revised to incorporate the additional statistical analysis noted above.
20e	Section 6.1.3 of the REEFEX SERA summarizes differences found between fish from the two reefs, and concludes with the speculation that "The differences in PCBs [sic] levels may be related to the physical differences found in the fish sampled from the two sites." Given the new analyses above, the converse, i.e., that differences in PCB levels may be the cause of the physical differences in white grunt (at least), appears equally likely. Similar analyses involving the vermilion snapper and black sea bass data might be instructive.	The sentence noted has been deleted. The conclusions for the supplemental fish section has been revised to read: "There were physical and physiological differences between the fish from the reference and target reefs. Fish from the target reef had larger livers, higher HSI, and more lipids (fish from the reference reef had significantly less lipid content). On a dry weight basis, there were significantly higher PCB levels in black sea bass, vermilion snapper, and white grunt sampled from the target reef."
20f	How use of whole body burden data would affect either the REEFEX SERA results or the new analyses above is not totally clear. Certainly, it would increase the levels of total PCBs and lipids measured in all fish. Whether this would change the number of exceedances of benchmarks remains to be seen. However, given the results of the new analyses (particularly those involving the	The estimates of whole body tissue analysis, and the uncertainty of such estimates, have been added to the report. The whole body concentration was also compared to the benchmarks. The calculations for whole body tissue residues are higher than the estimates derived solely from analysis of fillets. Because the fillets were analyzed with "skin on" the increases were not drastic (see Regression analysis of Fig. 10a, 10b, 10c)

	relationships between lipids and total PCBs), it is reasonable to speculate that the differences between fish from the two reefs would be magnified.	(see _Regression_analysis_of Fig. 10a, 10b, 10c).
21.	Comments concerning the relevance of sediment samples taken from the ex-ARGERHOLM to either a generic risk assessment or the specific ex-Vermilion risk assessment (see General Comment 1) have been offered by previous reviewers. Although modeling approaches could be used to provide additional sediment information relative to shallow reefs, the ex-ARGERHOLM data apparently are the only actual measurements that exist. I believe their use in the REEFEX SERA is appropriate, but would ascribe a low level of confidence to any associated results. However, I don't necessarily agree with the all of reasons posited in the REEFEX SERA for "a fair amount of uncertainty" in using the SINKEX data (p. 6-7). For example, the contribution of "other sources of coastal pollution at the shallow water reef" (2nd paragraph on p. 6-7) is essentially irrelevant, because the SINKEX data were not compared to shallow-water ex-Navy reef sediments. In fact, that the ex-ARGERHOLM is thought to be isolated (by depth and location) from other pollution sources suggests that any contaminant signal detected around the ship would be due solely to the presence of the ship, and not to other sources. Thus (ignoring for the moment the depth-related physical and chemical differences between the sites, and the undocumented level of contaminants remaining on either ship), data from the ex-ARGERHOLM might be viewed as fairly representative of sunken ex-Navy vessels. I also think that the statement concerning the relevance of ERLs and ERMs (3rd paragraph on p. 6-7) is without basis. The empirical methods used by Ed Long and colleagues make no assumptions about habitat use (e.g., deep water versus near coastal) by test organisms – they used whatever data they could get that met their quality assurance screening – and I am aware of no a priori reason to assume differences in susceptibility to chemicals related to depth of habitat. Besides, the point is not relevant, because no organisms from either SINKEX or REEFEX were actually tested. Finally, with the exception of its last sentence, I find the entire last paragraph of Section 6.2.2 irrelevant to the use of the SINKEX sediment data in this assessment.	The section has been revised to address the comments noted. The following summary has been included in Section 6.2.2. "Biological tests conducted for the sediments from the ex-AGERHOLM (SINKEX, Gauthier et al. 2003) showed "no significant difference" between the Inner Ring (3 m from ship) and Outer Ring (1 km from ship). Toxicity tests conducted for the SINKEX site included 10-day *Rhepoxynius* (Survival* and Reburial) and 28-day *Neanthes* (Survival and Growth+). Bioaccumulation tests (28-d) were also conducted for *Nephtys* and *Macoma*, which showed no significant difference in PCB bioaccumulation between the Inner Ring and Outer Ring. Notes: *10% survival difference was statistically different, but did not meet Green Book species-specific requirements to show a 20% difference, based on inherent variability in response of this particular species. + Large difference in Zero Time size of test organisms caused uncertainty in results, but worms from the Inner Ring grew faster, relative to control worms, than those of the Outer Ring. " Statement about the relevancy of ERLs and ERMs has been deleted. See summary of toxicity tests conducted for SINKEX, above.
22.	For the reasons given in Specific Comment 8 above, the TSV benchmark is not protective of all aquatic species (see first paragraph of Section 6.3.2 on p. 6-12).	Sentence has been revised to read: "Generally, the TSV benchmark (Dyer et al. 2000, Shepard 1998) was the most conservative benchmark."

	Section 7. Literature Review – not reviewed	
	Section 8. Uncertainty	
23.	Although it provides interesting information about comparative studies among reefs, and is relevant to reefing decisions, this section have very little to do with the uncertainties of the REEFEX SERA. The only discussion directly pertinent to the toxicological risks of reefed ex-Navy vessels occurs at the very end of the section, and even that is primarily a restatement of the conclusions offered earlier in the report. I am surprised that no mention of the supplement fish sampling issue was made – to me, this is one of the more critical sources of error in the entire REEFEX SERA. Like much of the individual discussions of uncertainties provided in Section 6, I didn't find that the narrative analysis here added much to understanding the strengths and limitations of the REEFEX SERA due to its lack of quantitative rigor.	The uncertainty section has been revised to provide a more comprehensive discussion on the uncertainty associated with the SERA and incorporates the points raised.
24.	It is important to remember that the samples collected and analyzed in support of the REEFEX SERA are just that – samples taken from natural populations existing at the time of collection. There are at least three implications of this fact that are relevant to considerations of uncertainty:	The issues raised have been incorporated into the discussion about uncertainty.
24a	·The degree to which the supplemental fish samples adequately represent the sampled reef populations is a function primarily of the sampling (and analysis) design. I have not yet had the opportunity to review this design in detail, but I note from the meeting minutes of the 28 June 2000 REEFEX TWG that multiple methods were employed to obtain fish, including baited traps, hook-and-line, and diver spearfishing. Each of these methods are known to introduce biases relative to the representativeness of the samples they collect. As an obvious example, diver spearfishing likely samples selectively for larger fish. Other sampling effects apparently were discussed during the referenced REEFEX TWG meeting as possible explanations for patterns in the sample sets. The issue here is that the representativeness of those samples is largely undocumented. It is an oversimplification to assume that sampling biases applied equally to the two reefs, as the realization of any biases can be a function of the populations sampled themselves. To illustrate, if the distribution of the sizes of individual black sea bass on one of the reefs was skewed (relative to that of the other reef) towards smaller sizes, the	Discussion about the uncertainty associated with fish sampling methods will be included in the revised report.

	spearfishing method would obtain more (and presumably larger) fish from the other reef. Of course, sampling bias can play out differently among species as well. Unquantified sampling bias is one reason why comparisons of fish sizes and abundances between reefs is fairly meaningless in the REEFEX SERA, but it also is a reason why appropriate control of covariates (such as size) is important when evaluating the similarities and differences in tissue residues, liver sizes, and so on.	
24b	· Even if we assume that the samples adequately represent the natural populations that existed at the time of collection, the resulting data only reflect a "snapshot in time." That is, the invertebrates and fish actually collected were those that survived the toxicological and ecological processes that preceded sample collection. The implication of this fact may be subtle, yet is potentially meaningful: individual organisms that had already died due to toxic effects (or, in fact, were never born due to reproductive effects experienced by their would-be parents) would not be represented in the samples collected. The tissue residue-based screening approaches used in the REEFEX SERA presumably controlled for this phenomenon to some extent (in their use of conservative effects thresholds), but the actual sample data sets which were compared against the residue-based benchmarks may have been biased towards lower residue levels. This is because individual organisms with sufficiently high residues (i.e., either as a function of higher exposures or of higher accumulation rates resulting from individual variability) were already dead.	The following discussion has been added to the Uncertainty Section. "Assuming that the samples adequately represent the natural populations present at the time of collection, the resulting data are only a "snapshot in time." That is, the invertebrates and fish actually collected were those that survived any potential toxicological and ecological processes that preceded sample collection. The tissue residue-based screening approaches controlled for this phenomenon to some extent (by using conservative effects thresholds), but the actual sample data sets which were compared against the residue-based benchmarks may have been biased towards lower residue levels."
24c	· Of course, the number of samples in a data set, together with biases reflected in that data set, determine the accuracy and precision of descriptions of the sampled population. Screening criteria that rely on the evaluations of the number of data points that fall below or above some value, like those developed in the REEFEX SERA for fish and invertebrate tissue residues (p 5-10), are sensitive to this accuracy and precision. Thus, there is some level of as-yet unquantified uncertainty associated with interpretation of a result like (Figure 37): 0 Cd - invertebrate observations above the BCV, 10 observations above the LOED, 12 observations at or above the NOED, 17 observations above the TSV, and 4 observations at or below the DL. The actual risks of exceeding any of these benchmarks might be represented by the number of exceeding observations, but overall sample size and inherent biases confound the confidence in results. Quantitative methods exist with which to resolve some of this	An analysis of the probability of exceeding a benchmark will be calculated for COCs that exceeded the initial screening level to provide some quantitative rigor to support management decisions that will be based on the results of the risk assessment.

	uncertainty (hypothesis testing to determine underlying distributions, corrections for known bias, etc.), and probabilistic methods like those used in Johnston et al. (2001, cited in the REEFEX SERA) can be used to quantify exceedance probabilities. Although I am not advocating full-blown probabilistic analyses in this screening-level assessment, such analyses can add rigor to the evaluation.	
24c	I have no a priori sense of the importance of these issues to the REEFEX SERA conclusions. However, the document provides little analysis or discussion of them. Although I am not advocating an endless series of increasingly-sophisticated analyses that delve into such issues, I do think that acknowledgment and exploration of these uncertainties is in order. It is up to the deliberative process to determine whether additional quantitative analysis is needed.	The uncertainty section has been revised to provide a more comprehensive discussion on the uncertainty associated with the SERA and incorporates the points raised.
	Section 9. Conclusions and Recommendations	
25	I note that Section 9 concludes summarily with the statement (p. 9-2) that "Based on the findings of negligible to low ecological risk of exposure to PCBs, creating artificial reefs with former Navy vessels containing PCBs in solid materials will not pose an unacceptable risk to the environment." Even without consideration of the problems associated the supplemental fish residue data, this conclusion strikes me as overstated for three reasons. First, it disregards the amount of PCBs on individual ex-Navy ships, apparently assuming that all ships will be like the ex-Vermilion (and ex-ARGERHOLM). Second, as a final conclusion it seemingly disregards the evidence associated with other COCs. And third, it assumes that no further assessment of risks is necessary. With respect to this last, it's interesting to note that the authors acknowledge in Section 2 and elsewhere that the SERA may indicate the need for additional assessment of ecological risk (e.g., from p. 6-13, "If a TSV is exceeded it does not necessarily mean that an observed tissue concentrations [sic] poses an adverse risk to biota, rather it indicates that the chemical requires a more detailed evaluation in later phases of the ecological risk assessment" – italics mine). I do not know whether consensus decisions were made in the REEFEX TWG about what would trigger additional assessment, but from Figure 51 I do note that risks of exposure inferred from fish tissue residues for Cd - demersal fish and for Pb - zooplankton fell in the lower right hand quadrant of the decision matrix (indicating elevated exposure that may be harmful), and that the currently reported total PCB concentrations in some white grunt exceeded the TSV by substantial amounts, even though those concentrations tell only part of the story. Do these findings warrant additional attention?	The conclusions section has been revised to accurately summarize the key findings of the risk assessment and incorporate the results of additional analysis conducted for COCs that exceeded initial screening levels. Future ships to be reefed will be cleaned in conformance with the "Best Management Practices for Preparing Vessels for Use as Artificial Reefs" (U.S. EPA 2004). The risk management decisions to remove solid materials containing PCBs with high leaching rates would be based on the potential risk predicted by the Prospective Risk Assessment Model (PRAM) following the process being developed for risk-based disposal of ex-Navy vessels.

Appendix 2. Raw Data for Fish and Invertebrates from "Levels of PCBs and Heavy Metals in Biota Found on ex-Military Ships Used as Artificial Reefs", Draft Report, by R.M. Martore, T.D. Mathews, and M. Bell, 1998. Marine Resources Division, South Carolina Marine Resources Center, South Carolina Department of Natural Resources, Charleston, SC, 26pp.

APPENDIX 2:
Raw Data for Fish and Invertebrates from “Levels of PCBs and Heavy Metals in Biota Found on ex-Military Ships Used as Artificial Reefs”, Draft Report, by R.M. Martore, T.D. Mathews, and M. Bell, 1998.

						dw_fish=	0.25		
						dw_invert=	0.2		
							ng/g dry	ng/g dry	
Endpoint	**name**	**species**	**group**	**site**	**rep**	**analyte**	**ConcDry**	**ConcWet**	**flag**
INVERTEBRATE	Sponge1	Haliclona sp	navy	Besty Ross	1	PCB	25	5	ND
INVERTEBRATE	Sponge2	Ircinai sp.	navy	Besty Ross	1	PCB	25	5	ND
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Besty Ross	1	Cd	4910	982	
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Besty Ross	2	Cd	3545	709	
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Besty Ross	1	Cr	4470	894	
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Besty Ross	2	Cr	2485	497	
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Besty Ross	1	Cu	5750	1150	
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Besty Ross	2	Cu	7750	1550	
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Besty Ross	1	Pb	3990	798	
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Besty Ross	2	Pb	4090	818	
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Besty Ross	1	PCB	25	5	ND
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Besty Ross	2	PCB	25	5	ND
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Besty Ross	3	PCB	25	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	1	Cd	10	2.5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	2	Cd	10	2.5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	3	Cd	10	2.5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	4	Cd	10	2.5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	1	Cr	548	137	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	2	Cr	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	3	Cr	1052	263	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	4	Cr	1272	318	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	1	Cu	472	118	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	2	Cu	576	144	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	3	Cu	1024	256	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	4	Cu	456	114	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	1	Mn	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	2	Mn	444	111	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	3	Mn	992	248	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	4	Mn	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	1	Ni	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	2	Ni	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	3	Ni	472	118	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	4	Ni	464	116	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	1	Pb	472	118	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	2	Pb	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	3	Pb	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	4	Pb	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	1	PCB	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	2	PCB	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	3	PCB	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	4	PCB	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	5	PCB	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	6	PCB	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	7	PCB	200	50	<LOQ
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	8	PCB	200	50	<LOQ
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	central contı	9	PCB	1348	337	
INVERTEBRATE	Crested Oyster	Ostreola equestris	reference	central contı	1	PCB	25	5	ND
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	reference	central contı	1	Cd	12.5	2.5	ND
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	reference	central contı	1	Cr	525	105	
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	reference	central contı	1	Cu	226500	45300	
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	reference	central contı	1	Mn	9550	1910	
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	reference	central contı	1	Ni	25	5	ND
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	reference	central contı	1	Pb	455	91	
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	reference	central contı	1	PCB	500	100	
DEMERSAL FISH	Gag Grouper	Mycteroperca microlepis	reference	central contı	1	Cd	10	2.5	ND
DEMERSAL FISH	Gag Grouper	Mycteroperca microlepis	reference	central contı	1	Cr	784	196	
DEMERSAL FISH	Gag Grouper	Mycteroperca microlepis	reference	central contı	1	Cu	648	162	
DEMERSAL FISH	Gag Grouper	Mycteroperca microlepis	reference	central contı	1	Mn	20	5	ND
DEMERSAL FISH	Gag Grouper	Mycteroperca microlepis	reference	central contı	1	Ni	20	5	ND
DEMERSAL FISH	Gag Grouper	Mycteroperca microlepis	reference	central contı	1	Pb	20	5	ND
DEMERSAL FISH	Gag Grouper	Mycteroperca microlepis	reference	central contı	1	PCB	20	5	ND
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	reference	central contı	1	Cd	10	2.5	ND
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	reference	central contı	1	Cr	5600	1400	
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	reference	central contı	1	Cu	496	124	
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	reference	central contı	1	Mn	860	215	
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	reference	central contı	1	Ni	544	136	
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	reference	central contı	1	Pb	20	5	ND
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	reference	central contı	1	PCB	20	5	ND
DEMERSAL FISH	Hake	Urophycis sp.	reference	central contı	1	Cd	1364	341	
DEMERSAL FISH	Hake	Urophycis sp.	reference	central contı	1	Cr	1840	460	
DEMERSAL FISH	Hake	Urophycis sp.	reference	central contı	1	Cu	200	50	
DEMERSAL FISH	Hake	Urophycis sp.	reference	central contı	1	Pb	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central contı	1	Cd	10	2.5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central contı	2	Cd	460	115	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central contı	3	Cd	10	2.5	ND

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Endpoint	name	species	group	site	rep	analyte	ConcDry	ConcWet	flag
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	1	Cr	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	2	Cr	360	90	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	3	Cr	804	201	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	1	Cu	652	163	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	2	Cu	1432	358	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	3	Cu	324	81	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	1	Mn	436	109	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	2	Mn	1612	403	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	3	Mn	524	131	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	1	Ni	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	2	Ni	436	109	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	3	Ni	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	1	Pb	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	2	Pb	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	3	Pb	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	1	PCB	200	50	<LOQ
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	2	PCB	200	50	<LOQ
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	3	PCB	200	50	<LOQ
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	central conti	4	PCB	20	5	ND
DEMERSAL FISH	Queen Angelfish	Holacanthus ciliaris	reference	central conti	1	Cd	10	2.5	ND
DEMERSAL FISH	Queen Angelfish	Holacanthus ciliaris	reference	central conti	1	Cr	2208	552	
DEMERSAL FISH	Queen Angelfish	Holacanthus ciliaris	reference	central conti	1	Cu	572	143	
DEMERSAL FISH	Queen Angelfish	Holacanthus ciliaris	reference	central conti	1	Mn	20	5	ND
DEMERSAL FISH	Queen Angelfish	Holacanthus ciliaris	reference	central conti	1	Ni	1192	298	
DEMERSAL FISH	Queen Angelfish	Holacanthus ciliaris	reference	central conti	1	Pb	20	5	ND
DEMERSAL FISH	Queen Angelfish	Holacanthus ciliaris	reference	central conti	1	PCB	20	5	ND
DEMERSAL FISH	Red Grouper	Epinephelus morio	reference	central conti	1	Cd	10	2.5	ND
DEMERSAL FISH	Red Grouper	Epinephelus morio	reference	central conti	1	Cr	388	97	
DEMERSAL FISH	Red Grouper	Epinephelus morio	reference	central conti	1	Cu	988	247	
DEMERSAL FISH	Red Grouper	Epinephelus morio	reference	central conti	1	Mn	20	5	ND
DEMERSAL FISH	Red Grouper	Epinephelus morio	reference	central conti	1	Ni	400	100	
DEMERSAL FISH	Red Grouper	Epinephelus morio	reference	central conti	1	Pb	20	5	ND
DEMERSAL FISH	Red Grouper	Epinephelus morio	reference	central conti	1	PCB	200	50	<LOQ
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	1	Cd	10	2.5	ND
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	2	Cd	10	2.5	ND
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	1	Cr	20	5	ND
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	2	Cr	596	149	
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	1	Cu	676	169	
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	2	Cu	688	172	
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	1	Mn	20	5	ND
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	2	Mn	20	5	ND
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	1	Ni	20	5	ND
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	2	Ni	564	141	
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	1	Pb	20	5	ND
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	2	Pb	20	5	ND
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	1	PCB	20	5	ND
DEMERSAL FISH	Scamp	Mycteroperca phenax	reference	central conti	2	PCB	464	116	
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	reference	central conti	1	Cd	8350	1670	
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	reference	central conti	1	Cr	545	109	
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	reference	central conti	1	Cu	7950	1590	
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	reference	central conti	1	Mn	2970	594	
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	reference	central conti	1	Ni	25	5	ND
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	reference	central conti	1	Pb	25	5	ND
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	reference	central conti	1	PCB	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Comanche	1	Cd	2755	551	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Comanche	1	Cr	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Comanche	1	Cu	2900	580	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Comanche	1	Mn	11150	2230	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Comanche	1	Ni	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Comanche	1	Pb	1525	305	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Comanche	1	PCB	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Comanche	2	PCB	25	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Comanche	1	Cd	10	2.5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Comanche	1	Cr	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Comanche	1	Cu	360	90	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Comanche	1	Mn	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Comanche	1	Ni	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Comanche	1	Pb	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Comanche	1	PCB	20	5	ND
INVERTEBRATE	Common American Auger	Terebra dislocata	other	Comanche	1	Cd	12.5	2.5	ND
INVERTEBRATE	Common American Auger	Terebra dislocata	other	Comanche	1	Cr	25	5	ND
INVERTEBRATE	Common American Auger	Terebra dislocata	other	Comanche	1	Cu	68000	13600	
INVERTEBRATE	Common American Auger	Terebra dislocata	other	Comanche	1	Mn	6800	1360	
INVERTEBRATE	Common American Auger	Terebra dislocata	other	Comanche	1	Ni	25	5	ND
INVERTEBRATE	Common American Auger	Terebra dislocata	other	Comanche	1	Pb	6150	1230	
INVERTEBRATE	Common American Auger	Terebra dislocata	other	Comanche	1	PCB	880	176	
INVERTEBRATE	Crested Oyster	Ostreola equestris	other	Comanche	1	PCB	25	5	ND
INVERTEBRATE	Purse Shell	Isognomon sp	other	Comanche	1	PCB	25	5	ND

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Endpoint	name	species	group	site	rep	analyte	ConcDry	ConcWet	flag
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	Cd	12.5	2.5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	2	Cd	14700	2940	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	Cr	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	2	Cr	570	114	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	Cu	3570	714	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	2	Cu	3185	637	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	Mn	6250	1250	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	2	Mn	11400	2280	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	Ni	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	2	Ni	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	Pb	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	2	Pb	725	145	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	PCB	950	190	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	Cd	2525	505	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	2	Cd	12.5	2.5	ND
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	Cr	5500	1100	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	2	Cr	25	5	ND
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	Cu	20500	4100	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	2	Cu	38500	7700	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	Mn	60500	12100	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	2	Mn	123000	24600	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	Ni	25	5	ND
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	2	Ni	25	5	ND
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	Pb	4210	842	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	2	Pb	1900	380	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	PCB	1160	232	
INVERTEBRATE	Crested Oyster	Ostreola equestris	other	Eagle's Nes	1	Cd	12.5	2.5	ND
INVERTEBRATE	Crested Oyster	Ostreola equestris	other	Eagle's Nes	1	Cr	25	5	ND
INVERTEBRATE	Crested Oyster	Ostreola equestris	other	Eagle's Nes	1	Cu	520000	104000	
INVERTEBRATE	Crested Oyster	Ostreola equestris	other	Eagle's Nes	1	Mn	12650	2530	
INVERTEBRATE	Crested Oyster	Ostreola equestris	other	Eagle's Nes	1	Ni	25	5	ND
INVERTEBRATE	Crested Oyster	Ostreola equestris	other	Eagle's Nes	1	Pb	25	5	ND
INVERTEBRATE	Crested Oyster	Ostreola equestris	other	Eagle's Nes	1	PCB	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	Cd	2855	571	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	2	Cd	18250	3650	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	3	Cd	5400	1080	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	Cr	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	2	Cr	5550	1110	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	3	Cr	1300	260	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	Cu	6250	1250	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	2	Cu	10050	2010	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	3	Cu	5550	1110	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	Mn	13750	2750	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	2	Mn	36000	7200	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	Ni	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	2	Ni	4190	838	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	Pb	1265	253	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	2	Pb	5650	1130	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	3	Pb	4710	942	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	1	PCB	540	108	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	2	PCB	840	168	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Eagle's Nes	3	PCB	250	50	<LOQ
INVERTEBRATE	Arc Shell	Anadara sp.	other	Eagle's Nes	1	Cd	14700	2940	
INVERTEBRATE	Arc Shell	Anadara sp.	other	Eagle's Nes	1	Cr	1210	242	
INVERTEBRATE	Arc Shell	Anadara sp.	other	Eagle's Nes	1	Cu	1230	246	
INVERTEBRATE	Arc Shell	Anadara sp.	other	Eagle's Nes	1	Mn	297000	59400	
INVERTEBRATE	Arc Shell	Anadara sp.	other	Eagle's Nes	1	Ni	25	5	ND
INVERTEBRATE	Arc Shell	Anadara sp.	other	Eagle's Nes	1	Pb	905	181	
INVERTEBRATE	Arc Shell	Anadara sp.	other	Eagle's Nes	1	PCB	865	173	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Eagle's Nes	1	Cd	10	2.5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Eagle's Nes	1	Cr	812	203	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Eagle's Nes	1	Cu	500	125	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Eagle's Nes	1	Mn	856	214	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Eagle's Nes	1	Ni	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Eagle's Nes	1	Pb	548	137	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	other	Eagle's Nes	1	PCB	408	102	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	Cd	1060	212	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	Cr	18850	3770	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	Cu	62000	12400	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	Mn	174000	34800	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	Ni	25	5	ND
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	Pb	272500	54500	
INVERTEBRATE	Common Slipper Shell	Crepidula fornicata	other	Eagle's Nes	1	PCB	925	185	
INVERTEBRATE	Convex Slipper Shell	Crepidula convexa	other	Eagle's Nes	1	Cd	1090	218	
INVERTEBRATE	Convex Slipper Shell	Crepidula convexa	other	Eagle's Nes	1	Cr	3550	710	
INVERTEBRATE	Convex Slipper Shell	Crepidula convexa	other	Eagle's Nes	1	Cu	45900	9180	
INVERTEBRATE	Convex Slipper Shell	Crepidula convexa	other	Eagle's Nes	1	Pb	59500	11900	
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	other	Eagle's Nes	1	Cd	10	2.5	ND

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Endpoint	name	species	group	site	rep	analyte	ConcDry	ConcWet	flag
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	other	Eagle's Nes	1	Cr	532	133	
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	other	Eagle's Nes	1	Cu	840	210	
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	other	Eagle's Nes	1	Mn	828	207	
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	other	Eagle's Nes	1	Ni	408	102	
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	other	Eagle's Nes	1	Pb	624	156	
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	other	Eagle's Nes	1	PCB	200	50	<LOQ
DEMERSAL FISH	Hake	Urophycis sp.	other	Eagle's Nes	1	Cd	1064	266	
DEMERSAL FISH	Hake	Urophycis sp.	other	Eagle's Nes	1	Cr	1768	442	
DEMERSAL FISH	Hake	Urophycis sp.	other	Eagle's Nes	1	Cu	3556	889	
DEMERSAL FISH	Hake	Urophycis sp.	other	Eagle's Nes	1	Pb	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Eagle's Nes	1	Cd	1116	279	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Eagle's Nes	1	Cr	3980	995	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Eagle's Nes	1	Cu	928	232	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Eagle's Nes	1	Pb	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Eagle's Nes	1	PCB	20	5	ND
DEMERSAL FISH	Sheepshead	Archosargus probatocephalus	other	Eagle's Nes	1	Cd	10	2.5	ND
DEMERSAL FISH	Sheepshead	Archosargus probatocephalus	other	Eagle's Nes	1	Cr	552	138	
DEMERSAL FISH	Sheepshead	Archosargus probatocephalus	other	Eagle's Nes	1	Cu	816	204	
DEMERSAL FISH	Sheepshead	Archosargus probatocephalus	other	Eagle's Nes	1	Mn	2064	516	
DEMERSAL FISH	Sheepshead	Archosargus probatocephalus	other	Eagle's Nes	1	Ni	1144	286	
DEMERSAL FISH	Sheepshead	Archosargus probatocephalus	other	Eagle's Nes	1	Pb	816	204	
DEMERSAL FISH	Sheepshead	Archosargus probatocephalus	other	Eagle's Nes	1	PCB	200	50	<LOQ
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Edisto	1	Cd	1375	275	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Edisto	2	Cd	9900	1980	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Edisto	1	Cr	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Edisto	2	Cr	8100	1620	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Edisto	1	Cu	1435	287	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Edisto	2	Cu	10150	2030	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Edisto	1	Mn	4830	966	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Edisto	2	Mn	14000	2800	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Edisto	1	Ni	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Edisto	2	Ni	7650	1530	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Edisto	1	Pb	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Edisto	2	Pb	9000	1800	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Edisto	1	PCB	1055	211	
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	1	Cd	2500	500	
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	2	Cd	3155	631	
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	1	Cr	1645	329	
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	2	Cr	1155	231	
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	1	Cu	34150	6830	
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	2	Cu	28500	5700	
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	1	Mn	13350	2670	
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	2	Mn	10150	2030	
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	1	Ni	25	5	ND
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	2	Ni	25	5	ND
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	1	Pb	3555	711	
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	2	Pb	2000	400	
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	1	PCB	1125	225	
INVERTEBRATE	Atlantic Deer Cowrie	Cypraea cervus	other	Edisto	2	PCB	250	50	<LOQ
INVERTEBRATE	Florida Spiny Jewel Box	Arcinella comuta	other	Edisto	1	Cd	4850	970	
INVERTEBRATE	Florida Spiny Jewel Box	Arcinella comuta	other	Edisto	1	Cr	505	101	
INVERTEBRATE	Florida Spiny Jewel Box	Arcinella comuta	other	Edisto	1	Cu	4765	953	
INVERTEBRATE	Florida Spiny Jewel Box	Arcinella comuta	other	Edisto	1	Mn	2730	546	
INVERTEBRATE	Florida Spiny Jewel Box	Arcinella comuta	other	Edisto	1	Ni	2040	408	
INVERTEBRATE	Florida Spiny Jewel Box	Arcinella comuta	other	Edisto	1	Pb	1110	222	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	1	Cd	10	2.5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	2	Cd	10	2.5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	1	Cr	3748	937	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	2	Cr	788	197	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	1	Cu	1892	473	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	2	Cu	1360	340	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	1	Mn	116800	29200	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	2	Mn	9080	2270	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	1	Ni	7400	1850	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	2	Ni	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	1	Pb	2576	644	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	2	Pb	2976	744	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	1	PCB	716	179	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Edisto	2	PCB	200	50	<LOQ
DEMERSAL FISH	Bank Sea Bass	Centropristis ocyurs	reference	northern cor	1	Cd	10	2.5	ND
DEMERSAL FISH	Bank Sea Bass	Centropristis ocyurs	reference	northern cor	1	Cr	576	144	
DEMERSAL FISH	Bank Sea Bass	Centropristis ocyurs	reference	northern cor	1	Cu	780	195	
DEMERSAL FISH	Bank Sea Bass	Centropristis ocyurs	reference	northern cor	1	Mn	948	237	
DEMERSAL FISH	Bank Sea Bass	Centropristis ocyurs	reference	northern cor	1	Ni	520	130	
DEMERSAL FISH	Bank Sea Bass	Centropristis ocyurs	reference	northern cor	1	Pb	444	111	
DEMERSAL FISH	Bank Sea Bass	Centropristis ocyurs	reference	northern cor	1	PCB	200	50	<LOQ
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	northern cor	1	Cd	10	2.5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	northern cor	1	Cr	500	125	

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Endpoint	name	species	group	site	rep	analyte	ConcDry	ConcWet	flag
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	northern cor	1	Cu	920	230	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	northern cor	1	Mn	1344	336	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	northern cor	1	Ni	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	northern cor	1	Pb	464	116	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	reference	northern cor	1	PCB	200	50	<LOQ
INVERTEBRATE	Common American Auger	Terebra dislocata	reference	northern cor	1	Cd	8150	1630	
INVERTEBRATE	Common American Auger	Terebra dislocata	reference	northern cor	1	Cr	2695	539	
INVERTEBRATE	Common American Auger	Terebra dislocata	reference	northern cor	1	Cu	57000	11400	
INVERTEBRATE	Common American Auger	Terebra dislocata	reference	northern cor	1	Mn	1190000	238000	
INVERTEBRATE	Common American Auger	Terebra dislocata	reference	northern cor	1	Ni	22500	4500	
INVERTEBRATE	Common American Auger	Terebra dislocata	reference	northern cor	1	Pb	2540	508	
INVERTEBRATE	Florida Spiny Jewel Box	Arcinella comuta	reference	northern cor	1	Cd	7000	1400	
INVERTEBRATE	Florida Spiny Jewel Box	Arcinella comuta	reference	northern cor	1	Cr	2260	452	
INVERTEBRATE	Florida Spiny Jewel Box	Arcinella comuta	reference	northern cor	1	Cu	8450	1690	
INVERTEBRATE	Florida Spiny Jewel Box	Arcinella comuta	reference	northern cor	1	Mn	6300	1260	
INVERTEBRATE	Florida Spiny Jewel Box	Arcinella comuta	reference	northern cor	1	Ni	3360	672	
INVERTEBRATE	Florida Spiny Jewel Box	Arcinella comuta	reference	northern cor	1	Pb	2085	417	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	northern cor	1	Cd	10	2.5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	northern cor	1	Cr	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	northern cor	1	Cu	1568	392	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	northern cor	1	Mn	2996	749	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	northern cor	1	Ni	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	northern cor	1	Pb	1028	257	
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	reference	northern cor	1	PCB	200	50	<LOQ
DEMERSAL FISH	Scorpion fish	Scorpaenidae	reference	northern cor	1	Cd	10	2.5	ND
DEMERSAL FISH	Scorpion fish	Scorpaenidae	reference	northern cor	1	Cr	20	5	ND
DEMERSAL FISH	Scorpion fish	Scorpaenidae	reference	northern cor	1	Cu	20	5	ND
DEMERSAL FISH	Scorpion fish	Scorpaenidae	reference	northern cor	1	Mn	20	5	ND
DEMERSAL FISH	Scorpion fish	Scorpaenidae	reference	northern cor	1	Ni	468	117	
DEMERSAL FISH	Scorpion fish	Scorpaenidae	reference	northern cor	1	Pb	576	144	
DEMERSAL FISH	Scorpion fish	Scorpaenidae	reference	northern cor	1	PCB	200	50	<LOQ
DEMERSAL FISH	Oyster Toadfish	Opsanus tau	reference	southern co	1	PCB	20	5	ND
DEMERSAL FISH	Oyster Toadfish	Opsanus tau	reference	southern co	2	PCB	20	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	navy	Vermillion	1	Cd	3445	689	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	navy	Vermillion	1	Cr	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	navy	Vermillion	1	Mn	9550	1910	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	navy	Vermillion	1	Ni	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	navy	Vermillion	1	Pb	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	navy	Vermillion	1	PCB	1175	235	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	navy	Vermillion	2	PCB	25	5	ND
INVERTEBRATE	Atlantic Hairy Triton	Cymatium pileare	navy	Vermillion	1	Cd	12.5	2.5	ND
INVERTEBRATE	Atlantic Hairy Triton	Cymatium pileare	navy	Vermillion	2	Cd	12.5	2.5	ND
INVERTEBRATE	Atlantic Hairy Triton	Cymatium pileare	navy	Vermillion	1	Cr	575	115	
INVERTEBRATE	Atlantic Hairy Triton	Cymatium pileare	navy	Vermillion	2	Cr	545	109	
INVERTEBRATE	Atlantic Hairy Triton	Cymatium pileare	navy	Vermillion	1	Mn	4810	962	
INVERTEBRATE	Atlantic Hairy Triton	Cymatium pileare	navy	Vermillion	2	Mn	5350	1070	
INVERTEBRATE	Atlantic Hairy Triton	Cymatium pileare	navy	Vermillion	1	Ni	25	5	ND
INVERTEBRATE	Atlantic Hairy Triton	Cymatium pileare	navy	Vermillion	2	Ni	25	5	ND
INVERTEBRATE	Atlantic Hairy Triton	Cymatium pileare	navy	Vermillion	1	Pb	745	149	
INVERTEBRATE	Atlantic Hairy Triton	Cymatium pileare	navy	Vermillion	2	Pb	25	5	ND
INVERTEBRATE	Atlantic Hairy Triton	Cymatium pileare	navy	Vermillion	1	PCB	250	50	<LOQ
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	navy	Vermillion	1	Cd	10	2.5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	navy	Vermillion	1	Cr	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	navy	Vermillion	1	Mn	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	navy	Vermillion	1	Ni	20	5	ND
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	navy	Vermillion	1	Pb	3612	903	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	navy	Vermillion	1	PCB	200	50	<LOQ
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	navy	Vermillion	1	Cd	640	128	
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	navy	Vermillion	1	Cr	25	5	ND
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	navy	Vermillion	1	Mn	13350	2670	
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	navy	Vermillion	1	Ni	25	5	ND
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	navy	Vermillion	1	Pb	25	5	ND
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	navy	Vermillion	1	PCB	620	124	
DEMERSAL FISH	Gag Grouper	Mycteroperca microlepis	navy	Vermillion	1	Cd	1556	389	
DEMERSAL FISH	Gag Grouper	Mycteroperca microlepis	navy	Vermillion	1	Cr	3188	797	
DEMERSAL FISH	Gag Grouper	Mycteroperca microlepis	navy	Vermillion	1	Ni	20	5	ND
DEMERSAL FISH	Gag Grouper	Mycteroperca microlepis	navy	Vermillion	1	Pb	4640	1160	
DEMERSAL FISH	Gag Grouper	Mycteroperca microlepis	navy	Vermillion	1	PCB	20	5	ND
INVERTEBRATE	Sea Cucumber	Holothuroidea	navy	Vermillion	1	Cd	12.5	2.5	ND
INVERTEBRATE	Sea Cucumber	Holothuroidea	navy	Vermillion	1	Cr	600	120	
INVERTEBRATE	Sea Cucumber	Holothuroidea	navy	Vermillion	1	Mn	2690	538	
INVERTEBRATE	Sea Cucumber	Holothuroidea	navy	Vermillion	1	Ni	25	5	ND
INVERTEBRATE	Sea Cucumber	Holothuroidea	navy	Vermillion	1	Pb	835	167	
INVERTEBRATE	Sea Cucumber	Holothuroidea	navy	Vermillion	1	PCB	545	109	
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	navy	Vermillion	1	Cd	5300	1060	
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	navy	Vermillion	1	Cr	25	5	ND
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	navy	Vermillion	1	Mn	1470	294	
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	navy	Vermillion	1	Ni	25	5	ND

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Endpoint	name	species	group	site	rep	analyte	ConcDry	ConcWet	flag
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	navy	Vermillion	1	Pb	25	5	ND
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	navy	Vermillion	1	PCB	25	5	ND
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Vermillion	1	Cd	3795	759	
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Vermillion	1	Cr	25	5	ND
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Vermillion	1	Mn	6700	1340	
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Vermillion	1	Ni	25	5	ND
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Vermillion	1	Pb	1105	221	
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Vermillion	1	PCB	1100	220	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Y-73 Reef	1	Cd	18400	3680	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Y-73 Reef	1	Cr	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Y-73 Reef	1	Cu	4955	991	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Y-73 Reef	1	Mn	16400	3280	
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Y-73 Reef	1	Ni	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Y-73 Reef	1	Pb	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Y-73 reef	1	PCB	250	50	<LOQ
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Y-73 reef	2	PCB	250	50	<LOQ
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	other	Y-73 reef	3	PCB	25	5	ND
DEMERSAL FISH	Gray Triggerfish	Balistes capriscus	other	Y-73 reef	1	PCB	200	50	<LOQ
DEMERSAL FISH	Hake	Urophycis sp.	other	Y-73 Reef	1	Cd	10	2.5	ND
DEMERSAL FISH	Hake	Urophycis sp.	other	Y-73 Reef	1	Cr	20	5	ND
DEMERSAL FISH	Hake	Urophycis sp.	other	Y-73 Reef	1	Cu	20	5	ND
DEMERSAL FISH	Hake	Urophycis sp.	other	Y-73 Reef	1	Mn	500	125	
DEMERSAL FISH	Hake	Urophycis sp.	other	Y-73 Reef	1	Ni	20	5	ND
DEMERSAL FISH	Hake	Urophycis sp.	other	Y-73 Reef	1	Pb	20	5	ND
DEMERSAL FISH	Hake	Urophycis sp.	other	Y-73 reef	1	PCB	20	5	ND
DEMERSAL FISH	Hake	Urophycis sp.	other	Y-73 reef	2	PCB	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Y-73 Reef	1	Cd	10	2.5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Y-73 Reef	1	Cr	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Y-73 Reef	1	Cu	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Y-73 Reef	1	Mn	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Y-73 Reef	1	Ni	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Y-73 Reef	1	Pb	20	5	ND
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Y-73 reef	1	PCB	200	50	<LOQ
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Y-73 reef	2	PCB	200	50	<LOQ
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Y-73 reef	3	PCB	200	50	<LOQ
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Y-73 reef	4	PCB	200	50	<LOQ
DEMERSAL FISH	Leopard Toadfish	Opsanus pardus	other	Y-73 reef	5	PCB	20	5	ND
INVERTEBRATE	Lion’s Paw Scallop	Nodipecten nodosus	other	Y-73 Reef	1	Cd	13450	2690	
INVERTEBRATE	Lion’s Paw Scallop	Nodipecten nodosus	other	Y-73 Reef	1	Cr	25	5	ND
INVERTEBRATE	Lion’s Paw Scallop	Nodipecten nodosus	other	Y-73 Reef	1	Cu	780	156	
INVERTEBRATE	Lion’s Paw Scallop	Nodipecten nodosus	other	Y-73 Reef	1	Mn	3940	788	
INVERTEBRATE	Lion’s Paw Scallop	Nodipecten nodosus	other	Y-73 Reef	1	Ni	25	5	ND
INVERTEBRATE	Lion’s Paw Scallop	Nodipecten nodosus	other	Y-73 Reef	1	Pb	975	195	
INVERTEBRATE	Lion’s Paw Scallop	Nodipecten nodosus	other	Y-73 reef	1	PCB	250	50	<LOQ
INVERTEBRATE	Lion’s Paw Scallop	Nodipecten nodosus	other	Y-73 reef	2	PCB	25	5	ND
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 Reef	1	Cd	6400	1280	
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 Reef	2	Cd	18200	3640	
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 Reef	1	Cr	505	101	
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 Reef	2	Cr	605	121	
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 Reef	1	Cu	3750	750	
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 Reef	2	Cu	8850	1770	
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 Reef	1	Mn	40000	8000	
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 Reef	2	Mn	13500	2700	
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 Reef	1	Ni	25	5	ND
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 Reef	2	Ni	500	100	
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 Reef	1	Pb	25	5	ND
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 Reef	2	Pb	1605	321	
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 reef	1	PCB	790	158	
INVERTEBRATE	Turkey Wing	Arca zebra	other	Y-73 reef	2	PCB	25	5	ND
INVERTEBRATE	Alantic Winged Oyster	Pteria colymbus	navy	Vermillion	1	Cu	1565	313	
INVERTEBRATE	Atlantic Hairy Triton	Cymatium pileare	navy	Vermillion	1	Cu	21900	4380	
INVERTEBRATE	Atlantic Hairy Triton	Cymatium pileare	navy	Vermillion	2	Cu	30750	6150	
DEMERSAL FISH	Black Sea Bass	Centropristis striatia	navy	Vermillion	1	Cu	844	211	
INVERTEBRATE	Florida Horse Conch	Pleuroploca gigantea	navy	Vermillion	1	Cu	29150	5830	
DEMERSAL FISH	Gag Grouper	Mycteroperca microlepis	navy	Vermillion	1	Cu	1144	286	
INVERTEBRATE	Sea Cucumber	Holothuroidea	navy	Vermillion	1	Cu	735	147	
INVERTEBRATE	Shovelnose Lobster	Scyllarides nodifer	navy	Vermillion	1	Cu	22100	4420	
INVERTEBRATE	Turkey Wing	Arca zebra	navy	Vermillion	1	Cu	3025	605	

Appendix 3. An Ecological Description of the Supplemental Fish Sampling Sites

Prepared by the
Marine Resources Division,
South Carolina Marine Resources Center
South Carolina Department of Natural Resources
Charleston, SC
November 2001

A3A. Vermilion Artificial Reef:

i. Background -

This site is comprised of a permitted manmade reef consisting of a single sunken ex-U.S. Navy ship hull. The reef was constructed in August 1988 by the South Carolina Department of Natural Resources (SCDNR) as part of its Marine Artificial Reef Program. The ex-USS Vermilion (LKA-107) was obtained by the State of South Carolina in 1987 from the U.S. Maritime Administration's inactive reserve fleet in the James River near Ft. Eustis, Virginia. The 460 foot-long (139m) ship was towed to Wilmington, North Carolina where it was cleaned, stripped and prepared for its new role as reef material by a private marine contractor and ship breaker.

The vessel was prepared to acceptable standards at that time (Stone, 1985) for all such artificial reef construction activity in the U.S. All commonly encountered potential shipboard pollutants such as fuels, oils, solid or liquid chemicals, liquid PCBs (electrical transformers and switchboards) and floatable materials such as plastics or wood were removed and properly disposed of by the contractor. To facilitate use of the ship in 110 feet of water and minimize its risk as a possible hazard to navigation, the overall height of the vessel was reduced to no greater than 55 feet (17m) above the keel. All structure above the O-1 level was removed. Large holes were cut in the sides of the ship and between watertight bulkheads. Internal watertight integrity was further breached by removing or welding open internal doors and hatches. After final inspection by U.S. Coast Guard Marine Safety Office Wilmington, the vessel was towed to its final destination and sunk by the use of explosive charges set by U.S. Navy Explosive Ordnance Disposal personnel (EOD Mobile Unit Six). The Vermilion sank quickly, and settled in an upright position on barren flat sand bottom 110 feet (33m) deep, approximately 32 miles southeast of the port of Georgetown, SC.

As with similar artificial reef structures utilized off the state (Bell, 1991; Bell and Martore, 1999), the Vermilion began a rapid transformation into a living hard bottom reef community, with colonization of commonly occurring invertebrate and vertebrate species taking place within days of its sinking. Within a matter of several months the Vermilion Reef had become a popular recreational diving and fishing destination for local citizens and tourists (Rhodes, et al., 1994). In September 1989, the ship was displaced approximately 700 feet (212m) west of its initial location during intense storm surge from hurricane Hugo (Bell and Hall, 1994). As a result of this process significant scouring around the hull resulted in a subsidence of the ship through the sandy sea floor and well into the underlying marl formations, resulting in a new maximum depth on the reef site

in excess of 135 feet (41m). Deep scouring around the ship was contained to within approximately 50 feet (15m) of the vessel, with the surrounding sand bottom maintaining its previous 110 (33m) foot depth.

ii. Site Characterization

The Vermillion lies on a northerly heading at 32° 57.525' N, 078° 40.041'W (approximate center of ship), in the southwestern corner of the permitted reef area. The ship is structurally intact with no visible signs of significant deterioration to the hull, superstructure, decks or major structural members. The vessel has a slight starboard list, with the maximum depth at the stern being approximately 10 feet (3m) deeper overall than the maximum depth at the bow. The highest point of the ship is a small section of the forward port side O-2 level deck (78 feet (23.6m) deep). The deepest part of the main deck is the starboard side stern area (115 feet (35m) deep). Continual scouring around the vessel maintains an area of exposed marl, which adds to the overall footprint of the hard bottom reef. At some points the water depth in this region immediately around the ship approaches 140 feet (42.4m) or greater.

After eleven years on the ocean floor, a well-developed marine epibenthic community has been established on the exposed vertical and horizontal surfaces of the ship. Much of the main deck and O-2 level deck is covered with patches of attached mollusks (*Arca sp, Pteria colymbus* and *Crepidula sp*), barnacles (*Balanus sp*), hard coral (*Oculina arbuscula and Astrangia sp*) and, and a broad coating of hydroids, bryozoans, tunicates, polychaete worms, encrusting sponges, algae and some octocorals (*Leptogorgis sp* and *Lophogorgia sp*). As observed in an earlier study of sessile biota on ship hull artificial reef structures off South Carolina (Wendt, et al., 1989), large sponges and corals commonly encountered on natural hard bottom habitats are absent on the ship, with significant coverage of exposed areas being from predominately less erect species from a variety of taxa. Both starboard and port sides of the Vermilion are thoroughly colonized by the same sessile species encountered on the horizontal surfaces, but with a visibly higher percentage of overall coverage and greater density of organisms. Octocorals (*Lophogorgia sp*) observed on the sides of the vessel also occur more frequently and are represented by much larger specimens than those found on horizontal surfaces such as the main deck. Wendt, et al. (1989) observed a similar trend of significantly greater biomass, percent cover and number of sessile species on vertical surfaces of ship reefs of varying ages when compared to horizontal surfaces on the same vessels.

A variety of motile invertebrate species were observed on the Vermilion, but it proved much harder to gain a sense of their overall community structure and significance due to their low density and cryptic nature. Many of the species encountered are known to be predators on sessile fouling organisms (Harris and Irons, 1982). Several species of gastropods were encountered on horizontal and some vertical surfaces, including *Cymatium pileare, Pleuroploca gigantea, Cypraea cervus* and *Terebra dislocata.* Most were seen on the main deck of the ship, with T. dislocata observed in the greatest number, occurring in several small clusters of multiple individuals. Several specimens of the motile bivalve *Nodipecten nodosus* were observed on the main deck of the ship as well. Other motile invertebrates encountered included numerous species of echinoderms (Asteroidea, Echinoidea, Ophiuroidea and Holothuroidea), one octopus, and several specimens of readily observable decapods (*Scyllarides nodifer, Petrochirus sp* and *Pagurus sp*). Internal spaces of the ship easily observable to divers appeared to have very diminished populations of motile or sessile invertebrates, although barnacles and some mollusks were noted immediately inside most hatches and doorways.

As a result of fishing activities and diver observations, 42 species of fishes representing 19 families were found to occur on the Vermilion Reef (Table Appendix 3.A-1). The species encountered are typical of those expected to occur on manmade reefs in a comparable depth of water off South Carolina (Bell, 1991), and are equally as likely to be represented in fish assemblages documented on and around naturally occurring hard bottom reef communities off the southeastern U.S. (Barans and Henry, 1984; Sedberry and Van Dolah, 1984; Wenner and Sedberry, 1989). Many of the demersal and pelagic fish species observed on the reef are typically targeted and landed by recreational and commercial fishermen on either manmade or naturally occurring hard bottom areas (Huntsman, 1976; Low and Waltz, 1988; Low, 1999). Based on estimated and measured sizes of fishes observed or captured around the ship it is apparent that a wide range of year groups of many of the demersal fish species closely associate with hard bottom reef structure such as the Vermilion at any given time. The important role played by hard bottom habitat (manmade or naturally occurring) has been documented for many of the species encountered in examinations of their life histories and movement patterns (Waltz, et al.,1982; Low and Waltz, 1991; Padgett, 1997; Potts, et al., 1998).

A3B. Northern Area Hard Bottom Reference Site:

i. Background

This site consists of a relatively small area of naturally occurring hard bottom or "live bottom," developed on a low to moderate relief, intermittent rocky outcropping located approximately 3.9 nautical miles west of the Vermilion Reef. The site was originally discovered by SCDNR biologists during a 1990 side scan sonar survey conducted to relocate the Vermilion following hurricane Hugo. Hard bottom of this type is common in small patchy locations in this general region, and commercial and recreational fishermen have taken advantage of its productivity for years. Descriptions of hard bottom reef habitat, its distribution along the southeastern U.S. and its critical role in the life histories of many key reef fish species can be found in the South Atlantic Fishery Management Council (SAFMC) Essential Fish Habitat Management Plan (1998). In an earlier examination of potential PCB uptake in biota found on ex-military vessels off South Carolina this specific site was used as one of three hard bottom reference sites along the coast (Bell, et al., 1997).

ii. Site Characterization

The study reference area is approximately 100 feet (30m) wide (east-west axis) by 600 feet (182m) long (north-south axis) with a center point of 32° 57.228'N, 078° 44.663'W. Water depths in the area range from 95 to 105 feet (28.8m to 31.8m), with the majority of the bottom in this area consisting of a broad pattern of blocky, irregular rock out-crops with sand between the joints and cracks. One section of moderately stepped scarp (8 feet (2.4m) of relief) exists near the center of the area, and extends almost continuously for approximately 150 feet (45.5m) along the north-south axis. The reference area itself is only a small portion of a much larger wide-spread geologic formation of exposed Pleistocene to Pliocene rock which occurs intermittently in offshore waters along the southeastern U.S. from Florida to North Carolina (Continental Shelf Associates, Inc, 1979).

Geological and biological characterizations of hard bottom reefs along the U.S. East Coast identical in nature to the reference area have been completed by numerous researchers (Henry, 1978; SCW&MRD, 1984). Epibenthic invertebrate communities (Wenner, et al., 1983; Wenner, et al., 1984) and groundfish assemblages (Grimes, et al., 1982; Sedberry and Van Dolah, 1984; Barans and Henry, 1984) occurring at several similar hard

bottom habitat sites off South Carolina have been described in detail. A clear picture of the importance of reef fish communities found on such sites to both commercial and recreational fisherman can be established through an examination of present and past fishing practices and results (Chester, et al., 1984; Rhodes, et al., 1994; Low, 1999).

The epibenthic invertebrate community on this site is similar in some respects to that present on the Vermilion Reef, but much older, more developed and more species rich overall. Obvious differences exist due simply to the physical characteristics of the substrates involved (rock versus steel; complex versus simple), their dimensions (8 feet (2.4m) versus 55 feet (17m) of relief) and their ages (thousands of years versus 12 years). Sessile species such as barnacles, hyroids, bryozoans and mollusks, found to be initial colonizers on manmade reef structures (SCW&MRD, 1984; Wendt, et al., 1989), were present on the natural rocky hard bottom site, but appeared to play a less dominant role in the coverage of primary space. Large basket sponges, stony corals (*Oculina arbuscula* and *Astrangia sp*) and octocorals (*Lophogorgia sp*) were easily detectable throughout the site, and several species of algae were thick in broad expanses on flat low relief rock and in sandy areas. Organisms such as worms or sponges capable of boring into the rock for protection or attachment could be found on this type substrate and not on the Vermilion. A few bivalves (*Arca zebra* and *Pteria colymbus*) were located, although well camouflaged and extremely difficult to detect without very close scrutiny.

Due to the complex bottom topography of this rocky hard bottom area, motile invertebrates were much harder to detect than those found on a manmade reef structure such as the Vermilion. An abundance of crevices, overhangs and holes in the marl formations provide abundant areas for more cryptic species to reside. Despite this, several gastropods (*Pleuroploca gigantea*, *Cymatium pileare*, *Fasciolaria sp* and *Oliva sayana)*, numerous echinoderms (primarily urchins), octopus, several lobster (*Scyllarides nodifer*) and several hermit crabs (*Pagurus sp)* were observed. None were observed in great numbers during the course of an individual dive on the reef.

Forty species of fishes representing 23 families were observed on this site during the course of the study (Table Appendix 3-2). Most were commonly encountered demersal or pelagic species typically associated with hard bottom reef habitat off the state (Sedberry and Van Dolah, 1984), with 67.5% of them being in common with species detected on the Vermilion Reef during the study period. Overall fish density on the site appeared to be significantly less than that experienced on the smaller manmade reef, although more sub-legal size grouper were seen in total on one dive in this area than on the entire Vermilion Reef in several dives. Despite lower fish density, fishing activity on the site proved to be far more productive, with much higher catch per unit of effort for targeted and other species than that experienced on the Vermilion Reef.

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Species List for Vermilion Reef

Family	Species	
Odontaspididae	sand tiger shark	*Odontaspis taurus*
Muraenidae	spotted moray	*Gymnothorax moringa*
Congridae	conger eel	*Conger oceanicus*
Serranidae	bank sea bass	*Centropristis ocyurus*
	black sea bass	*Centropristis striata*
	rock hind	*Epinephelus adscensionis*
	graysby	*Epinephelus cruentatus*
	gag	*Mycteroperca microlepis*
	scamp	*Mycteroperca phenax*
	greater soapfish	*Rypticus saponaceus*
Echeneidae	remora	*Remora remora*
Carangidae	crevalle jack	*Caranx hippos*
	bar jack	*Caranx ruber*
	round scad	*Decapterus punctatus*
	greater amberjack	*Seriola dumerili*
	almaco jack	*Seriola rivoliana*
	permit	*Trachinotus falcatus*
Coryphaenidae	dolphin	*Coryphaena hippurus*
Lutjanidae	gray snapper	*Lutjanus griseus*
	vermilion snapper	*Rhomboplites aurorubens*
Haemulidae	tomtate	*Haemulon aurolineatum*
	white grunt	*Haemulon plumieri*
Sparidae	sheepshead	*Archosargus probatocephalus*
	whitebone porgy	*Calamus leucosteus*
	knobbed porgy	*Calamus nodosus*
	spottail pinfish	*Diplodus holbrooki*
	red porgy	*Pagrus pagrus*
	scup	*Stenotomus chrysops*
Sciaenidae	cubbyu	*Equetus umbrosus*
Ephippidae	Atlantic spadefish	*Chaetodipterus faber*
Chaetodontidae	spotfin butterflyfish	*Chaetodon ocellatus*
Pomacanthidae	blue angelfish	*Holacanthus bermudensis*
Pomacentridae	bicolor damselfish	*Pomacentrus partitus*
	cocoa damselfish	*Pomacentrus variabilis*
Sphyraenidae	great barracuda	*Sphyraena barracuda*
Labridae	spanish hogfish	*Bodianus rufus*
	slippery dick	*Halichoeres bivittatus*
Scombridae	king mackerel	*Scomberomorus cavalla*
	Spanish mackerel	*Scomberomorus maculatus*
	yellowfin tuna	*Thunnus albacares*
Balistidae	gray triggerfish	*Balistes capriscus*
	planehead filefish	*Monacanthus hispidus*

Species List for Northern Live Bottom Area

Family	Species	
Muraenidae	spotted moray	*Gymnothorax moringa*
Gadidae	hake	*Urophycis sp.*
Holocentridae	squirrelfish	*Holocentrus adscensionis*
Serranidae	bank sea bass	*Centropristis ocyurus*
	black sea bass	*Centropristis striata*
	sand perch	*Diplectrum fomosum*
	rock hind	*Epinephelus adscensionis*
	gag	*Mycteroperca microlepis*
	scamp	*Mycteroperca phenax*
	greater soapfish	*Rypticus saponaceus*
Apogonidae	cardinalfish	*Apogon sp.*
Echeneidae	remora	*Remora remora*
Carangidae	bar jack	*Caranx ruber*
	greater amberjack	*Seriola dumerili*
Coryphaenidae	dolphin	*Coryphaena hippurus*
Lutjanidae	vermilion snapper	*Rhomboplites aurorubens*
Haemulidae	tomtate	*Haemulon aurolineatum*
	white grunt	*Haemulon plumieri*
Sparidae	jolthead porgy	*Calamus bajonado*
	whitebone porgy	*Calamus leucosteus*
	knobbed porgy	*Calamus nodosus*
	spottail pinfish	*Diplodus holbrooki*
	pinfish	*Lagadon rhomboides*
	red porgy	*Pagrus pagrus*
	scup	*Stenotomus chrysops*
Sciaenidae	jackknife-fish	*Equatus lanceolatus*
Mullidae	spotted goatfish	*Pseudupeneus maculatus*
Chaetodontidae	spotfin butterflyfish	*Chaetodon ocellatus*
Pomacanthidae	blue angelfish	*Holacanthus bermudensis*
	french angelfish	*Pomacanthus paru*
Pomacentridae	cocoa damselfish	*Pomacentrus variabilis*
Sphyraenidae	great barracuda	*Sphyraena barracuda*
Labridae	Spanish hogfish	*Bodianus rufus*
	slippery dick	*Halichoeres bivittatus*
	hogfish	*Lachnolaimus maximus*
Acanthuridae	ocean surgeonfish	*Acanthurus bahianus*
Scombridae	little tunny	*Euthynnus alletteratus*
Balistidae	gray triggerfish	*Balistes capriscus*
	planehead filefish	*Monacanthus hispidus*
Tetraodontidae	bandtail puffer	*Sphoeroides spengleri*
Cheloniidae	loggerhead turtle	*Caretta caretta*

A3D. Letter Application to the Department of Transportation for Transfer of Ships Pursuant to Public Law 92-402, as amended by Public Law 98-623

Letter Application to the Departm nt of Transportation
for Transfer of Ships Pursuant to Public Law 92-402
Approved August 22, 1972 as Amended by Public Law 98-623

Part I. Applicant

a. State: South Carolina

b. Agency: South Carolina Wildlife and Marine Resources Department
South Carolina Marine Resources Division (SCMRD)
P. O. Box 12559
Charleston, S.C. 29412

c. Project Coordinator: Mr. Mel Bell
South Carolina Marine Resources Division
Recreational Resources Development
Section
P. O. Box 12559
Charleston, S.C. 29412
(803) 795-6350

Part II. Number of Ships Desired: One (1) ship. The Ex-LKA Vermilion (C2-S-AJ3), from the James River Reserve Fleet.

Part III. Preparation of Ship for Sinking

a. Contractor: To be selected by competitive bid under the laws of the State of South Carolina.

b. Location Where Work To Be Done: Dependent upon selection of contractor. Most likely in immediate area of Norfolk, Virginia.

c. Description of Preparation Process: Exact process will depend on condition of the vessel, including extent of prior stripping, degree of prior oil/fuel removal and overall cleanliness.

1-2. Oil Removal and Tank Cleaning: Oil in tanks will be heated and pumped from the tanks into storage vessels. All possible oil will be removed and the ship shall be as clean as is practical. Any residual oil will be covered by two inches of sand which will be spread evenly over the tank bottom. The tanks will then be filled with water and sealed prior to sinking, if such an action will not make the hull un-seaworthy before it is towed to the reef site. Biological processes should break down any residual oil before the tanks rust and allow exchange with ocean water.

3. Disposal Procedure for Oil and Other Hazardous Material: Oil will be pumped into storage tanks and sold locally to users of Bunker C. oil. No hazardous materials will be used in cleaning the ship. Any hazardous material which may be on board the ship will be removed and disposed of correctly. All cargo

spaces including lower decks will be removed for scrap; therefore, any residual hazardous material, if present, will be removed with the cargo spaces. Regional EPA will be contacted if hazardous materials are encountered.

4. Intended Removals: Extent of metal removals will be dependent upon current value of various types of scrap, and therefore the amount of preparation costs which can be defrayed through extensive stripping. All non-ferrous metal will be removed by the Salvage Contractor. All machinery and structures above the level of the first deck (approximately 32 vertical feet above the keel) will be removed for scrap. All machinery and materials below the 32-foot deck line will be removed to the double hull with the exception of the hull plates, the first deck and the bulkheads running from port to starboard.

5. Intended Disposal of Above Removals: Materials removed will be sold by the Salvage Contractor for recycling to help reduce the cost of final preparation of the ship to the State.

6. Materials Remaining Aboard: Other than the steel hull, and some transverse bulkheads, no materials will remain aboard with the exception of the oil residue cited in Part III. c.1.

7. Provision for Inspection of Preparation Processes: Inspections will be made by officials of the U.S. Coast Guard and the South Carolina Wildlife and Marine Resources Department prior to final acceptance of all contracted preparation work.

8. Detoxification Process for Hazardous Materials: No hazardous materials will be left aboard. If unanticipated materials are encountered, the regional office of EPA will be contacted for advice on disposing of the material.

Part IV. Locations where Ship will be sunk

a. Geographical Position: The intended position for this reef (33°01.00N/79°39.70'W) is 148°T, 36 miles from Murrells Inlet and 115°T, 26 miles from the entrance to Winyah Bay (see attached chart). Since a detailed site-selection survey has not been completed, this position is only approximate until confirmation has been made.

The location for this reef is being chosen to provide the large number of offshore recreational sport fishermen in the Georgetown and Murrells Inlet areas with access to a deep water artificial reef. The reef will be about an equal run from boat launching and marina facilities in each area.

There are currently three artificial reefs in the vicinity of Winyah Bay and three in the vicinity of Murrells Inlet. All of these reefs are in shallower water and no further than 12 miles offshore. This new reef would be about 30 miles offshore in 90 to 100 feet of water, and approximately 15 miles from the

nearest other artificial reef. The new reef will make one deep water reef available to offshore fishermen from two major access points.

b. Ocean Conditions: The specific details of this section can not be discussed until the site selection survey has been completed.

c. Effects of Reef on Other Uses of Area: In the approximate area selected for this reef, no established commercial or recreational fisheries are know to exist. The area is charted as flat sand bottom (potentially low in productivity). No submerged pipelines, submarine cables, living coral reefs, beaches or historically valuable shipwrecks exist within a 20 mile radius of this approximate location. A reef on this location will not provide any hazard to navigation or interference with any other use of the area. The SCMRD will provide information to NOAA/NOS in up-dating the appropriate nautical charts once the reef is established.

Part V. Procedure for Sinking Ship: Ship breaking contractors will be given the opportunity to bid on the job of salvaging the vessel. The ship will then be reduced to a total height of approximately 30 to 40 feet through the ship breaking operation. Upon completion of all hull preparations, a final inspection will be conducted by the U.S. Coast Guard and the SCMRD. Once the vessel passes this final inspection it will be towed from the salvage facility to the designated reef site by a towing contractor employed by the SCMRD.

Demolition assistance in sinking the vessel will be requested from the U.S. Navy Explosive Ordnance Disposal Mobil Unit at Naval Weapons Station, Charleston, S.C. Explosive charges will be placed on the inside of the hull once the ship is in position. The detonated charges will blow holes in the hull, allowing the vessel to flood and sink in the desired manner. This navy unit has provided assistance to SCMRD's Artificial Reef Program on numerous occasions in the sinking of other similar vessels along the coast.

Part VI. Method of Marking Location

a. Type of Buoy: If a buoy is used to mark the reef, a primary artificial reef buoy (see attached drawing) will be used. These buoys are currently used by SCMRD's Reef Program on most of its' offshore artificial reefs. A Private Aids to Navigation Permit will first be obtained from the U.S. Coast Guard Aids to Navigation Office in Miami, Florida. As with a similar offshore artificial reef off Little River Inlet, this reef may not be marked by a buoy due to its' distance offshore (25-35 miles). Since recreational fishing vessels transiting this far out usually possess Loran C Navigational capability a buoy may not be deemed necessary. In this case, exact Loran C coordinates will be made available to the public through various sport fishing related publications produced by the SCMRD.

b. Charting: The exact position of the reef will be reported to the U.S. Coast Guard, U.S. Army Corps of Engineers, and the National Ocean Survey for inclusion on the NOAA nautical charts.

c. Depth of Water: Water depth in the proposed area for sinking is approximately 90 to 100 feet. Since the exact location for the reef has not been confirmed, a precise reading is not available at this time. Once a complete site selection survey has been conducted, detailed bathymetric data on the chosen site will be in hand.

d. Buoy Maintenance: If a Private Aid to Navigation is established on this reef it will be maintained in accordance with U.S. Coast Guard Regulations by SCMRD's Artificial Reef Program. Over thirty such buoys are currently being maintained on South Carolina's artificial reefs. All of these buoys are Permanent Aids to Navigation, and as such are replaced when damaged or lost. They are also monitored and serviced on a regular basis.

e. Minimum Depth of Water Over Ship When In Place: Since this information is also dependent upon the depth of water at the exact reef site, no precise figure can be given at this time. However, given a vessel profile of 30 to 40 feet, and a water depth of 90 to 100 feet, the minimum clearance over the ship could be from 50 to 60 feet.

Part VII. Conservation Goals

a. Goals: The State of South Carolina has been officially constructing artificial reefs for use by saltwater recreational anglers since 1967. The South Carolina Wildlife and Marine Resources Department established an on-going Artificial Reef Program in 1972, and at that time assumed all responsibility for permitting, constructing, marking and managing the states' system of artificial reefs. There are currently twenty active permitted areas being utilized for artificial reef construction in this system. The majority of these reefs are located within twelve miles of land and easily accessible to a large number of offshore recreational anglers. In many cases these artificial reefs provide the only reliable fishing spots anywhere close to land for several major fisheries access points.

The goal of the South Carolina Artificial Reef Program is to provide enhanced angling opportunities for the State's vastly expanding saltwater recreational fishery through the wise use of a well developed system of carefully designed, permitted, constructed and monitored artificial reefs. In such a system, artificial reefs are viewed as a fisheries management tool created to aid established recreational fisheries and provide for the healthy expansion of new fisheries as future needs arise.

APPENDIX 4. Data from Supplemental Fish Sampling

Appendix 4. Data from Supplemental Fish Sampling

A4A. Fish Samples

A4B. Total PCB For Fillets

A4C. Estimating PCB concentrations in whole body fish tissues

A4C.1. Assumptions

Table A4C-1 Winter flounder

Table A4C-2 Sable fish

Table A4C-3 Puget Sound and Georgia Basin

Table A4C-4 Solids and lipids measured in REEFEX fish

Table A4C-5 Sensitivity of parameters

A4C.2 FISH DATA

Averages for all groups

A4C.3. Whole Body Concentrations

Averages for all groups

A4D. Regression analysis of supplemental fish data

A4D.1. Correlation Analysis for All Fish

A4D.2. Correlation Analysis for Vermilion Snapper

A4D.3. Correlation Analysis for White Grunt

A4D.4. Correlation Analysis for Black Seabass

A4D.5. Results of Regression Analysis

Figure A4D-1 Body Weight vs Age

Figure A4D-2 Body Weight vs Liver Weight

Figure A4D-3 Body Weight vs Lipid Content

Figure A4D-4 Body Weight vs HSI

Figure A4D-5 Body Weight vs Log(tPCB)

Figure A4D-6 Body Weight vs Log(tPCB/Lipid)

Figure A4D-7 %Lipid vs HSI

Figure A4D-8 %Lipid vs Log(tPCB/Lipid)

Figure A4D-9 Log(PCB/Lipid) vs HSI

Figure A4D-10 Benchmarks and Body Weight vs tPCB (whole body)

A4E. Analysis of Homologs and PCB Congeners

A4E.1. Listing of variable names and definitions

A4E.2. Raw Data for homologs and congeners

A4E.3. Sample specific detection limits for homologs and congeners

A4E.4. Qualifier codes reported for homologs and congeners

A4E.5. Results of Normality Tests for homologs and congeners

Figure A4E-1 Example histograms.

A4E.6. Statistical Summary for homologs and congeners

Figure A4E-2 Distribution of homologs and congers from reference and target reefs for all fish.

Figure A4E-3 Average homologs and congeners from reference and target reefs for all fish.

Figure A4E-4 Distribution of homologs and congers from reference and target reefs for vermilion snapper.

Figure A4E-5 Average homologs and congeners from reference and target reefs for vermilion snapper.

Figure A4E-6 Distribution of homologs and congers from reference and target reefs for white grunt.

Figure A4E-7 Average homologs and congeners from reference and target reefs for white grunt.

Figure A4E-8 Distribution of homologs and congers from reference and target reefs for black sea bass.

Figure A4E-9 Average homologs and congeners from reference and target reefs for black sea bass.

4E.7. Results from Principal Component Analysis

Figure A4E-10 Plots of principal component loading scores for the raw data.

A4F. Analysis of potential toxicity from dioxin like coplanar PCB congeners

A4F.1. Table A4F-1 Parameter values from literature.

A4F.2. Dioxin TEC for Fish

A4F.3. Dioxin TEQ for Fish

Table A4F-2. Summary statistics for fish and fish egg TEQs.

Figure A4F-1 Fish TEQ

Figure A4F-2 FishEgg TEQs

Figure A4F-3 Sum and mean of TEC for fish and fish eggs.

A4F.4. Dietary Dioxin TEC for Birds

A4F.5. Dietary Dioxin TEQ for Birds

Table A4F-3. Summary statistics for bird dietary TEQs.

Figure A4F-4 Bird dietary TEQ

Figure A4F-5 Sum and mean of TEC for bird dietary exposure.

A4F.6. Dietary Dioxin TEC for Mammals

A4F.7. Dietary Dioxin TEQ for Mammals

Table A4F-4. Summary statistics for mammal dietary TEQs.

Figure A4F-6 Mammal dietary TEQ

Figure A4F-7 Sum and mean of TEC for mammal dietary exposure.

A4F.8. Summary of TEQs calculated assuming ND=0

A4F.9 TEQs Calculated assuming ND=DL

ID_to_use	Sample Identification	Site	Species	Genis_sp	Total Length (mm)	Total Weight (g)	Filet Weight (g)	Liver Weight (g)	Sex	Age
NEHC-0010	FS-01-SB-R	Reference	Black Seabass	Centropristis ocyurus	422	1128	194	11.82	M	9
NEHC-0041	FS-02-SB-R	Reference	Black Seabass	Centropristis ocyurus	394	916	132	4.5	M	7
NEHC-0049	FS-03-SB-R	Reference	Black Seabass	Centropristis ocyurus	370	699	104	3.6	M	6
NEHC-0026	FS-04-SB-R	Reference	Black Seabass	Centropristis ocyurus	345	646	80	3.4	M	5
NEHC-0033	FS-05-SB-R	Reference	Black Seabass	Centropristis ocyurus	322	585	148	4.2	F	4
NEHC-0011	FS-06-SB-R	Reference	Black Seabass	Centropristis ocyurus	315	383	120	1.6	F	4
NEHC-0044	FS-07-SB-R	Reference	Black Seabass	Centropristis ocyurus	327	504	148	2.3	F	5
NEHC-0005	FS-08-SB-R	Reference	Black Seabass	Centropristis ocyurus	252	265	79	1.5	F	3
NEHC-0023	FS-09-SB-R	Reference	Black Seabass	Centropristis ocyurus	278	374	100	2.6	F	4
NEHC-0046	FS-10-SB-R	Reference	Black Seabass	Centropristis ocyurus	342	634	158	3.3	M	5
NEHC-0017	FS-11-SB-R	Reference	Black Seabass	Centropristis ocyurus	306	421	110	3.4	M	4
NEHC-0034	FS-12-SB-R	Reference	Black Seabass	Centropristis ocyurus	282	331	95	3	F	4
NEHC-0016	FS-13-SB-R	Reference	Black Seabass	Centropristis ocyurus	297	373	117	2.2	F	4
NEHC-0024	FS-14-SB-R	Reference	Black Seabass	Centropristis ocyurus	255	323	74	2.5	F	3
NEHC-0048	FS-15-SB-R	Reference	Black Seabass	Centropristis ocyurus	266	352	87	5.5	F	3
NEHC-0004	FS-16-SB-R	Reference	Black Seabass	Centropristis ocyurus	286	288	85	1.5	F	4
NEHC-0042	FS-17-SB-R	Reference	Black Seabass	Centropristis ocyurus	289	330	108	3.1	F	4
NEHC-0007	FS-18-SB-R	Reference	Black Seabass	Centropristis ocyurus	272	345	94	5	F	3
NEHC-0002	FS-19-SB-R	Reference	Black Seabass	Centropristis ocyurus	280	265	75	1.7	F	4
NEHC-0003	FS-20-SB-R	Reference	Black Seabass	Centropristis ocyurus	333	511	163	3.6	F	5
FS-01-VS-R	FS-01-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	304	417	167	3.6	F	4
FS-02-VS-R	FS-02-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	285	351	137	3.32	F	4
NEHC-0035	FS-03-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	274	282	112	2.37	F	4
NEHC-0019	FS-04-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	308	419	159	5.66	F	4
FS-05-VS-R	FS-05-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	273	309	128	2.04	F	4
NEHC-0015	FS-06-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	270	317	119	2.78	F	3
FS-07-VS-R	FS-07-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	276	303	121		M	4
NEHC-0009	FS-08-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	270	270	110	1.7	F	3
FS-09-VS-R	FS-09-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	315	463	192	5.63	F	5
FS-10-VS-R	FS-10-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	295	424	147	3.75	F	5
FS-11-VS-R	FS-11-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	290	324	125	1.93	M	4
NEHC-0030	FS-12-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	299	375	158	2.63	M	4
FS-13-VS-R	FS-13-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	265	321	107	2.43	F	3
FS-14-VS-R	FS-14-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	274	338	138	3.91	F	4

ID_to_use	Sample Identification	Site	Species	Genis_sp	Total Length (mm)	Total Weight (g)	Filet Weight (g)	Liver Weight (g)	Sex	Age
FS-15-VS-R	FS-15-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	285	348	123	2.24	M	5
FS-16-VS-R	FS-16-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	295	355	139	3.35	F	5
FS-17-VS-R	FS-17-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	265	284	109	3.38	F	3
FS-18-VS-R	FS-18-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	278	319	124	3.29	F	4
NEHC-0018	FS-19-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	294	405	149	3.82	F	5
NEHC-0040	FS-20-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	283	280	102	1.49	M	4
FS-21-VS-R	FS-21-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	270	306	102	2.52	F	3
FS-22-VS-R	FS-22-VS-R	Reference	Vermilion Snapper	Rhomboplites aurorubens	284	291	114	1.25	F	4
FS-01-WG-R	FS-01-WG-R	Reference	White Grunt	Haemulon plumieri	405	1433	444	40.24	F	9
BLIND-04091	FS-01-WG-R	Reference	White Grunt	Haemulon plumieri	405	1433	444	40.24	F	9
FS-02-WG-R	FS-02-WG-R	Reference	White Grunt	Haemulon plumieri	397	1062	293	5.15	F	8
FS-03-WG-R	FS-03-WG-R	Reference	White Grunt	Haemulon plumieri	370	970	268	13.3	F	7
NEHC-0025	FS-04-WG-R	Reference	White Grunt	Haemulon plumieri	325	572	168	4.87	F	5
NEHC-0039	FS-05-WG-R	Reference	White Grunt	Haemulon plumieri	307	479	148	4.49	F	5
FS-06-WG-R	FS-06-WG-R	Reference	White Grunt	Haemulon plumieri	317	526	151	4.26	M	5
NEHC-0001	FS-07-WG-R	Reference	White Grunt	Haemulon plumieri	350	729	234	5.85	M	7
FS-08-WG-R	FS-08-WG-R	Reference	White Grunt	Haemulon plumieri	281	381	116	2.97	M	4
FS-09-WG-R	FS-09-WG-R	Reference	White Grunt	Haemulon plumieri	297	510	147	4.48	F	5
FS-10-WG-R	FS-10-WG-R	Reference	White Grunt	Haemulon plumieri	305	501	145	3.16	M	5
NEHC-0028	FS-11-WG-R	Reference	White Grunt	Haemulon plumieri	290	442	127	3.68	M	4
FS-12-WG-R	FS-12-WG-R	Reference	White Grunt	Haemulon plumieri	382	861	244	5.03	M	8
FS-13-WG-R	FS-13-WG-R	Reference	White Grunt	Haemulon plumieri	401	1091	357	5.78	M	9
FS-14-WG-R	FS-14-WG-R	Reference	White Grunt	Haemulon plumieri	345	678	184	6.27	F	7
NEHC-0051	FS-15-WG-R	Reference	White Grunt	Haemulon plumieri	260	346	99	2.74	M	4
FS-16-WG-R	FS-16-WG-R	Reference	White Grunt	Haemulon plumieri	275	380	111	2.69	F	4
FS-17-WG-R	FS-17-WG-R	Reference	White Grunt	Haemulon plumieri	265	317	84	1.9	M	4
FS-18-WG-R	FS-18-WG-R	Reference	White Grunt	Haemulon plumieri	240	242	65	1.41	Immature	3
FS-19-WG-R	FS-19-WG-R	Reference	White Grunt	Haemulon plumieri	355	748	222	4.97	M	7
FS-20-WG-R	FS-20-WG-R	Reference	White Grunt	Haemulon plumieri	232	223	66	1.52	Immature	3
FS-01-TF-R	FS-01-TF-R	Reference	Toadfish		290	550		6.5	M	
FS-02-TF-R	FS-02-TF-R	Reference	Toadfish		299	585		7.8	F	
NEHC-0006	FS-01-SB-T	Target	Black Seabass	Centropristis ocyurus	315	546	72	5.5	F	4
NEHC-0027	FS-02-SB-T	Target	Black Seabass	Centropristis ocyurus	292	520	198	11.44	F	4
NEHC-0050	FS-03-SB-T	Target	Black Seabass	Centropristis ocyurus	321	639	232	16.47	F	5

ID_to_use	Sample Identification	Site	Species	Genis_sp	Total Length (mm)	Total Weight (g)	Filet Weight (g)	Liver Weight (g)	Sex	Age
NEHC-0047	FS-04-SB-T	Target	Black Seabass	Centropristis ocyurus	315	663	259	19.49	M	4
NEHC-0053	FS-05-SB-T	Target	Black Seabass	Centropristis ocyurus	300	530	174	14.75	F	4
NEHC-0013	FS-06-SB-T	Target	Black Seabass	Centropristis ocyurus	355	917	342	26.84	F	5
NEHC-0022	FS-07-SB-T	Target	Black Seabass	Centropristis ocyurus	425	1231	431	20.76	M	9
NEHC-0021	FS-08-SB-T	Target	Black Seabass	Centropristis ocyurus	310	513	150	17.47	Immature	4
NEHC-0031	FS-09-SB-T	Target	Black Seabass	Centropristis ocyurus	336	713	248	19.82	F	5
NEHC-0036	FS-10-SB-T	Target	Black Seabass	Centropristis ocyurus	296	515	162	16.08	F	4
NEHC-0043	FS-11-SB-T	Target	Black Seabass	Centropristis ocyurus	267	391	144	10.83	M	3
FS-01-VS-T	FS-01-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	314	444	161	7.37	F	4
FS-02-VS-T	FS-02-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	314	449	193	5.32	M	4
FS-03-VS-T	FS-03-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	305	425	169	5.42	F	4
FS-04-VS-T	FS-04-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	335	615	231	11.82	F	5
NEHC-0038	FS-05-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	355	777	326	5.62	M	6
FS-06-VS-T	FS-06-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	346	620	270	6.54	M	5
FS-07-VS-T	FS-07-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	305	441	190	4.31	M	4
NEHC-0029	FS-08-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	320	496	206	8.65	F	5
FS-09-VS-T	FS-09-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	348	612	260	6.85	M	5
NEHC-0008	FS-10-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	305	440	183	6.25	F	4
FS-11-VS-T	FS-11-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	310	457	191	7.11	M	4
FS-12-VS-T	FS-12-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	334	513	194	11.77	F	5
FS-13-VS-T	FS-13-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	320	525	219	12.22	F	5
NEHC-0052	FS-14-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	295	381	157	3.81	M	4
FS-15-VS-T	FS-15-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	358	720	304	11.26	F	6
FS-16-VS-T	FS-16-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	305	436	194	7.82	F	4
FS-17-VS-T	FS-17-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	295	400	159	8.13	F	4
FS-18-VS-T	FS-18-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	302	392	170	3.6	F	4
NEHC-0037	FS-19-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	314	471	196	6.99	F	4
FS-20-VS-T	FS-20-VS-T	Target	Vermilion Snapper	Rhomboplites aurorubens	360	697	290	9.28	F	6
FS-01-WG-T	FS-01-WG-T	Target	White Grunt	Haemulon plumieri	374	1012	347	18.5	F	7
FS-02-WG-T	FS-02-WG-T	Target	White Grunt	Haemulon plumieri	422	1329	470	32.01	M	10
FS-03-WG-T	FS-03-WG-T	Target	White Grunt	Haemulon plumieri	293	489	163	12.93	F	5
FS-04-WG-T	FS-04-WG-T	Target	White Grunt	Haemulon plumieri	274	424	128	13.13	F	4
BLIND-03-091	FS-04-WG-T	Target	White Grunt	Haemulon plumieri	274	424	128	13.13	F	4
FS-05-WG-T	FS-05-WG-T	Target	White Grunt	Haemulon plumieri	250	304	104	6.55	F	3

ID_to_use	Sample Identification	Site	Species	Genis_sp	Total Length (mm)	Total Weight (g)	Filet Weight (g)	Liver Weight (g)	Sex	Age
NEHC-0045	FS-06-WG-T	Target	White Grunt	Haemulon plumieri	233	227	71	3.1	F	3
FS-07-WG-T	FS-07-WG-T	Target	White Grunt	Haemulon plumieri	321	676	237	13.1	F	5
FS-08-WG-T	FS-08-WG-T	Target	White Grunt	Haemulon plumieri	258	276	96	3.01	F	4
FS-09-WG-T	FS-09-WG-T	Target	White Grunt	Haemulon plumieri	243	241	84	1.66	Immature	3
FS-10-WG-T	FS-10-WG-T	Target	White Grunt	Haemulon plumieri	378	999	317	28.78	M	7
FS-11-WG-T	FS-11-WG-T	Target	White Grunt	Haemulon plumieri	315	568	198	11.61	M	5
NEHC-0020	FS-12-WG-T	Target	White Grunt	Haemulon plumieri	365	928	302	20.2	F	7
NEHC-0012	FS-13-WG-T	Target	White Grunt	Haemulon plumieri	274	344	113	6.56	M	4
FS-14-WG-T	FS-14-WG-T	Target	White Grunt	Haemulon plumieri	235	227	72	2.39	Immature	3
FS-15-WG-T	FS-15-WG-T	Target	White Grunt	Haemulon plumieri	422	1464	515	29.46	M	10
FS-16-WG-T	FS-16-WG-T	Target	White Grunt	Haemulon plumieri	247	279	87	4	F	3
FS-17-WG-T	FS-17-WG-T	Target	White Grunt	Haemulon plumieri	440	1709	537	39.03	F	11
FS-18-WG-T	FS-18-WG-T	Target	White Grunt	Haemulon plumieri	432	1592	492	34.87	F	10
NEHC-0014	FS-19-WG-T	Target	White Grunt	Haemulon plumieri	255	311	99	4.7	Immature	4
NEHC-0032	FS-20-WG-T	Target	White Grunt	Haemulon plumieri	374	962	294	7.93		7

			AYXS Analytical Services						
site	species	ID	dry weight %	lipid (wet) %	lipid (dry) %	Fillet tPCB ng/g dry	**WB tPCB** ng/g dry		
Site	SP	ID	X_DRY	X_LIPIDW	X_LIPIDD	X_PCB	w_PCB		
Reference	Black Seabass	FS-01-SB-R	22.8	2.8	12.4	142.65	169.37	Reference	Black Seabas
Reference	Black Seabass	FS-02-SB-R	22.1	0.7	3.4	29.32	37.10	Reference	Black Seabas
Reference	Black Seabass	FS-03-SB-R	21.0	0.4	1.7	27.76	39.06	Reference	Black Seabas
Reference	Black Seabass	FS-04-SB-R	20.8	0.4	2.0	18.90	26.06	Reference	Black Seabas
Reference	Black Seabass	FS-05-SB-R	21.3	0.4	1.8	17.16	24.88	Reference	Black Seabas
Reference	Black Seabass	FS-06-SB-R	18.0	0.3	1.6	29.56	38.74	Reference	Black Seabas
Reference	Black Seabass	FS-07-SB-R	21.0	0.8	4.0	31.38	36.99	Reference	Black Seabas
Reference	Black Seabass	FS-08-SB-R	21.6	0.9	3.9	32.62	39.16	Reference	Black Seabas
Reference	Black Seabass	FS-09-SB-R	21.8	0.7	3.3	19.14	24.35	Reference	Black Seabas
Reference	Black Seabass	FS-10-SB-R	20.0	0.3	1.4	13.95	19.89	Reference	Black Seabas
Reference	Black Seabass	FS-11-SB-R	21.3	0.1	0.5	26.73	64.50	Reference	Black Seabas
Reference	Black Seabass	FS-12-SB-R	22.1	0.3	1.4	15.27	25.08	Reference	Black Seabas
Reference	Black Seabass	FS-13-SB-R	20.2	0.1	0.5	17.93	36.72	Reference	Black Seabas
Reference	Black Seabass	FS-14-SB-R	21.3	0.5	2.5	29.21	40.28	Reference	Black Seabas
Reference	Black Seabass	FS-15-SB-R	20.0	0.3	1.6	19.70	37.93	Reference	Black Seabas
Reference	Black Seabass	FS-16-SB-R	21.5	0.2	1.0	16.60	25.83	Reference	Black Seabas
Reference	Black Seabass	FS-17-SB-R	21.2	0.6	2.7	15.98	21.87	Reference	Black Seabas
Reference	Black Seabass	FS-18-SB-R	20.5	0.4	1.8	14.31	25.85	Reference	Black Seabas
Reference	Black Seabass	FS-19-SB-R	19.7	0.2	1.0	13.48	22.22	Reference	Black Seabas
Reference	Black Seabass	FS-20-SB-R	21.2	0.3	1.2	14.62	23.40	Reference	Black Seabas
Reference	Vermilion Snapper	FS-01-VS-R	28.0	6.0	21.3	19.36	20.53	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-02-VS-R	26.0	5.8	22.3	53.85	57.32	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-03-VS-R	28.6	5.9	20.7	23.15	24.59	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-04-VS-R	27.5	4.1	14.9	22.93	25.34	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-05-VS-R	27.0	4.9	18.2	20.85	21.99	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-06-VS-R	29.9	6.5	21.7	22.27	23.83	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-07-VS-R	25.0	4.0	16.0	19.92	21.30	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-08-VS-R	27.6	5.9	21.4	16.32	17.17	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-09-VS-R	25.4	3.5	13.7	14.23	15.54	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-10-VS-R	27.0	5.5	20.4	26.63	28.86	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-11-VS-R	25.0	3.4	13.6	34.08	36.61	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-12-VS-R	27.3	4.2	15.4	46.48	49.25	Reference	Vermilion Sn

			AYXS Analytical Services						
site	species	ID	dry weight %	lipid (wet) %	lipid (dry) %	Fillet tPCB ng/g dry	**WB tPCB** ng/g dry		
Reference	Vermilion Snapper	FS-13-VS-R	29.0	7.2	24.8	16.69	18.02	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-14-VS-R	30.0	10.6	35.4	18.35	19.17	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-15-VS-R	26.0	4.8	18.6	40.78	43.96	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-16-VS-R	25.5	4.6	17.9	29.99	32.20	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-17-VS-R	26.4	5.8	21.9	18.20	19.53	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-18-VS-R	26.4	5.0	19.1	16.09	17.28	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-19-VS-R	28.9	5.6	19.4	35.33	38.13	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-20-VS-R	25.1	2.0	7.9	26.42	29.19	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-21-VS-R	24.7	3.3	13.5	24.77	27.40	Reference	Vermilion Sn
Reference	Vermilion Snapper	FS-22-VS-R	22.5	1.1	5.0	28.32	31.53	Reference	Vermilion Sn
Reference	White Grunt	FS-01-WG-R	27.7	6.4	23.2	49.37	55.87	Reference	White Grunt
Reference	White Grunt	FS-02-WG-R	22.5	1.2	5.4	13.11	15.24	Reference	White Grunt
Reference	White Grunt	FS-03-WG-R	22.8	1.6	7.1	14.39	17.79	Reference	White Grunt
Reference	White Grunt	FS-04-WG-R	23.3	1.5	6.4	11.03	13.09	Reference	White Grunt
Reference	White Grunt	FS-05-WG-R	23.0	1.3	5.6	10.26	12.41	Reference	White Grunt
Reference	White Grunt	FS-06-WG-R	21.4	0.5	2.1	3.90	5.50	Reference	White Grunt
Reference	White Grunt	FS-07-WG-R	24.9	1.7	6.9	143.21	166.29	Reference	White Grunt
Reference	White Grunt	FS-08-WG-R	21.8	0.8	3.5	5.73	7.25	Reference	White Grunt
Reference	White Grunt	FS-09-WG-R	21.8	0.6	2.8	3.36	4.54	Reference	White Grunt
Reference	White Grunt	FS-10-WG-R	21.3	0.7	3.5	5.49	6.79	Reference	White Grunt
Reference	White Grunt	FS-11-WG-R	23.2	1.2	5.1	7.96	9.70	Reference	White Grunt
Reference	White Grunt	FS-12-WG-R	21.0	0.5	2.4	8.81	11.41	Reference	White Grunt
Reference	White Grunt	FS-13-WG-R	22.3	0.5	2.2	16.47	21.08	Reference	White Grunt
Reference	White Grunt	FS-14-WG-R	18.5	0.4	2.0	4.53	6.76	Reference	White Grunt
Reference	White Grunt	FS-15-WG-R	24.0	1.9	7.8	8.33	9.69	Reference	White Grunt
Reference	White Grunt	FS-16-WG-R	21.0	0.8	3.7	7.71	9.60	Reference	White Grunt
Reference	White Grunt	FS-17-WG-R	23.0	0.4	1.7	2.83	3.94	Reference	White Grunt
Reference	White Grunt	FS-18-WG-R	22.0	0.6	2.9	2.57	3.24	Reference	White Grunt
Reference	White Grunt	FS-19-WG-R	21.0	0.6	3.0	9.71	12.36	Reference	White Grunt
Reference	White Grunt	FS-20-WG-R	22.0	1.4	6.4	5.00	5.83	Reference	White Grunt
Target	Black Seabass	FS-01-SB-T	21.6	1.2	5.7	69.01	88.77	Target	Black Seabas
Target	Black Seabass	FS-02-SB-T	29.7	7.8	26.2	157.12	170.04	Target	Black Seabas
Target	Black Seabass	FS-03-SB-T	29.0	9.1	31.2	192.41	207.95	Target	Black Seabas

			AYXS Analytical Services						
site	species	ID	dry weight %	lipid (wet) %	lipid (dry) %	Fillet tPCB ng/g dry	**WB tPCB** ng/g dry		
Target	Black Seabass	FS-04-SB-T	27.0	5.9	22.0	150.37	166.75	Target	Black Seabas
Target	Black Seabass	FS-05-SB-T	25.0	3.7	14.7	40.00	47.45	Target	Black Seabas
Target	Black Seabass	FS-06-SB-T	27.0	7.5	27.6	180.85	197.33	Target	Black Seabas
Target	Black Seabass	FS-07-SB-T	25.5	3.9	15.1	346.98	391.74	Target	Black Seabas
Target	Black Seabass	FS-08-SB-T	24.3	2.2	8.9	211.88	288.41	Target	Black Seabas
Target	Black Seabass	FS-09-SB-T	27.4	5.3	19.5	68.34	77.68	Target	Black Seabas
Target	Black Seabass	FS-10-SB-T	28.0	6.3	22.5	86.07	98.09	Target	Black Seabas
Target	Black Seabass	FS-11-SB-T	27.0	5.0	18.7	141.48	160.44	Target	Black Seabas
Target	Vermilion Snapper	FS-01-VS-T	28.0	5.6	19.8	39.64	43.58	Target	Vermilion Sn
Target	Vermilion Snapper	FS-02-VS-T	29.0	6.4	22.2	30.90	32.57	Target	Vermilion Sn
Target	Vermilion Snapper	FS-03-VS-T	30.0	6.4	21.2	26.77	28.68	Target	Vermilion Sn
Target	Vermilion Snapper	FS-04-VS-T	27.0	4.3	15.9	48.89	54.88	Target	Vermilion Sn
Target	Vermilion Snapper	FS-05-VS-T	29.0	4.3	14.7	171.38	182.21	Target	Vermilion Sn
Target	Vermilion Snapper	FS-06-VS-T	28.0	4.9	17.3	28.86	30.62	Target	Vermilion Sn
Target	Vermilion Snapper	FS-07-VS-T	43.0	5.7	13.4	23.95	25.76	Target	Vermilion Sn
Target	Vermilion Snapper	FS-08-VS-T	30.8	6.9	22.2	40.21	43.11	Target	Vermilion Sn
Target	Vermilion Snapper	FS-09-VS-T	28.0	4.9	17.6	81.07	86.49	Target	Vermilion Sn
Target	Vermilion Snapper	FS-10-VS-T	25.7	3.1	11.9	55.96	62.41	Target	Vermilion Sn
Target	Vermilion Snapper	FS-11-VS-T	29.0	6.5	22.4	150.34	160.34	Target	Vermilion Sn
Target	Vermilion Snapper	FS-12-VS-T	38.0	1.7	4.5	7.66	11.23	Target	Vermilion Sn
Target	Vermilion Snapper	FS-13-VS-T	29.0	5.8	20.0	33.90	37.10	Target	Vermilion Sn
Target	Vermilion Snapper	FS-14-VS-T	28.0	5.9	21.0	40.00	42.38	Target	Vermilion Sn
Target	Vermilion Snapper	FS-15-VS-T	30.0	6.8	22.7	65.33	69.53	Target	Vermilion Sn
Target	Vermilion Snapper	FS-16-VS-T	28.0	6.1	21.8	32.43	34.47	Target	Vermilion Sn
Target	Vermilion Snapper	FS-17-VS-T	28.0	5.6	20.0	45.00	49.25	Target	Vermilion Sn
Target	Vermilion Snapper	FS-18-VS-T	28.0	5.8	20.7	33.29	34.93	Target	Vermilion Sn
Target	Vermilion Snapper	FS-19-VS-T	29.0	3.8	13.1	36.21	40.12	Target	Vermilion Sn
Target	Vermilion Snapper	FS-20-VS-T	27.0	4.7	17.4	34.30	36.96	Target	Vermilion Sn
Target	White Grunt	FS-01-WG-T	25.9	4.8	18.4	269.11	300.88	Target	White Grunt
Target	White Grunt	FS-02-WG-T	28.7	7.1	24.7	5121.95	5639.22	Target	White Grunt
Target	White Grunt	FS-03-WG-T	29.4	6.1	20.9	350.34	396.15	Target	White Grunt
Target	White Grunt	FS-04-WG-T	28.5	5.5	19.5	281.20	327.09	Target	White Grunt
Target	White Grunt	FS-05-WG-T	24.8	3.7	14.9	85.89	98.98	Target	White Grunt

			AYXS Analytical Services						
site	species	ID	dry weight %	lipid (wet) %	lipid (dry) %	Fillet tPCB ng/g dry	**WB tPCB** ng/g dry		
Target	White Grunt	FS-06-WG-T	25.0	1.6	6.2	193.66	241.48	Target	White Grunt
Target	White Grunt	FS-07-WG-T	28.4	7.2	25.3	136.97	149.63	Target	White Grunt
Target	White Grunt	FS-08-WG-T	24.7	2.4	9.7	180.57	206.17	Target	White Grunt
Target	White Grunt	FS-09-WG-T	23.1	2.7	11.7	1372.29	1510.88	Target	White Grunt
Target	White Grunt	FS-10-WG-T	25.3	4.4	17.4	2446.64	2855.80	Target	White Grunt
Target	White Grunt	FS-11-WG-T	25.3	4.4	17.4	150.99	170.26	Target	White Grunt
Target	White Grunt	FS-12-WG-T	28.1	5.6	20.0	1683.17	1896.67	Target	White Grunt
Target	White Grunt	FS-13-WG-T	25.3	2.7	10.6	152.79	182.56	Target	White Grunt
Target	White Grunt	FS-14-WG-T	23.5	2.0	8.5	234.47	273.17	Target	White Grunt
Target	White Grunt	FS-15-WG-T	24.9	4.5	18.1	2261.04	2536.20	Target	White Grunt
Target	White Grunt	FS-16-WG-T	27.9	5.1	18.3	1440.86	1612.23	Target	White Grunt
Target	White Grunt	FS-17-WG-T	25.6	4.9	19.0	645.79	735.57	Target	White Grunt
Target	White Grunt	FS-18-WG-T	28.7	7.3	25.5	4808.36	5348.79	Target	White Grunt
Target	White Grunt	FS-19-WG-T	25.9	3.7	14.2	152.33	173.64	Target	White Grunt
Target	White Grunt	FS-20-WG-T	23.7	3.0	12.7	408.60	458.02	Target	White Grunt
			dry weight	lipid (wet)	lipid (dry)				
		Average	25.3	3.5	12.9				

site	species	ID		tPCB/lipid ng/g dry lipid	log(tPCB)	log(tPCB/ Lipid)	**tPCB ppm Wet Weight**	dry weight %	lipid (wet) %
Site	SP	ID		X_PCBL	LX_PCB	LX_PCNL		A_DRY	A_LIPIDW
Reference	Black Seabass	FS-01-SB-R	FS-01-SB-R	1148.41	2.1543	3.0601	0.033	24.3	3.5
Reference	Black Seabass	FS-02-SB-R	FS-02-SB-R	872.14	1.4672	2.9406	0.006	21.4	0.6
Reference	Black Seabass	FS-03-SB-R	FS-03-SB-R	1642.25	1.4434	3.2154	0.006	19.5	0.2
Reference	Black Seabass	FS-04-SB-R	FS-04-SB-R	945.00	1.2765	2.9754	0.004	19.9	0.2
Reference	Black Seabass	FS-05-SB-R	FS-05-SB-R	962.17	1.2345	2.9833	0.004	20.5	0.2
Reference	Black Seabass	FS-06-SB-R	FS-06-SB-R	1900.00	1.4707	3.2788	0.005	18.8	0.4
Reference	Black Seabass	FS-07-SB-R	FS-07-SB-R	793.66	1.4967	2.8996	0.007	20.8	0.4
Reference	Black Seabass	FS-08-SB-R	FS-08-SB-R	828.24	1.5135	2.9182	0.007	20.3	1.2
Reference	Black Seabass	FS-09-SB-R	FS-09-SB-R	585.67	1.2819	2.7677	0.004	21.1	0.5
Reference	Black Seabass	FS-10-SB-R	FS-10-SB-R	990.53	1.1446	2.9959	0.003	20.1	0.3
Reference	Black Seabass	FS-11-SB-R	FS-11-SB-R	4871.79	1.4270	3.6877	0.006	18.2	0.5
Reference	Black Seabass	FS-12-SB-R	FS-12-SB-R	1069.62	1.1839	3.0292	0.003	19.8	0.3
Reference	Black Seabass	FS-13-SB-R	FS-13-SB-R	3300.00	1.2537	3.5185	0.004	20.0	0.4
Reference	Black Seabass	FS-14-SB-R	FS-14-SB-R	1190.05	1.4655	3.0756	0.006	20.1	0.4
Reference	Black Seabass	FS-15-SB-R	FS-15-SB-R	1195.15	1.2945	3.0774	0.004	19.7	0.4
Reference	Black Seabass	FS-16-SB-R	FS-16-SB-R	1700.00	1.2200	3.2304	0.004	20.1	0.5
Reference	Black Seabass	FS-17-SB-R	FS-17-SB-R	595.78	1.2037	2.7751	0.003	20.6	0.5
Reference	Black Seabass	FS-18-SB-R	FS-18-SB-R	813.89	1.1556	2.9106	0.003	20.5	0.7
Reference	Black Seabass	FS-19-SB-R	FS-19-SB-R	1330.00	1.1296	3.1239	0.003	18.3	0.6
Reference	Black Seabass	FS-20-SB-R	FS-20-SB-R	1240.00	1.1648	3.0934	0.003	20.3	0.4
Reference	Vermilion Snapper	FS-01-VS-R	FS-01-VS-R	91.09	1.2868	1.9595	0.005	M	M
Reference	Vermilion Snapper	FS-02-VS-R	FS-02-VS-R	241.38	1.7312	2.3827	0.014	M	M
Reference	Vermilion Snapper	FS-03-VS-R	FS-03-VS-R	111.78	1.3646	2.0484	0.007	26.3	4.3
Reference	Vermilion Snapper	FS-04-VS-R	FS-04-VS-R	154.19	1.3604	2.1881	0.006	25.2	2.6
Reference	Vermilion Snapper	FS-05-VS-R	FS-05-VS-R	114.43	1.3191	2.0585	0.006	M	M
Reference	Vermilion Snapper	FS-06-VS-R	FS-06-VS-R	102.62	1.3477	2.0112	0.007	28.5	9.9
Reference	Vermilion Snapper	FS-07-VS-R	FS-07-VS-R	124.50	1.2993	2.0952	0.005	23.2	3.5
Reference	Vermilion Snapper	FS-08-VS-R	FS-08-VS-R	76.18	1.2127	1.8819	0.005	26.8	9.0
Reference	Vermilion Snapper	FS-09-VS-R	FS-09-VS-R	104.02	1.1532	2.0171	0.004	M	M
Reference	Vermilion Snapper	FS-10-VS-R	FS-10-VS-R	130.73	1.4254	2.1164	0.007	M	M
Reference	Vermilion Snapper	FS-11-VS-R	FS-11-VS-R	250.59	1.5325	2.3990	0.009	23.9	2.8
Reference	Vermilion Snapper	FS-12-VS-R	FS-12-VS-R	301.81	1.6672	2.4797	0.013	25.7	3.2

site	species	ID		tPCB/lipid ng/g dry lipid	log(tPCB)	log(tPCB/ Lipid)	**tPCB ppm Wet Weight**	dry weight %	lipid (wet) %
Reference	Vermilion Snapper	FS-13-VS-R	FS-13-VS-R	67.22	1.2224	1.8275	0.005	M	M
Reference	Vermilion Snapper	FS-14-VS-R	FS-14-VS-R	51.83	1.2637	1.7146	0.006	M	M
Reference	Vermilion Snapper	FS-15-VS-R	FS-15-VS-R	219.46	1.6105	2.3414	0.011	M	M
Reference	Vermilion Snapper	FS-16-VS-R	FS-16-VS-R	167.98	1.4770	2.2253	0.008	M	M
Reference	Vermilion Snapper	FS-17-VS-R	FS-17-VS-R	83.22	1.2600	1.9202	0.005	M	M
Reference	Vermilion Snapper	FS-18-VS-R	FS-18-VS-R	84.13	1.2066	1.9249	0.004	M	M
Reference	Vermilion Snapper	FS-19-VS-R	FS-19-VS-R	182.37	1.5481	2.2610	0.010	27.4	4.9
Reference	Vermilion Snapper	FS-20-VS-R	FS-20-VS-R	332.66	1.4219	2.5220	0.007	23.7	1.5
Reference	Vermilion Snapper	FS-21-VS-R	FS-21-VS-R	184.04	1.3939	2.2649	0.006	M	M
Reference	Vermilion Snapper	FS-22-VS-R	FS-22-VS-R	567.86	1.4520	2.7542	0.006	M	M
Reference	White Grunt	FS-01-WG-R	FS-01-WG-R	212.95	1.6934	2.3283	0.014	M	M
Reference	White Grunt	FS-02-WG-R	FS-02-WG-R	243.80	1.1176	2.3870	0.003	22.3	1.3
Reference	White Grunt	FS-03-WG-R	FS-03-WG-R	201.23	1.1579	2.3037	0.003	M	M
Reference	White Grunt	FS-04-WG-R	FS-04-WG-R	172.48	1.0426	2.2367	0.003	22.2	0.8
Reference	White Grunt	FS-05-WG-R	FS-05-WG-R	182.95	1.0112	2.2623	0.002	21.7	1.0
Reference	White Grunt	FS-06-WG-R	FS-06-WG-R	182.10	0.5908	2.2603	0.001	M	M
Reference	White Grunt	FS-07-WG-R	FS-07-WG-R	2063.58	2.1560	3.3146	0.036	22.6	1.7
Reference	White Grunt	FS-08-WG-R	FS-08-WG-R	163.19	0.7585	2.2127	0.001	M	M
Reference	White Grunt	FS-09-WG-R	FS-09-WG-R	119.61	0.5261	2.0778	0.001	M	M
Reference	White Grunt	FS-10-WG-R	FS-10-WG-R	157.89	0.7398	2.1984	0.001	M	M
Reference	White Grunt	FS-11-WG-R	FS-11-WG-R	157.00	0.9009	2.1959	0.002	22.5	0.8
Reference	White Grunt	FS-12-WG-R	FS-12-WG-R	364.89	0.9450	2.5622	0.002	M	M
Reference	White Grunt	FS-13-WG-R	FS-13-WG-R	755.67	1.2167	2.8783	0.004	M	M
Reference	White Grunt	FS-14-WG-R	FS-14-WG-R	226.49	0.6561	2.3550	0.001	M	M
Reference	White Grunt	FS-15-WG-R	FS-15-WG-R	106.78	0.9208	2.0285	0.002	24.1	1.2
Reference	White Grunt	FS-16-WG-R	FS-16-WG-R	210.39	0.8873	2.3230	0.002	M	M
Reference	White Grunt	FS-17-WG-R	FS-17-WG-R	162.50	0.4512	2.2109	0.001	M	M
Reference	White Grunt	FS-18-WG-R	FS-18-WG-R	88.28	0.4096	1.9459	0.001	M	M
Reference	White Grunt	FS-19-WG-R	FS-19-WG-R	329.03	0.9874	2.5172	0.002	M	M
Reference	White Grunt	FS-20-WG-R	FS-20-WG-R	78.57	0.6990	1.8953	0.001	20.2	1.2
Target	Black Seabass	FS-01-SB-T	FS-01-SB-T	1201.61	1.8389	3.0798	0.015	22.1	1.7
Target	Black Seabass	FS-02-SB-T	FS-02-SB-T	600.57	2.1962	2.7786	0.047	29.1	5.4
Target	Black Seabass	FS-03-SB-T	FS-03-SB-T	616.57	2.2842	2.7900	0.056	30.7	7.0

site	species	ID		tPCB/lipid ng/g dry lipid	log(tPCB)	log(tPCB/ Lipid)	**tPCB ppm Wet Weight**	dry weight %	lipid (wet) %
Target	Black Seabass	FS-04-SB-T	FS-04-SB-T	684.65	2.1772	2.8355	0.041	19.5	6.2
Target	Black Seabass	FS-05-SB-T	FS-05-SB-T	272.48	1.6021	2.4353	0.010	25.8	2.5
Target	Black Seabass	FS-06-SB-T	FS-06-SB-T	654.16	2.2573	2.8157	0.049	27.2	10.4
Target	Black Seabass	FS-07-SB-T	FS-07-SB-T	2300.30	2.5403	3.3618	0.089	23.3	2.7
Target	Black Seabass	FS-08-SB-T	FS-08-SB-T	2388.31	2.3261	3.3781	0.052	22.4	1.9
Target	Black Seabass	FS-09-SB-T	FS-09-SB-T	350.47	1.8347	2.5447	0.019	26.3	4.0
Target	Black Seabass	FS-10-SB-T	FS-10-SB-T	382.54	1.9349	2.5827	0.024	26.3	6.0
Target	Black Seabass	FS-11-SB-T	FS-11-SB-T	758.44	2.1507	2.8799	0.038	25.4	4.6
Target	Vermilion Snapper	FS-01-VS-T	FS-01-VS-T	199.96	1.5982	2.3010	0.011	27.0	6.2
Target	Vermilion Snapper	FS-02-VS-T	FS-02-VS-T	139.09	1.4899	2.1433	0.009	M	M
Target	Vermilion Snapper	FS-03-VS-T	FS-03-VS-T	126.00	1.4276	2.1004	0.008	M	M
Target	Vermilion Snapper	FS-04-VS-T	FS-04-VS-T	307.26	1.6892	2.4875	0.013	M	M
Target	Vermilion Snapper	FS-05-VS-T	FS-05-VS-T	1164.84	2.2340	3.0663	0.050	27.3	3.8
Target	Vermilion Snapper	FS-06-VS-T	FS-06-VS-T	166.43	1.4603	2.2212	0.008	M	M
Target	Vermilion Snapper	FS-07-VS-T	FS-07-VS-T	179.16	1.3794	2.2532	0.010	M	M
Target	Vermilion Snapper	FS-08-VS-T	FS-08-VS-T	180.93	1.6043	2.2575	0.012	30.3	4.7
Target	Vermilion Snapper	FS-09-VS-T	FS-09-VS-T	461.66	1.9089	2.6643	0.023	M	M
Target	Vermilion Snapper	FS-10-VS-T	FS-10-VS-T	472.13	1.7479	2.6741	0.014	26.0	5.1
Target	Vermilion Snapper	FS-11-VS-T	FS-11-VS-T	670.77	2.1771	2.8266	0.044	M	M
Target	Vermilion Snapper	FS-12-VS-T	FS-12-VS-T	171.18	0.8841	2.2334	0.003	M	M
Target	Vermilion Snapper	FS-13-VS-T	FS-13-VS-T	169.48	1.5302	2.2291	0.010	27.2	6.3
Target	Vermilion Snapper	FS-14-VS-T	FS-14-VS-T	190.38	1.6021	2.2796	0.011	27.0	6.0
Target	Vermilion Snapper	FS-15-VS-T	FS-15-VS-T	288.24	1.8151	2.4597	0.020	M	M
Target	Vermilion Snapper	FS-16-VS-T	FS-16-VS-T	148.85	1.5109	2.1728	0.009	M	M
Target	Vermilion Snapper	FS-17-VS-T	FS-17-VS-T	225.00	1.6532	2.3522	0.013	M	M
Target	Vermilion Snapper	FS-18-VS-T	FS-18-VS-T	160.69	1.5223	2.2060	0.009	M	M
Target	Vermilion Snapper	FS-19-VS-T	FS-19-VS-T	276.56	1.5588	2.4418	0.011	27.7	3.9
Target	Vermilion Snapper	FS-20-VS-T	FS-20-VS-T	197.02	1.5352	2.2945	0.009	M	M
Target	White Grunt	FS-01-WG-T	FS-01-WG-T	1464.29	2.4299	3.1656	0.070	M	M
Target	White Grunt	FS-02-WG-T	FS-02-WG-T	20733.43	3.7094	4.3167	1.470	M	M
Target	White Grunt	FS-03-WG-T	FS-03-WG-T	1680.26	2.5445	3.2254	0.103	M	M
Target	White Grunt	FS-04-WG-T	FS-04-WG-T	1444.04	2.4490	3.1596	0.080	M	M
Target	White Grunt	FS-05-WG-T	FS-05-WG-T	575.68	1.9339	2.7602	0.021	M	M

Appendix A4B Total PCB

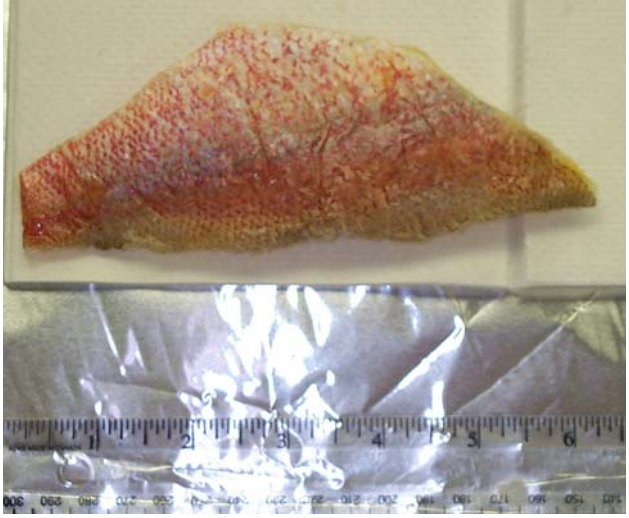
site	species	ID		tPCB/lipid ng/g dry lipid	log(tPCB)	log(tPCB/ Lipid)	**tPCB ppm Wet Weight**	dry weight %	lipid (wet) %
Target	White Grunt	FS-06-WG-T	FS-06-WG-T	3109.21	2.2870	3.4926	0.048	23.2	1.4
Target	White Grunt	FS-07-WG-T	FS-07-WG-T	541.78	2.1366	2.7338	0.039	M	M
Target	White Grunt	FS-08-WG-T	FS-08-WG-T	1858.33	2.2566	3.2691	0.045	M	M
Target	White Grunt	FS-09-WG-T	FS-09-WG-T	11740.74	3.1374	4.0697	0.317	23.4	2.2
Target	White Grunt	FS-10-WG-T	FS-10-WG-T	14068.18	3.3886	4.1482	0.619	M	M
Target	White Grunt	FS-11-WG-T	FS-11-WG-T	866.21	2.1789	2.9376	0.038	M	M
Target	White Grunt	FS-12-WG-T	FS-12-WG-T	8428.87	3.2261	3.9258	0.473	27.7	3.5
Target	White Grunt	FS-13-WG-T	FS-13-WG-T	1444.03	2.1841	3.1596	0.039	26.9	2.9
Target	White Grunt	FS-14-WG-T	FS-14-WG-T	2755.00	2.3701	3.4401	0.055	23.9	1.7
Target	White Grunt	FS-15-WG-T	FS-15-WG-T	12511.11	3.3543	4.0973	0.563	M	M
Target	White Grunt	FS-16-WG-T	FS-16-WG-T	7882.35	3.1586	3.8967	0.402	M	M
Target	White Grunt	FS-17-WG-T	FS-17-WG-T	3391.57	2.8101	3.5304	0.165	M	M
Target	White Grunt	FS-18-WG-T	FS-18-WG-T	18878.25	3.6820	4.2760	1.380	M	M
Target	White Grunt	FS-19-WG-T	FS-19-WG-T	1070.65	2.1828	3.0296	0.039	26.5	3.6
Target	White Grunt	FS-20-WG-T	FS-20-WG-T	3220.34	2.6113	3.5079	0.097	23.4	1.9
								dry weight	lipid (wet)
		Average						23.5	2.7

site	species	ID	Arthur D. Little Inc. lipid (dry) %	tPCB ng/g dry	tPCB/lipid ng/g dry lipid	log(tPCB)	log(tPCB/ Lipid)	**tPCB ppm Wet Weight**
Site	SP	ID	A_LIPIDD	AEPCB	AEPCBL	LAEPCB	LAEPCBL	
Reference	Black Seabass	FS-01-SB-R	14.2	228.90	1611.97	2.3596	3.2074	0.0556
Reference	Black Seabass	FS-02-SB-R	2.9	15.00	511.95	1.1761	2.7092	0.0032
Reference	Black Seabass	FS-03-SB-R	1.3	14.00	1102.36	1.1461	3.0423	0.0027
Reference	Black Seabass	FS-04-SB-R	1.2	7.80	655.46	0.8921	2.8165	0.0016
Reference	Black Seabass	FS-05-SB-R	1.1	15.00	1388.89	1.1761	3.1427	0.0031
Reference	Black Seabass	FS-06-SB-R	2.4	18.00	756.30	1.2553	2.8787	0.0034
Reference	Black Seabass	FS-07-SB-R	2.1	2.69	126.89	0.4298	2.1034	0.0006
Reference	Black Seabass	FS-08-SB-R	6.0	66.70	1109.82	1.8241	3.0453	0.0135
Reference	Black Seabass	FS-09-SB-R	2.3	9.40	408.70	0.9731	2.6114	0.0020
Reference	Black Seabass	FS-10-SB-R	1.3	2.79	214.62	0.4456	2.3317	0.0006
Reference	Black Seabass	FS-11-SB-R	2.6	56.00	2153.85	1.7482	3.3332	0.0102
Reference	Black Seabass	FS-12-SB-R	1.5	2.88	188.24	0.4594	2.2747	0.0006
Reference	Black Seabass	FS-13-SB-R	2.1	14.00	660.38	1.1461	2.8198	0.0028
Reference	Black Seabass	FS-14-SB-R	1.8	79.39	4536.57	1.8998	3.6567	0.0160
Reference	Black Seabass	FS-15-SB-R	1.8	3.41	185.33	0.5328	2.2679	0.0007
Reference	Black Seabass	FS-16-SB-R	2.4	2.89	120.42	0.4609	2.0807	0.0006
Reference	Black Seabass	FS-17-SB-R	2.3	2.68	115.52	0.4281	2.0626	0.0006
Reference	Black Seabass	FS-18-SB-R	3.6	2.69	74.72	0.4298	1.8734	0.0006
Reference	Black Seabass	FS-19-SB-R	3.0	5.00	166.11	0.6990	2.2204	0.0009
Reference	Black Seabass	FS-20-SB-R	2.0	2.69	133.83	0.4298	2.1266	0.0005
Reference	Vermilion Snapper	FS-01-VS-R	M	M	M	M	M	
Reference	Vermilion Snapper	FS-02-VS-R	M	M	M	M	M	
Reference	Vermilion Snapper	FS-03-VS-R	16.4	38.00	231.71	1.5798	2.3649	0.0100
Reference	Vermilion Snapper	FS-04-VS-R	10.5	22.00	209.52	1.3424	2.3212	0.0055
Reference	Vermilion Snapper	FS-05-VS-R	M	M	M	M	M	
Reference	Vermilion Snapper	FS-06-VS-R	34.6	55.02	159.02	1.7405	2.2014	0.0157
Reference	Vermilion Snapper	FS-07-VS-R	15.3	37.20	243.14	1.5705	2.3859	0.0086
Reference	Vermilion Snapper	FS-08-VS-R	33.4	33.00	98.80	1.5185	1.9948	0.0088
Reference	Vermilion Snapper	FS-09-VS-R	M	M	M	M	M	
Reference	Vermilion Snapper	FS-10-VS-R	M	M	M	M	M	
Reference	Vermilion Snapper	FS-11-VS-R	11.8	36.36	308.14	1.5606	2.4887	0.0087
Reference	Vermilion Snapper	FS-12-VS-R	12.5	80.00	640.00	1.9031	2.8062	0.0206

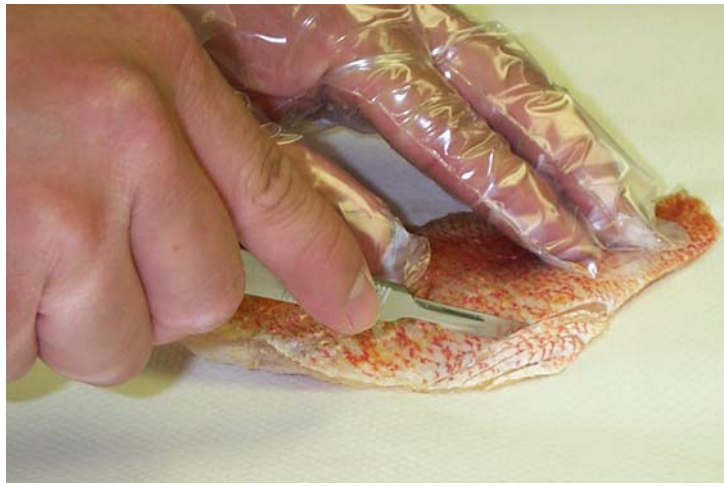
			Arthur D. Little Inc.					
site	species	ID	lipid (dry) %	tPCB ng/g dry	tPCB/lipid ng/g dry lipid	log(tPCB)	log(tPCB/ Lipid)	**tPCB ppm Wet Weight**
Reference	Vermilion Snapper	FS-13-VS-R	M	M	M	M	M	
Reference	Vermilion Snapper	FS-14-VS-R	M	M	M	M	M	
Reference	Vermilion Snapper	FS-15-VS-R	M	M	M	M	M	
Reference	Vermilion Snapper	FS-16-VS-R	M	M	M	M	M	
Reference	Vermilion Snapper	FS-17-VS-R	M	M	M	M	M	
Reference	Vermilion Snapper	FS-18-VS-R	M	M	M	M	M	
Reference	Vermilion Snapper	FS-19-VS-R	17.9	69.00	385.47	1.8388	2.5860	0.0189
Reference	Vermilion Snapper	FS-20-VS-R	6.4	14.00	218.41	1.1461	2.3393	0.0033
Reference	Vermilion Snapper	FS-21-VS-R	M	M	M	M	M	
Reference	Vermilion Snapper	FS-22-VS-R	M	M	M	M	M	
Reference	White Grunt	FS-01-WG-R	M	M	M	M	M	
Reference	White Grunt	FS-02-WG-R	5.7	18.30	322.18	1.2625	2.5081	0.0041
Reference	White Grunt	FS-03-WG-R	M	M	M	M	M	
Reference	White Grunt	FS-04-WG-R	3.8	2.57	68.53	0.4099	1.8359	0.0006
Reference	White Grunt	FS-05-WG-R	4.4	6.70	151.58	0.8261	2.1807	0.0015
Reference	White Grunt	FS-06-WG-R	M	M	M	M	M	
Reference	White Grunt	FS-07-WG-R	7.6	184.00	2427.44	2.2648	3.3851	0.0416
Reference	White Grunt	FS-08-WG-R	M	M	M	M	M	
Reference	White Grunt	FS-09-WG-R	M	M	M	M	M	
Reference	White Grunt	FS-10-WG-R	M	M	M	M	M	
Reference	White Grunt	FS-11-WG-R	3.6	4.40	122.91	0.6435	2.0896	0.0010
Reference	White Grunt	FS-12-WG-R	M	M	M	M	M	
Reference	White Grunt	FS-13-WG-R	M	M	M	M	M	
Reference	White Grunt	FS-14-WG-R	M	M	M	M	M	
Reference	White Grunt	FS-15-WG-R	4.9	0.32	6.50	-0.4949	0.8132	0.0001
Reference	White Grunt	FS-16-WG-R	M	M	M	M	M	
Reference	White Grunt	FS-17-WG-R	M	M	M	M	M	
Reference	White Grunt	FS-18-WG-R	M	M	M	M	M	
Reference	White Grunt	FS-19-WG-R	M	M	M	M	M	
Reference	White Grunt	FS-20-WG-R	6.0	2.40	39.74	0.3802	1.5992	0.0005
Target	Black Seabass	FS-01-SB-T	7.8	120.56	1539.72	2.0812	3.1874	0.0266
Target	Black Seabass	FS-02-SB-T	18.4	196.20	1066.30	2.2927	3.0279	0.0571
Target	Black Seabass	FS-03-SB-T	22.7	170.20	749.78	2.2310	2.8749	0.0523

			Arthur D. Little Inc.					
site	species	ID	lipid (dry) %	tPCB ng/g dry	tPCB/lipid ng/g dry lipid	log(tPCB)	log(tPCB/ Lipid)	**tPCB ppm Wet Weight**
Target	Black Seabass	FS-04-SB-T	31.7	250.00	788.64	2.3979	2.8969	0.0488
Target	Black Seabass	FS-05-SB-T	9.8	49.20	503.58	1.6920	2.7021	0.0127
Target	Black Seabass	FS-06-SB-T	38.3	272.50	711.49	2.4354	2.8522	0.0741
Target	Black Seabass	FS-07-SB-T	11.5	424.00	3686.96	2.6274	3.5667	0.0988
Target	Black Seabass	FS-08-SB-T	8.5	317.20	3714.29	2.5013	3.5699	0.0711
Target	Black Seabass	FS-09-SB-T	15.2	84.00	552.63	1.9243	2.7424	0.0221
Target	Black Seabass	FS-10-SB-T	22.7	110.00	484.58	2.0414	2.6854	0.0289
Target	Black Seabass	FS-11-SB-T	18.0	175.80	976.67	2.2450	2.9897	0.0447
Target	Vermilion Snapper	FS-01-VS-T	23.0	47.30	205.65	1.6749	2.3131	0.0128
Target	Vermilion Snapper	FS-02-VS-T	M	M	M	M	M	
Target	Vermilion Snapper	FS-03-VS-T	M	M	M	M	M	
Target	Vermilion Snapper	FS-04-VS-T	M	M	M	M	M	
Target	Vermilion Snapper	FS-05-VS-T	14.0	212.00	1514.29	2.3263	3.1802	0.0579
Target	Vermilion Snapper	FS-06-VS-T	M	M	M	M	M	
Target	Vermilion Snapper	FS-07-VS-T	M	M	M	M	M	
Target	Vermilion Snapper	FS-08-VS-T	15.4	57.60	374.03	1.7604	2.5729	0.0175
Target	Vermilion Snapper	FS-09-VS-T	M	M	M	M	M	
Target	Vermilion Snapper	FS-10-VS-T	19.6	130.00	663.27	2.1139	2.8217	0.0338
Target	Vermilion Snapper	FS-11-VS-T	M	M	M	M	M	
Target	Vermilion Snapper	FS-12-VS-T	M	M	M	M	M	
Target	Vermilion Snapper	FS-13-VS-T	23.1	48.59	210.35	1.6865	2.3229	0.0132
Target	Vermilion Snapper	FS-14-VS-T	22.2	58.60	263.96	1.7679	2.4215	0.0158
Target	Vermilion Snapper	FS-15-VS-T	M	M	M	M	M	
Target	Vermilion Snapper	FS-16-VS-T	M	M	M	M	M	
Target	Vermilion Snapper	FS-17-VS-T	M	M	M	M	M	
Target	Vermilion Snapper	FS-18-VS-T	M	M	M	M	M	
Target	Vermilion Snapper	FS-19-VS-T	14.2	47.60	335.21	1.6776	2.5253	0.0132
Target	Vermilion Snapper	FS-20-VS-T	M	M	M	M	M	
Target	White Grunt	FS-01-WG-T	M	M	M	M	M	
Target	White Grunt	FS-02-WG-T	M	M	M	M	M	
Target	White Grunt	FS-03-WG-T	M	M	M	M	M	
Target	White Grunt	FS-04-WG-T	M	M	M	M	M	
Target	White Grunt	FS-05-WG-T	M	M	M	M	M	

			Arthur D. Little Inc.					
site	species	ID	lipid (dry) %	tPCB ng/g dry	tPCB/lipid ng/g dry lipid	log(tPCB)	log(tPCB/ Lipid)	**tPCB ppm Wet Weight**
Target	White Grunt	FS-06-WG-T	6.0	271.00	4501.66	2.4330	3.6534	0.0629
Target	White Grunt	FS-07-WG-T	M	M	M	M	M	
Target	White Grunt	FS-08-WG-T	M	M	M	M	M	
Target	White Grunt	FS-09-WG-T	9.2	1192.00	12900.43	3.0763	4.1106	0.2789
Target	White Grunt	FS-10-WG-T	M	M	M	M	M	
Target	White Grunt	FS-11-WG-T	M	M	M	M	M	
Target	White Grunt	FS-12-WG-T	12.7	1788.96	14086.30	3.2526	4.1488	0.4955
Target	White Grunt	FS-13-WG-T	10.6	234.00	2207.55	2.3692	3.3439	0.0629
Target	White Grunt	FS-14-WG-T	7.3	215.23	2960.52	2.3329	3.4714	0.0514
Target	White Grunt	FS-15-WG-T	M	M	M	M	M	
Target	White Grunt	FS-16-WG-T	M	M	M	M	M	
Target	White Grunt	FS-17-WG-T	M	M	M	M	M	
Target	White Grunt	FS-18-WG-T	M	M	M	M	M	
Target	White Grunt	FS-19-WG-T	13.6	170.90	1256.62	2.2327	3.0992	0.0453
Target	White Grunt	FS-20-WG-T	8.1	478.10	5887.93	2.6795	3.7700	0.1119
			lipid (dry)					
		Average	10.8					

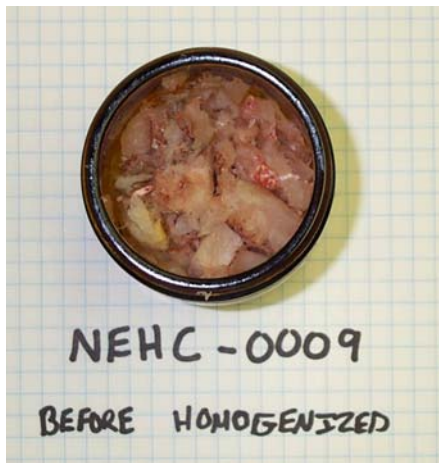


A. Vermilion Snapper fillet with skin on



B. Scoring skin with scalpel

C. Preparing fillet

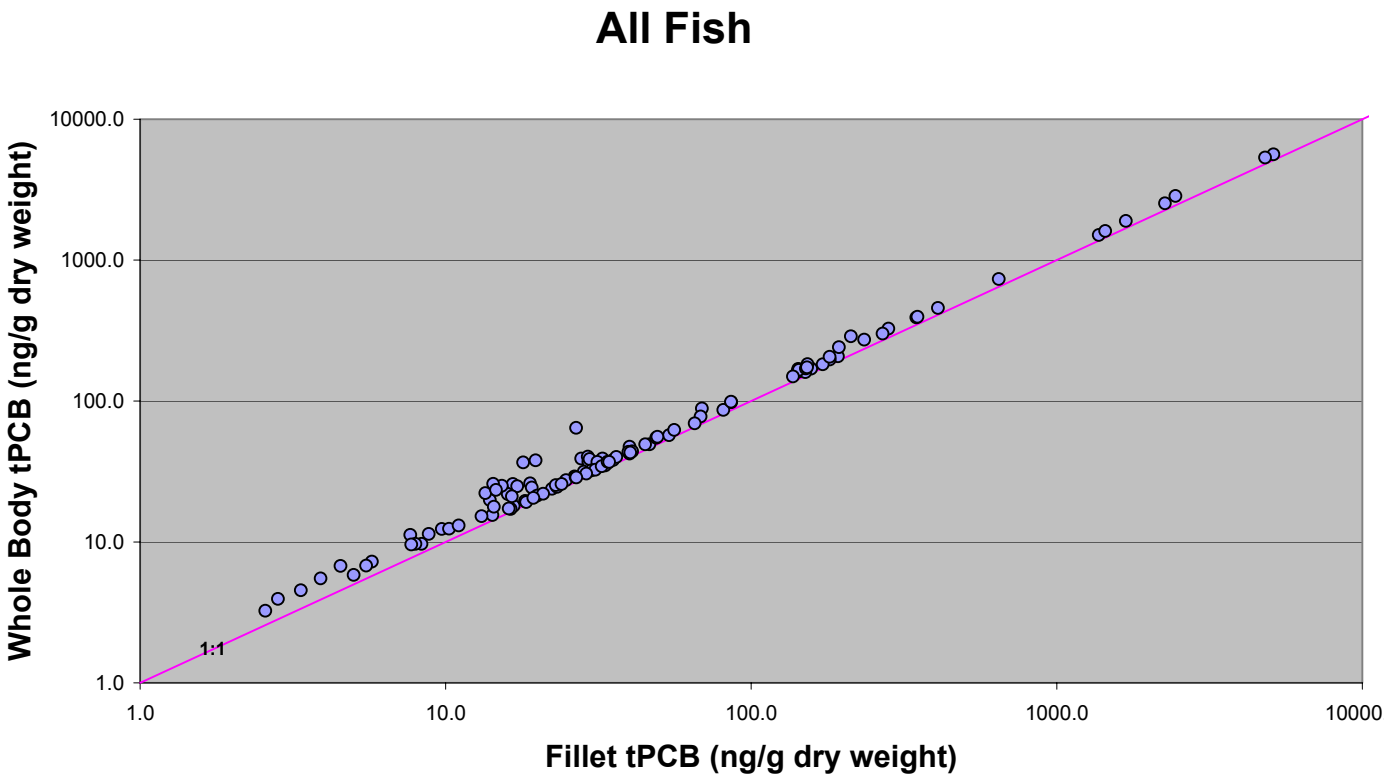


D. Sample prior to homogenization

E. Homogenizing the sample

F. Homogenized sample for extraction

Figure A4c-1. Procedure used for preparing the fish fillets with skin on prior to analysis for lipids and PCBs (photos by Axys Environ. Ltd., Sidney, Canada).



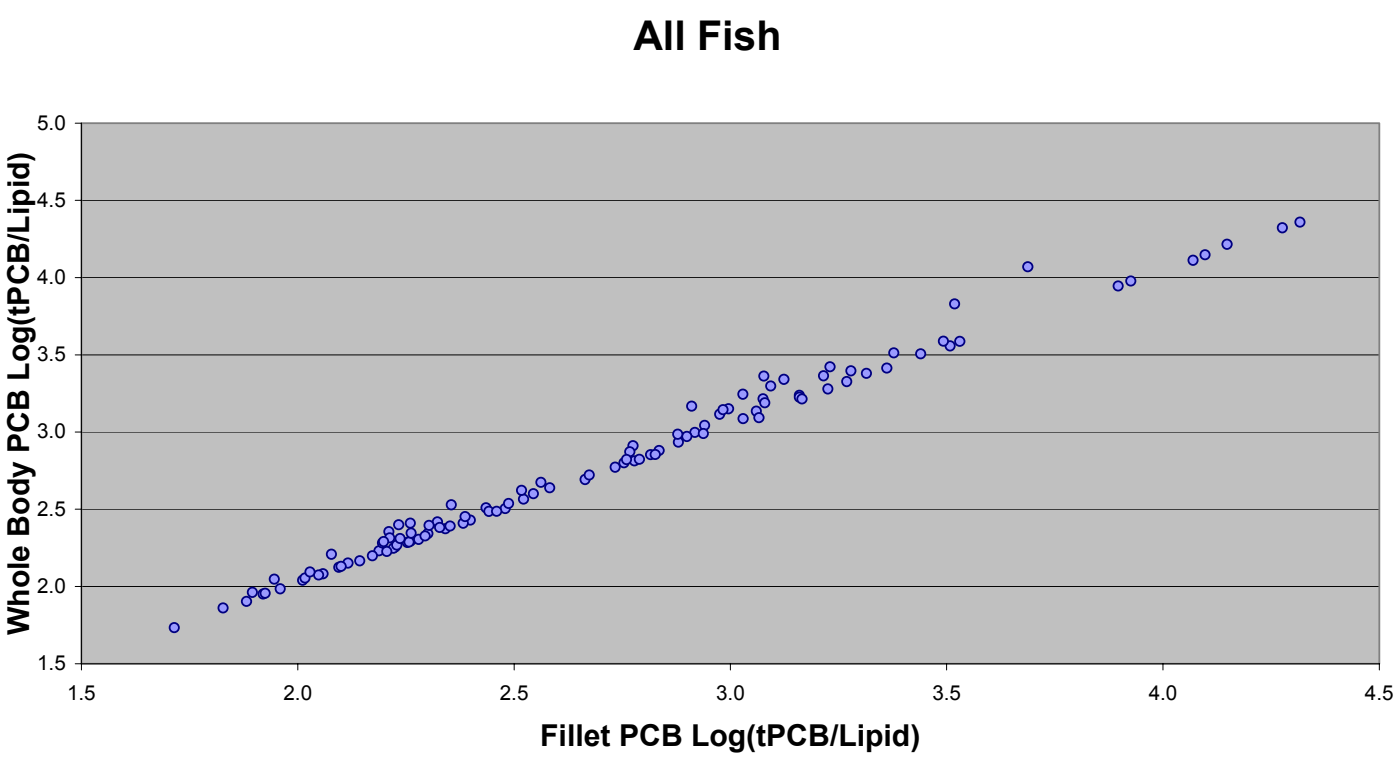
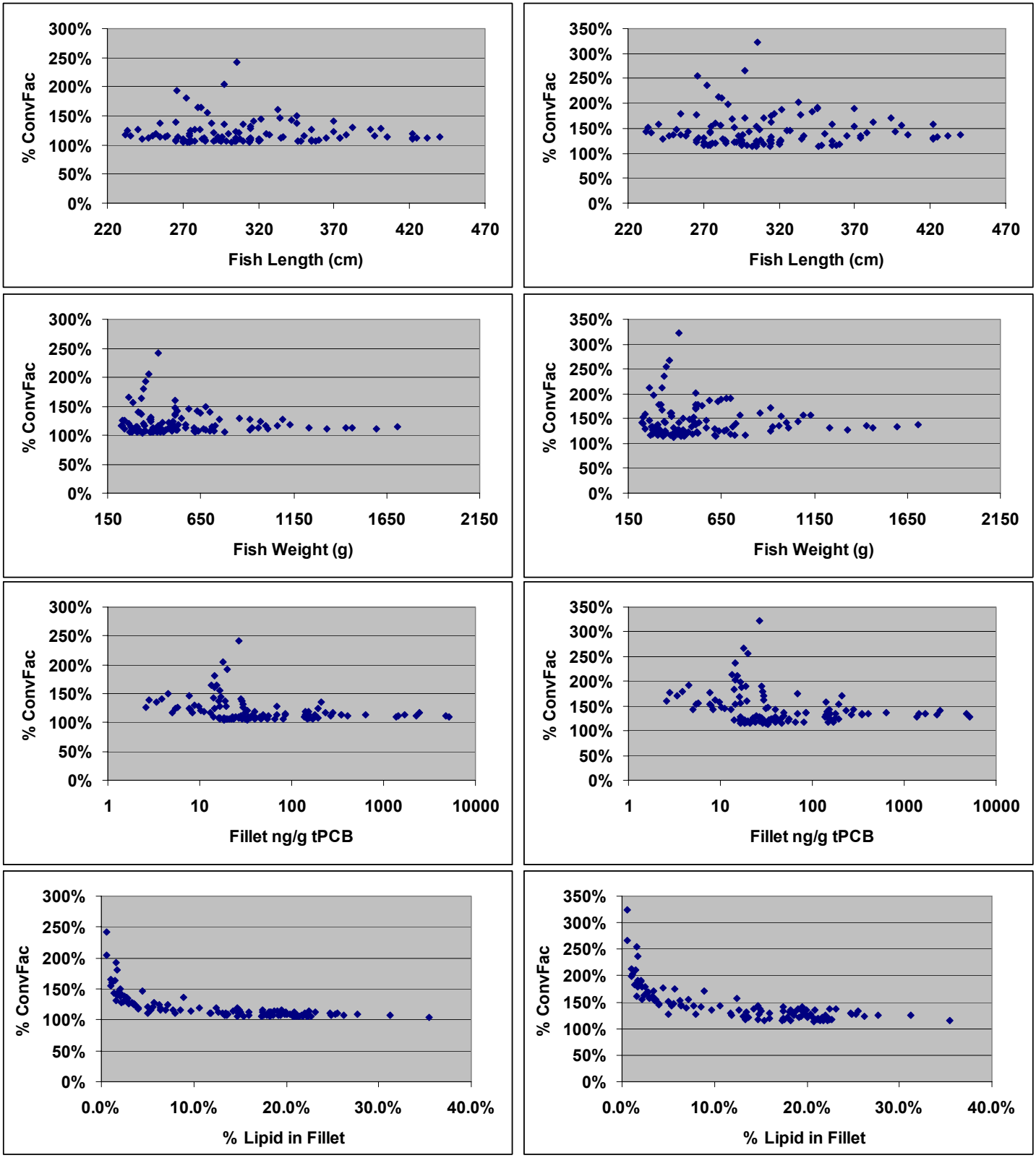


Figure A4c-2. Relationship between tPCB ng/g dry weight measured in whole body and fillet (A) and Log(tPCB/g lipid) (B) for the reefex fish.

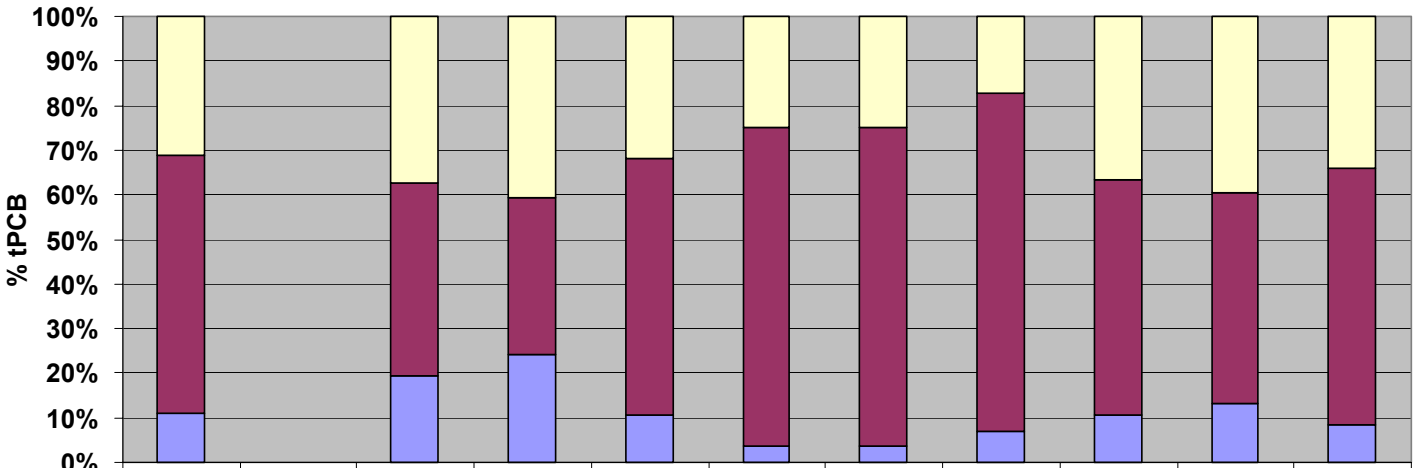


A. Base Parameters for calculating whole body tissue concentration

B. Alternative parameter values: **LL +**42% **OL +**46% **LD +**13%

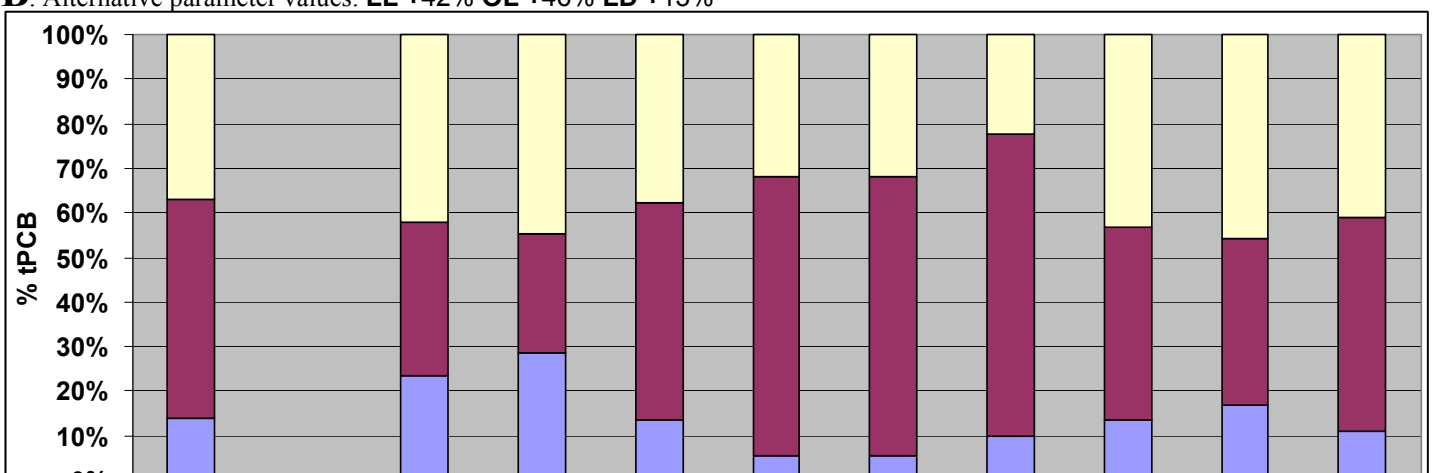
Figure A4c-3. The relationship between fish length, weight, fillet tPCB (ng/g), fillet lipid content versus whole body to fillet conversion factor (ConvFac) calculated with the base parameters (left panel, A), and alternative parameter values (right panel, B) in Table A4c-4 (B).

A. Base Parameters for calculating whole body tissue concentration



	all	BSB	BSB-R	BSB-T	VS	VS-R	VS-T	WG	WG-R	WG-T
Other	31.2%	38%	41%	32%	25%	25%	17%	37%	40%	34%
Fillet	57.7%	43%	35%	58%	71%	71%	76%	53%	47%	58%
Liver	11.1%	19%	24%	10%	4%	4%	7%	11%	13%	8%

B. Alternative parameter values: **LL +**42% **OL +**46% **LD +**13%



	all	BSB	BSB-R	BSB-T	VS	VS-R	VS-T	WG	WG-R	WG-T
Other	37.1%	42%	45%	38%	32%	32%	22%	43%	46%	41%
Fillet	48.8%	34%	27%	49%	63%	63%	68%	43%	37%	48%
Liver	14.1%	23%	29%	14%	5%	5%	10%	14%	17%	11%

Figure A4c-4. The percent of PCBs present in liver, fillet, and other tissues calculated using the base parameters (A) and calculated using the alternative parameter values in Table A4c-4 (B).

A4C.1 Assumptions

EQUATIONS

$$tPCB_{Liver}\ ng = CtPCBL\ \frac{ng\ tPCB}{g\ lipid\ dry} \times LL\frac{g\ lipid\ dry}{g\ liver\ dry} \times LD\frac{(g\ liver\ dry)(g\ fillet\ wet)}{(g\ liver\ wet)(g\ fillet\ dry)} \times DW\frac{g\ fillet\ dry}{g\ fillet\ wet} \times LW\ g\ liver\ wet \quad [1]$$

$$tPCB_{Fillet}\ ng = CtPCBL\ \frac{ng\ tPCB}{g\ lipid\ dry} \times FL\frac{g\ lipid\ dry}{g\ fillet\ dry} \times DW\frac{g\ fillet\ dry}{g\ fillet\ wet} \times 2FW\ g\ fillet\ wet \quad [2]$$

$$tPCB_{Other}\ ng = CtPCBL\ \frac{ng\ tPCB}{g\ lipid\ dry} \times FL\frac{g\ lipid\ dry}{g\ fillet\ dry} \times OL\frac{(g\ lipid\ dry)(g\ fillet\ dry)}{(g\ other\ dry)(g\ lipid\ dry)} \times OW\frac{(g\ other\ dry)(g\ fillet\ wet)}{(g\ other\ wet)(g\ fillet\ dry)} \times DW\frac{g\ fillet\ dry}{g\ fillet\ wet} \times (BW - LW - 2FW)\ g\ other\ wet \quad [3]$$

Whole Body Tissue Concentration:

$$\frac{tPCB_{WholeBody}\ ng}{g} = \frac{(tPCB_{Liver}\ ng + tPCB_{Fillet}\ ng + tPCB_{Other}\ ng}{BW\ g\ tissue\ (wet)} \times \frac{g\ tissue\ (wet)}{WW\ g\ tissue\ (dry)} \quad [4]$$

CtPCBL = Concentration of total PCB per unit lipid
LW = wet weight of liver (g liver wet)
FW = wet weight of fillet (g fillet wet)
BW = wet weight of whole fish (g fish wet)
Conversion factors:
- **LL** = fraction of liver that is lipid (g lipid dry/g liver dry)
- **LD** = dry:wet weight of liver/dry:wet weight of fillet
- **DW** = dry:wet weight of fillet
- **FL** = fraction of fillet that is lipid (g lipid dry/g fillet dry)
- **OL** = fraction of other tissue that is lipid expressed as ratio (lipid other tissue)/(lipid fillet)
- **OW** = dry:wet weight of other tissue expressed as ratio (dry:wet other)/(dry:wet fillet)
- **WW** = whole body dry:wet ratio
  = ((**LW**/**BW**)**LD** + 2**FW**/**BW** + ((**BW** − **LW** − 2**FW**)/**BW**)**OW**)**DW**

FACTS

Fillets were processed with "skin on"
Fillet weight in fish = 2 times weight of fillet analyzed
Other tissue weight = whole body weight - 2*fillet weight - liver weight

ASSUMPTIONS

1	PCB concentration is proportional to lipid		
2	Fraction of lipids in Liver	**LL =**	0.5496 (average of sable fish and winter flounder)
3	Ratio lipids in other tissues : fillet lipids ("Skin on")	**OL =**	1.2000 (20% more lipid than fillet in other tissues)
4	Ratio btwn liver:tissue dry weight ("skin off")	**LD =**	1.6565 (from winter flounder liver:tissue)
5	Ratio btwn other tissue:fillet tissue dry weight	**OW =**	1.0000 (same dry:wet ratio)

Table A4C-1. Relationship between winter flounder fillets and liver reported in Estuarine Ecological Risk Assessment for Portsmouth Naval Shipyard (MESO-E 2000, Table VI-1)

Winter Flounder (Adult)		n	Fillet (Skin off) Solid g/g wet	Lipid g/g dry	Lipid g/g wet	Ratio Liver : Fillet Solid (wet)	Lipid (dry)	Lipid (wet)
Fillet (Skin off)	All	19	0.1991	0.0266	0.0053			
	Gulf of Maine	5	0.1905	0.0231	0.0044			
	Portsmouth Harbor	14	0.2077	0.0301	0.0063			
			Liver					
Liver	All	14	0.3298	0.3225	0.1064	1.66	12.12	20.08
	Gulf of Maine	2	0.3410	0.3223	0.1099	1.79	13.95	24.98
	Portsmouth Harbor	12	0.3231	0.3226	0.1042	1.56	10.72	16.67

Table A4C-2. Relationship between liver and fillets reported for sable fish from the SINKEX deep ocean study (Gauthier et al. 2003).

Sable Fish (Adult)		n	Fillet (Skin off) Solid g/g wet	Lipid g/g dry	Ratio liver : muscle	Solid wet	Lipid dry
Fillet (Skin off)	all	38	0.3160	0.5553			
	ship	15	0.3090	0.5349			
	reference	24	0.3205	0.5686			
			Liver				
Liver	all	21	0.4633	0.7767	all	1.4661	1.3987
	ship	5	0.4776	0.7416	ship	1.5456	1.3864
	reference	17	0.4589	0.7877	reference	1.4318	1.3853

Table A4C-3. Fraction of solids and lipids measured in fish from the PUGET SOUND and GEORGIA BASIN (Johnston et al. in prep).

				Whole Body	
WHOLE BODY	Species		n	Solid g/g wet	Lipid g/g dry
	Rat Fish	Sinclair Inet	6	0.2969	0.1153
	Rat Fish	Strait of Georgia	6	0.2713	0.0923
	Rock Sole	Sinclair Inlet	3	0.1903	0.0145
	Rock Sole	Nisqually Reach	3	0.1780	0.0068
	Sand Sole	Sinclair Inlet	3	0.1656	0.0053
	Sand Sole	Port Gardner	3	0.2032	0.0187
	Surf Perch	Sinclair Inlet	3	0.2286	0.0305
	Surf Perch	Nisqually Reach	2	0.2398	0.0325
	Staghorn Sculpin	Sinclair Inlet	2	0.1840	0.0111
	Staghorn Sculpin	Strait of Georgia	3	0.1829	0.0093
	English Sole	Sinclair Inlet	9	0.2209	0.0135
	English Sole	Strait of Georgia	3	0.1909	0.0086

Table A4C-4. Fraction of solids and lipids measured in the from this study (REEFEX FISH).

			Fillet (Skin on)		
		n	Solid g/g wet	Lipid g/g dry	Lipid g/g wet
Fillet (Skin on)	all REEFEX	113	0.2534	0.1293	0.0351
Black Seabass	all	31	0.2294	0.0844	0.0221
Black Seabass	Reference	20	0.2098	0.0248	0.0053
Black Seabass	Target	11	0.2650	0.1927	0.0526
Vermilion Snapper	all	42	0.2813	0.1816	0.0511
Vermilion Snapper	Reference	22	0.2676	0.1832	0.0499
Vermilion Snapper	Target	20	0.2963	0.1799	0.0525
White Grunt	all	40	0.2428	0.1091	0.0283
White Grunt	Reference	20	0.2242	0.0518	0.0123
White Grunt	Target	20	0.2613	0.1665	0.0443

Table A4c-5. The precent change in whole body to fillet tPCB concentration (ConvFac), lipid content (Lratio), and tPCB/lipid (ConvFacL) as function of varing LL, OL, and LD seperately (A) and combined (B). The base values used in the wholebody tPCB calcualtion are shown in boldface.

(A) Parameter Sensitivity

Parameter				Percent change from base condition			
LL	ConvFac	Lratio	ConvFacL	LL	ConvFac	Lratio	ConvFacL
0.32	1.14	1.31	0.89	-42%	-6%	-13%	5%
0.55	1.21	1.50	0.85	0%	0%	0%	0%
0.78	1.28	1.69	0.81	42%	6%	13%	-4%
OL							
1.20	1.21	1.50	0.85	0%	0%	0%	0%
1.70	1.37	1.66	0.86	42%	13%	11%	2%
1.75	1.38	1.67	0.86	46%	14%	12%	2%
LD							
1.47	1.19	1.50	0.84	0%	0%	0%	0%
1.66	1.21	1.50	0.85	13%	1%	0%	1%
OW							
0.50	1.22	1.50	0.85	-50%	1%	0%	0%
1.00	1.21	1.50	0.85	0%	0%	0%	0%
1.50	1.20	1.50	0.85	50%	-1%	0%	0%

(B) Alternative parameters

Parameter	Change	Value	ConvFac	Lratio	ConvFacL
LL	42%	0.78	1.45	1.86	0.83
OL	46%	1.75			
LD	13%	1.66			

			AXYS Analytical Services							
site	species	ID	mtPCB liver ng	mtPCB Fillets ng	mtPCB ng	WB dry:wet	WB tPCB ng/g dry	WB log(tPCB) log(ng/g)	WB tPCB/ lipid ng/g lipid	WB Log(tPCB/ lipid) log (ng/g lipid)
Site	SP	ID	mtPCBLiver	mtPCBFillet	mtPCBOther	WW	X_PCBWB	XLGPCBW	X_LPCBW	XLLPCBW
Reference	Black Seabass	FS-11-SB-R	3215.9	1254.0	1351.6	0.2144	64.5	1.810	11756	4.070
Reference	Black Seabass	FS-10-SB-R	595.2	881.6	1053.6	0.2007	19.9	1.299	1412	3.150
Reference	Black Seabass	FS-04-SB-R	609.8	630.4	2281.7	0.2092	26.1	1.416	1303	3.115
Reference	Black Seabass	FS-03-SB-R	1130.3	1212.6	3409.9	0.2107	39.1	1.592	2311	3.364
Reference	Black Seabass	FS-02-SB-R	789.6	1710.7	5035.0	0.2217	37.1	1.569	1104	3.043
Reference	Black Seabass	FS-01-SB-R	2815.4	12610.0	28399.0	0.2294	169.4	2.229	1363	3.135
Reference	Black Seabass	FS-19-SB-R	406.3	399.0	361.7	0.1982	22.2	1.347	2192	3.341
Reference	Black Seabass	FS-08-SB-R	244.1	1112.3	891.3	0.2166	39.2	1.593	994	2.997
Reference	Black Seabass	FS-16-SB-R	499.3	606.9	499.1	0.2158	25.8	1.412	2645	3.422
Reference	Black Seabass	FS-14-SB-R	576.9	920.6	1287.5	0.2141	40.3	1.605	1641	3.215
Reference	Black Seabass	FS-17-SB-R	356.6	732.2	451.1	0.2134	21.9	1.340	815	2.911
Reference	Black Seabass	FS-12-SB-R	646.5	642.2	559.7	0.2226	25.1	1.399	1757	3.245
Reference	Black Seabass	FS-18-SB-R	758.7	550.8	534.4	0.2067	25.9	1.413	1471	3.168
Reference	Black Seabass	FS-15-SB-R	1196.9	685.6	815.6	0.2021	37.9	1.579	2301	3.362
Reference	Black Seabass	FS-13-SB-R	1337.8	849.4	595.9	0.2032	36.7	1.565	6757	3.830
Reference	Black Seabass	FS-09-SB-R	302.1	834.0	857.7	0.2189	24.4	1.387	745	2.872
Reference	Black Seabass	FS-06-SB-R	498.1	1276.8	902.7	0.1805	38.7	1.588	2490	3.396
Reference	Black Seabass	FS-07-SB-R	349.0	1950.6	1626.7	0.2106	37.0	1.568	935	2.971
Reference	Black Seabass	FS-20-SB-R	861.9	1010.6	674.8	0.2131	23.4	1.369	1985	3.298
Reference	Black Seabass	FS-05-SB-R	782.6	1080.4	1247.4	0.2137	24.9	1.396	1395	3.145
Target	Black Seabass	FS-11-SB-T	2019.0	11001.6	4225.1	0.2749	160.4	2.205	860	2.935
Target	Black Seabass	FS-04-SB-T	3279.99	21030.80	6114.85	0.2752	166.7	2.222	759	2.880
Target	Black Seabass	FS-07-SB-T	11101.2	76373.2	37024.9	0.2582	391.7	2.593	2597	3.414
Target	Black Seabass	FS-08-SB-T	9232.9	15450.0	12083.8	0.2485	288.4	2.460	3251	3.512
Target	Black Seabass	FS-10-SB-T	1568.0	7808.4	5058.7	0.2857	98.1	1.992	436	2.639
Target	Black Seabass	FS-02-SB-T	1859.1	18493.2	6307.9	0.3015	170.0	2.231	650	2.813
Target	Black Seabass	FS-05-SB-T	914.7	3480.0	2007.0	0.2546	47.4	1.676	323	2.509
Target	Black Seabass	FS-01-SB-T	1299.1	2145.6	7089.4	0.2173	88.8	1.948	1546	3.189
Target	Black Seabass	FS-03-SB-T	2681.0	25891.2	10615.2	0.2949	208.0	2.318	666	2.824
Target	Black Seabass	FS-09-SB-T	1730.3	9275.2	4424.7	0.2786	77.7	1.890	398	2.600
Target	Black Seabass	FS-06-SB-T	4313.2	33379.2	12072.7	0.2750	197.3	2.295	714	2.854
Reference	Vermilion Snap	FS-07-VS-R	66.0	1205.2	350.6	0.2513	21.3	1.328	133	2.124
Reference	Vermilion Snap	FS-20-VS-R	113.1	1350.5	591.9	0.2515	29.2	1.465	368	2.565
Reference	Vermilion Snap	FS-15-VS-R	116.3	2607.6	1268.9	0.2610	44.0	1.643	237	2.374
Reference	Vermilion Snap	FS-11-VS-R	110.1	2130.0	736.8	0.2510	36.6	1.564	269	2.430
Reference	Vermilion Snap	FS-12-VS-R	197.5	4013.2	859.1	0.2745	49.2	1.692	320	2.505
Reference	Vermilion Snap	FS-13-VS-R	43.1	1035.8	607.3	0.2914	18.0	1.256	73	1.861

			AXYS Analytical Services							
site	species	ID	mtPCB liver ng	mtPCB Fillets ng	mtPCB ng	WB dry:wet	WB tPCB ng/g dry	WB log(tPCB) log(ng/g)	WB tPCB/ lipid ng/g lipid	WB Log(tPCB/ lipid) log (ng/g lipid)
Reference	Vermilion Snap	FS-17-VS-R	67.7	1048.6	361.4	0.2664	19.5	1.291	89	1.951
Reference	Vermilion Snap	FS-06-VS-R	77.7	1585.1	609.2	0.3008	23.8	1.377	110	2.041
Reference	Vermilion Snap	FS-21-VS-R	104.2	1246.4	729.4	0.2480	27.4	1.438	204	2.309
Reference	Vermilion Snap	FS-08-VS-R	32.6	992.2	261.4	0.2775	17.2	1.235	80	1.904
Reference	Vermilion Snap	FS-05-VS-R	57.4	1441.3	344.3	0.2712	22.0	1.342	121	2.082
Reference	Vermilion Snap	FS-14-VS-R	55.4	1520.8	384.1	0.3025	19.2	1.283	54	1.734
Reference	Vermilion Snap	FS-03-VS-R	69.0	1482.9	441.9	0.2875	24.6	1.391	119	2.075
Reference	Vermilion Snap	FS-18-VS-R	66.4	1051.5	344.5	0.2653	17.3	1.238	90	1.956
Reference	Vermilion Snap	FS-22-VS-R	145.1	1450.1	471.3	0.2252	31.5	1.499	632	2.801
Reference	Vermilion Snap	FS-02-VS-R	189.7	3836.0	1237.8	0.2616	57.3	1.758	257	2.410
Reference	Vermilion Snap	FS-19-VS-R	183.1	3039.6	1262.9	0.2905	38.1	1.581	197	2.294
Reference	Vermilion Snap	FS-10-VS-R	120.5	2113.9	1089.3	0.2716	28.9	1.460	142	2.151
Reference	Vermilion Snap	FS-16-VS-R	130.8	2129.5	677.0	0.2570	32.2	1.508	180	2.256
Reference	Vermilion Snap	FS-01-VS-R	83.6	1810.3	516.4	0.2816	20.5	1.312	97	1.985
Reference	Vermilion Snap	FS-04-VS-R	218.6	2006.6	721.9	0.2776	25.3	1.404	170	2.231
Reference	Vermilion Snap	FS-09-VS-R	135.6	1390.1	318.7	0.2564	15.5	1.191	114	2.055
Target	Vermilion Snap	FS-14-VS-T	184.9	3516.8	849.3	0.2818	42.4	1.627	202	2.305
Target	Vermilion Snap	FS-07-VS-T	302.3	3914.0	700.7	0.4328	25.8	1.411	193	2.285
Target	Vermilion Snap	FS-02-VS-T	195.4	3458.6	620.2	0.2923	32.6	1.513	147	2.166
Target	Vermilion Snap	FS-11-VS-T	1259.1	16655.2	3552.0	0.2930	160.3	2.205	715	2.855
Target	Vermilion Snap	FS-09-VS-T	806.1	11804.0	2319.5	0.2821	86.5	1.937	493	2.692
Target	Vermilion Snap	FS-06-VS-T	277.4	4363.2	712.3	0.2819	30.6	1.486	177	2.247
Target	Vermilion Snap	FS-05-VS-T	1728.3	32404.4	7119.8	0.2914	182.2	2.261	1238	3.093
Target	Vermilion Snap	FS-18-VS-T	147.5	3168.8	541.3	0.2817	34.9	1.543	169	2.227
Target	Vermilion Snap	FS-17-VS-T	466.3	4006.8	1116.9	0.2837	49.3	1.692	246	2.391
Target	Vermilion Snap	FS-03-VS-T	186.5	2714.1	786.1	0.3025	28.7	1.458	135	2.130
Target	Vermilion Snap	FS-16-VS-T	296.7	3523.0	437.8	0.2833	34.5	1.537	158	2.199
Target	Vermilion Snap	FS-10-VS-T	691.3	5270.4	1170.7	0.2597	62.4	1.795	527	2.721
Target	Vermilion Snap	FS-01-VS-T	375.7	3574.2	1526.9	0.2831	43.6	1.639	220	2.342
Target	Vermilion Snap	FS-19-VS-T	510.4	4116.0	907.3	0.2928	40.1	1.603	306	2.486
Target	Vermilion Snap	FS-08-VS-T	439.4	5108.8	1121.2	0.3119	43.1	1.635	194	2.288
Target	Vermilion Snap	FS-12-VS-T	697.0	1129.1	395.4	0.3857	11.2	1.050	251	2.400
Target	Vermilion Snap	FS-13-VS-T	546.8	4305.5	882.1	0.2944	37.1	1.569	185	2.268
Target	Vermilion Snap	FS-04-VS-T	892.7	6098.4	2236.3	0.2734	54.9	1.739	345	2.538
Target	Vermilion Snap	FS-20-VS-T	449.4	5370.8	1197.0	0.2724	37.0	1.568	212	2.327
Target	Vermilion Snap	FS-15-VS-T	886.4	11916.8	2369.4	0.3031	69.5	1.842	307	2.487
Reference	White Grunt	FS-17-WG-R	64.6	109.2	114.7	0.2309	3.9	0.596	227	2.355
Reference	White Grunt	FS-15-WG-R	63.9	396.0	348.6	0.2412	9.7	0.986	124	2.094

			AXYS Analytical Services							
site	species	ID	mtPCB liver ng	mtPCB Fillets ng	mtPCB ng	WB dry:wet	WB tPCB ng/g dry	WB log(tPCB) log(ng/g)	WB tPCB/ lipid ng/g lipid	WB Log(tPCB/ lipid) log (ng/g lipid)
Reference	White Grunt	FS-08-WG-R	96.2	290.0	219.0	0.2191	7.2	0.860	206	2.315
Reference	White Grunt	FS-11-WG-R	121.9	468.6	408.1	0.2330	9.7	0.987	191	2.282
Reference	White Grunt	FS-10-WG-R	96.8	339.3	291.8	0.2139	6.8	0.832	195	2.291
Reference	White Grunt	FS-06-WG-R	151.1	251.9	219.9	0.2151	5.5	0.741	257	2.410
Reference	White Grunt	FS-07-WG-R	2739.6	16707.6	10930.6	0.2506	166.3	2.221	2396	3.380
Reference	White Grunt	FS-19-WG-R	312.6	905.8	732.0	0.2109	12.4	1.092	419	2.622
Reference	White Grunt	FS-12-WG-R	350.9	902.8	816.9	0.2108	11.4	1.057	473	2.674
Reference	White Grunt	FS-13-WG-R	884.7	2616.8	1632.6	0.2233	21.1	1.324	967	2.985
Reference	White Grunt	FS-20-WG-R	23.9	145.2	118.1	0.2210	5.8	0.766	92	1.962
Reference	White Grunt	FS-18-WG-R	24.9	73.5	75.0	0.2208	3.2	0.511	112	2.047
Reference	White Grunt	FS-16-WG-R	108.2	359.6	301.9	0.2110	9.6	0.982	262	2.418
Reference	White Grunt	FS-05-WG-R	172.0	698.6	505.5	0.2314	12.4	1.094	221	2.345
Reference	White Grunt	FS-09-WG-R	106.3	215.2	185.8	0.2193	4.5	0.657	162	2.208
Reference	White Grunt	FS-04-WG-R	178.2	863.5	712.8	0.2343	13.1	1.117	205	2.311
Reference	White Grunt	FS-14-WG-R	239.2	308.4	305.4	0.1861	6.8	0.830	338	2.529
Reference	White Grunt	FS-03-WG-R	555.5	1758.1	1655.9	0.2301	17.8	1.250	249	2.396
Reference	White Grunt	FS-02-WG-R	257.2	1728.7	1666.8	0.2257	15.2	1.183	283	2.452
Reference	White Grunt	FS-01-WG-R	2157.0	12121.2	8268.0	0.2816	55.9	1.747	241	2.382
Target	White Grunt	FS-13-WG-T	2184.3	8746.2	5175.3	0.2565	182.6	2.261	1725	3.237
Target	White Grunt	FS-11-WG-T	2316.3	15127.2	7352.3	0.2564	170.3	2.231	977	2.990
Target	White Grunt	FS-10-WG-T	93255.7	392446.0	249744.2	0.2578	2855.8	3.456	16421	4.215
Target	White Grunt	FS-02-WG-T	173406.3	1381800.0	629730.4	0.2915	5639.2	3.751	22827	4.358
Target	White Grunt	FS-15-WG-T	83551.5	579890.0	273307.2	0.2523	2536.2	3.404	14034	4.147
Target	White Grunt	FS-20-WG-T	5513.4	56977.2	42566.6	0.2384	458.0	2.661	3610	3.557
Target	White Grunt	FS-14-WG-T	1408.7	7934.4	5329.9	0.2366	273.2	2.436	3210	3.506
Target	White Grunt	FS-09-WG-T	4098.7	53256.0	27137.7	0.2320	1510.9	3.179	12926	4.111
Target	White Grunt	FS-19-WG-T	1184.9	7801.2	5120.4	0.2612	173.6	2.240	1220	3.087
Target	White Grunt	FS-06-WG-T	2193.0	6872.8	4756.8	0.2522	241.5	2.383	3877	3.588
Target	White Grunt	FS-08-WG-T	1257.8	8563.2	4334.6	0.2488	206.2	2.314	2122	3.327
Target	White Grunt	FS-16-WG-T	8008.4	69948.0	48722.4	0.2816	1612.2	3.207	8820	3.945
Target	White Grunt	FS-05-WG-T	851.3	4430.4	2286.3	0.2515	99.0	1.996	663	2.822
Target	White Grunt	FS-04-WG-T	4910.8	20480.0	14867.5	0.2903	327.1	2.515	1680	3.225
Target	White Grunt	FS-03-WG-T	5815.0	33578.0	18548.7	0.2991	396.2	2.598	1900	3.279
Target	White Grunt	FS-07-WG-T	1835.0	18438.6	8817.9	0.2876	149.6	2.175	592	2.772
Target	White Grunt	FS-12-WG-T	43559.1	285692.0	172436.9	0.2850	1896.7	3.278	9498	3.978
Target	White Grunt	FS-01-WG-T	6387.4	48371.8	25050.2	0.2621	300.9	2.478	1637	3.214
Target	White Grunt	FS-18-WG-T	171997.3	1357920.0	949103.3	0.2911	5348.8	3.728	21000	4.322
Target	White Grunt	FS-17-WG-T	30790.5	177210.0	118002.1	0.2593	735.6	2.867	3863	3.587

			AXYS Analytical Services							
site	species	ID	mtPCB liver ng	mtPCB Fillets ng	mtPCB ng	WB dry:wet	WB tPCB ng/g dry	WB log(tPCB) log(ng/g)	WB tPCB/ lipid ng/g lipid	WB Log(tPCB/ lipid) log (ng/g lipid)
		Average for all data	6415.3	44326.8	25190.3	0.2556	264.7	1.72	1861	2.774
Summary for each Group										
	Black Seabass	all	1870.0	8234.8	5156.8	0.2316	86.3	1.8	1922	3.136
	Black Seabass	Reference	898.6	1547.5	2641.8	0.2108	39.0	1.5	2369	3.252
	Black Seabass	Target	3636.2	20393.5	9729.5	0.2695	172.2	2.2	1109	2.925
	Vermilion Snapper	all	326.7	4212.0	1065.4	0.2834	41.1	1.5	249	2.299
	Vermilion Snapper	Reference	108.3	1840.3	644.8	0.2692	28.1	1.4	184	2.186
	Vermilion Snapper	Target	567.0	6820.9	1528.1	0.2991	55.3	1.7	321	2.422
	White Grunt	all	16330.8	114418.6	66047.5	0.2450	637.8	1.9	3506	2.993
	White Grunt	Reference	435.2	2063.0	1475.5	0.2255	19.9	1.0	381	2.423
	White Grunt	Target	32226.3	226774.2	130619.5	0.2646	1255.7	2.8	6630	3.563

			AXIS Analytical Services										
			Measured	Estimated	Fillet tPCB	WB tPCB	tPCB	lipid	tPCB/lipid				
site	species	ID	Fillet (Skin on)	Whole Body	ng/g dry	ng/g dry weight	WB:fillet	WB:fillet	WB:fillet		Percent tPCB found in		
Site	SP	ID	%lipid fillet	%lipid WB	X_PCB	x_PCBWB	ConvFac	Lratio	ConvFacL	% difference	%liver	%fillet	%other
Reference	Black Seabass	FS-11-SB-R	0.5%	2.7%	26.73	64.50	2.41	4.88	0.49	241%	55%	22%	23%
Reference	Black Seabass	FS-10-SB-R	1.4%	3.0%	13.95	19.89	1.43	2.11	0.68	143%	24%	35%	42%
Reference	Black Seabass	FS-04-SB-R	2.0%	3.7%	18.90	26.06	1.38	1.84	0.75	138%	17%	18%	65%
Reference	Black Seabass	FS-03-SB-R	1.7%	3.3%	27.76	39.06	1.41	1.93	0.73	141%	20%	21%	59%
Reference	Black Seabass	FS-02-SB-R	3.4%	5.0%	29.32	37.10	1.27	1.50	0.84	127%	10%	23%	67%
Reference	Black Seabass	FS-01-SB-R	12.4%	16.4%	142.65	169.37	1.19	1.32	0.90	119%	6%	29%	65%
Reference	Black Seabass	FS-19-SB-R	1.0%	2.9%	13.48	22.22	1.65	2.84	0.58	165%	35%	34%	31%
Reference	Black Seabass	FS-08-SB-R	3.9%	5.7%	32.62	39.16	1.20	1.44	0.83	120%	11%	49%	40%
Reference	Black Seabass	FS-16-SB-R	1.0%	2.4%	16.60	25.83	1.56	2.44	0.64	156%	31%	38%	31%
Reference	Black Seabass	FS-14-SB-R	2.5%	4.7%	29.21	40.28	1.38	1.91	0.72	138%	21%	33%	46%
Reference	Black Seabass	FS-17-SB-R	2.7%	5.3%	15.98	21.87	1.37	1.97	0.70	137%	23%	48%	29%
Reference	Black Seabass	FS-12-SB-R	1.4%	3.8%	15.27	25.08	1.64	2.65	0.62	164%	35%	35%	30%
Reference	Black Seabass	FS-18-SB-R	1.8%	5.8%	14.31	25.85	1.81	3.29	0.55	181%	41%	30%	29%
Reference	Black Seabass	FS-15-SB-R	1.6%	6.1%	19.70	37.93	1.93	3.69	0.52	193%	44%	25%	30%
Reference	Black Seabass	FS-13-SB-R	0.5%	2.2%	17.93	36.72	2.05	4.01	0.51	205%	48%	31%	21%
Reference	Black Seabass	FS-09-SB-R	3.3%	5.3%	19.14	24.35	1.27	1.62	0.78	127%	15%	42%	43%
Reference	Black Seabass	FS-06-SB-R	1.6%	2.9%	29.56	38.74	1.31	1.89	0.69	131%	19%	48%	34%
Reference	Black Seabass	FS-07-SB-R	4.0%	5.5%	31.38	36.99	1.18	1.38	0.85	118%	9%	50%	41%
Reference	Black Seabass	FS-20-SB-R	1.2%	3.1%	14.62	23.40	1.60	2.61	0.61	160%	34%	40%	26%
Reference	Black Seabass	FS-05-SB-R	1.8%	3.8%	17.16	24.88	1.45	2.13	0.68	145%	25%	35%	40%
Target	Black Seabass	FS-11-SB-T	18.7%	24.7%	141.48	160.44	1.13	1.32	0.86	113%	12%	64%	24%
Target	Black Seabass	FS-04-SB-T	22.0%	28.1%	150.37	166.75	1.11	1.28	0.87	111%	11%	69%	20%
Target	Black Seabass	FS-07-SB-T	15.1%	19.3%	346.98	391.74	1.13	1.28	0.88	113%	9%	61%	30%
Target	Black Seabass	FS-08-SB-T	8.9%	16.9%	211.88	288.41	1.36	1.91	0.71	136%	25%	42%	33%
Target	Black Seabass	FS-10-SB-T	22.5%	29.5%	86.07	98.09	1.14	1.31	0.87	114%	11%	54%	35%
Target	Black Seabass	FS-02-SB-T	26.2%	30.8%	157.12	170.04	1.08	1.18	0.92	108%	7%	69%	24%
Target	Black Seabass	FS-05-SB-T	14.7%	21.3%	40.00	47.45	1.19	1.45	0.82	119%	14%	54%	31%
Target	Black Seabass	FS-01-SB-T	5.7%	9.1%	69.01	88.77	1.29	1.58	0.81	129%	12%	20%	67%
Target	Black Seabass	FS-03-SB-T	31.2%	36.8%	192.41	207.95	1.08	1.18	0.92	108%	7%	66%	27%
Target	Black Seabass	FS-09-SB-T	19.5%	25.6%	68.34	77.68	1.14	1.31	0.87	114%	11%	60%	29%
Target	Black Seabass	FS-06-SB-T	27.6%	34.0%	180.85	197.33	1.09	1.23	0.89	109%	9%	67%	24%
Reference	Vermilion Snappe	FS-07-VS-R	16.0%	18.2%	19.92	21.30	1.07	1.14	0.94	107%	4%	74%	22%
Reference	Vermilion Snappe	FS-20-VS-R	7.9%	9.5%	26.42	29.19	1.11	1.19	0.92	111%	6%	66%	29%
Reference	Vermilion Snappe	FS-15-VS-R	18.6%	20.9%	40.78	43.96	1.08	1.12	0.96	108%	3%	65%	32%
Reference	Vermilion Snappe	FS-11-VS-R	13.6%	15.4%	34.08	36.61	1.07	1.13	0.95	107%	4%	72%	25%
Reference	Vermilion Snappe	FS-12-VS-R	15.4%	17.2%	46.48	49.25	1.06	1.11	0.95	106%	4%	79%	17%
Reference	Vermilion Snappe	FS-13-VS-R	24.8%	27.7%	16.69	18.02	1.08	1.12	0.97	108%	3%	61%	36%
Reference	Vermilion Snappe	FS-17-VS-R	21.9%	25.0%	18.20	19.53	1.07	1.15	0.94	107%	5%	71%	24%
Reference	Vermilion Snappe	FS-06-VS-R	21.7%	24.2%	22.27	23.83	1.07	1.11	0.96	107%	3%	70%	27%
Reference	Vermilion Snappe	FS-21-VS-R	13.5%	16.1%	24.77	27.40	1.11	1.19	0.93	111%	5%	60%	35%
Reference	Vermilion Snappe	FS-08-VS-R	21.4%	23.3%	16.32	17.17	1.05	1.09	0.97	105%	3%	77%	20%
Reference	Vermilion Snappe	FS-05-VS-R	18.2%	20.0%	20.85	21.99	1.05	1.10	0.96	105%	3%	78%	19%
Reference	Vermilion Snappe	FS-14-VS-R	35.4%	38.3%	18.35	19.17	1.04	1.08	0.96	104%	3%	78%	20%
Reference	Vermilion Snappe	FS-03-VS-R	20.7%	23.0%	23.15	24.59	1.06	1.11	0.96	106%	3%	74%	22%
Reference	Vermilion Snappe	FS-18-VS-R	19.1%	21.9%	16.09	17.28	1.07	1.14	0.94	107%	5%	72%	24%
Reference	Vermilion Snappe	FS-22-VS-R	5.0%	6.2%	28.32	31.53	1.11	1.25	0.89	111%	7%	70%	23%

			AXIS Analytical Services										
			Measured	Estimated	Fillet tPCB	WB tPCB	tPCB	lipid	tPCB/lipid				
site	species	ID	Fillet (Skin on)	Whole Body	ng/g dry	ng/g dry weight	WB:fillet	WB:fillet	WB:fillet		Percent tPCB found in		
Site	SP	ID	%lipid fillet	%lipid WB	X_PCB	x_PCBWB	ConvFac	Lratio	ConvFacL	% difference	%liver	%fillet	%other
Reference	Vermilion Snappe	FS-02-VS-R	22.3%	25.0%	53.85	57.32	1.06	1.12	0.95	106%	4%	73%	24%
Reference	Vermilion Snappe	FS-19-VS-R	19.4%	22.0%	35.33	38.13	1.08	1.13	0.95	108%	4%	68%	28%
Reference	Vermilion Snappe	FS-10-VS-R	20.4%	23.2%	26.63	28.86	1.08	1.14	0.95	108%	4%	64%	33%
Reference	Vermilion Snappe	FS-16-VS-R	17.9%	20.5%	29.99	32.20	1.07	1.15	0.94	107%	4%	72%	23%
Reference	Vermilion Snappe	FS-01-VS-R	21.3%	23.6%	19.36	20.53	1.06	1.11	0.96	106%	3%	75%	21%
Reference	Vermilion Snappe	FS-04-VS-R	14.9%	18.0%	22.93	25.34	1.10	1.21	0.91	110%	7%	68%	24%
Reference	Vermilion Snappe	FS-09-VS-R	13.7%	16.6%	14.23	15.54	1.09	1.21	0.90	109%	7%	75%	17%
Target	Vermilion Snappe	FS-14-VS-T	21.0%	23.5%	40.00	42.38	1.06	1.12	0.95	106%	4%	77%	19%
Target	Vermilion Snappe	FS-07-VS-T	13.4%	14.8%	23.95	25.76	1.08	1.11	0.97	108%	6%	80%	14%
Target	Vermilion Snappe	FS-02-VS-T	22.2%	24.8%	30.90	32.57	1.05	1.11	0.95	105%	5%	81%	15%
Target	Vermilion Snappe	FS-11-VS-T	22.4%	25.7%	150.34	160.34	1.07	1.15	0.93	107%	6%	78%	17%
Target	Vermilion Snappe	FS-09-VS-T	17.6%	20.0%	81.07	86.49	1.07	1.14	0.93	107%	5%	79%	16%
Target	Vermilion Snappe	FS-06-VS-T	17.3%	19.6%	28.86	30.62	1.06	1.13	0.94	106%	5%	82%	13%
Target	Vermilion Snappe	FS-05-VS-T	14.7%	16.4%	171.38	182.21	1.06	1.12	0.95	106%	4%	79%	17%
Target	Vermilion Snappe	FS-18-VS-T	20.7%	22.8%	33.29	34.93	1.05	1.10	0.95	105%	4%	82%	14%
Target	Vermilion Snappe	FS-17-VS-T	20.0%	24.3%	45.00	49.25	1.09	1.22	0.90	109%	8%	72%	20%
Target	Vermilion Snappe	FS-03-VS-T	21.2%	24.1%	26.77	28.68	1.07	1.14	0.94	107%	5%	74%	21%
Target	Vermilion Snappe	FS-16-VS-T	21.8%	25.3%	32.43	34.47	1.06	1.16	0.91	106%	7%	83%	10%
Target	Vermilion Snappe	FS-10-VS-T	11.9%	15.1%	55.96	62.41	1.12	1.27	0.88	112%	10%	74%	16%
Target	Vermilion Snappe	FS-01-VS-T	19.8%	23.8%	39.64	43.58	1.10	1.20	0.92	110%	7%	65%	28%
Target	Vermilion Snappe	FS-19-VS-T	13.1%	16.1%	36.21	40.12	1.11	1.23	0.90	111%	9%	74%	16%
Target	Vermilion Snappe	FS-08-VS-T	22.2%	25.6%	40.21	43.11	1.07	1.15	0.93	107%	7%	77%	17%
Target	Vermilion Snappe	FS-12-VS-T	4.5%	7.9%	7.66	11.23	1.47	1.76	0.83	147%	31%	51%	18%
Target	Vermilion Snappe	FS-13-VS-T	20.0%	24.5%	33.90	37.10	1.09	1.23	0.89	109%	10%	75%	15%
Target	Vermilion Snappe	FS-04-VS-T	15.9%	20.2%	48.89	54.88	1.12	1.27	0.88	112%	10%	66%	24%
Target	Vermilion Snappe	FS-20-VS-T	17.4%	20.4%	34.30	36.96	1.08	1.17	0.92	108%	6%	77%	17%
Target	Vermilion Snappe	FS-15-VS-T	22.7%	25.8%	65.33	69.53	1.06	1.14	0.93	106%	6%	79%	16%
Reference	White Grunt	FS-17-WG-R	1.7%	3.3%	2.83	3.94	1.40	1.91	0.73	140%	22%	38%	40%
Reference	White Grunt	FS-15-WG-R	7.8%	10.2%	8.33	9.69	1.16	1.31	0.89	116%	8%	49%	43%
Reference	White Grunt	FS-08-WG-R	3.5%	5.7%	5.73	7.25	1.26	1.63	0.78	126%	16%	48%	36%
Reference	White Grunt	FS-11-WG-R	5.1%	7.4%	7.96	9.70	1.22	1.46	0.83	122%	12%	47%	41%
Reference	White Grunt	FS-10-WG-R	3.5%	5.4%	5.49	6.79	1.24	1.54	0.80	124%	13%	47%	40%
Reference	White Grunt	FS-06-WG-R	2.1%	4.4%	3.90	5.50	1.41	2.05	0.69	141%	24%	40%	35%
Reference	White Grunt	FS-07-WG-R	6.9%	9.1%	143.21	166.29	1.16	1.32	0.88	116%	9%	55%	36%
Reference	White Grunt	FS-19-WG-R	3.0%	4.9%	9.71	12.36	1.27	1.66	0.77	127%	16%	46%	38%
Reference	White Grunt	FS-12-WG-R	2.4%	4.1%	8.81	11.41	1.29	1.71	0.76	129%	17%	44%	39%
Reference	White Grunt	FS-13-WG-R	2.2%	3.6%	16.47	21.08	1.28	1.66	0.77	128%	17%	51%	32%
Reference	White Grunt	FS-20-WG-R	6.4%	8.5%	5.00	5.83	1.17	1.34	0.87	117%	8%	51%	41%
Reference	White Grunt	FS-18-WG-R	2.9%	4.6%	2.57	3.24	1.26	1.59	0.80	126%	14%	42%	43%
Reference	White Grunt	FS-16-WG-R	3.7%	5.8%	7.71	9.60	1.24	1.58	0.79	124%	14%	47%	39%
Reference	White Grunt	FS-05-WG-R	5.6%	8.2%	10.26	12.41	1.21	1.46	0.83	121%	12%	51%	37%
Reference	White Grunt	FS-09-WG-R	2.8%	5.2%	3.36	4.54	1.35	1.86	0.73	135%	21%	42%	37%
Reference	White Grunt	FS-04-WG-R	6.4%	8.9%	11.03	13.09	1.19	1.39	0.86	119%	10%	49%	41%
Reference	White Grunt	FS-14-WG-R	2.0%	4.9%	4.53	6.76	1.49	2.45	0.61	149%	28%	36%	36%
Reference	White Grunt	FS-03-WG-R	7.1%	11.0%	14.39	17.79	1.24	1.54	0.81	124%	14%	44%	42%
Reference	White Grunt	FS-02-WG-R	5.4%	7.0%	13.11	15.24	1.16	1.30	0.89	116%	7%	47%	46%

			AXIS Analytical Services										
			Measured	Estimated	Fillet tPCB	WB tPCB	tPCB	lipid	tPCB/lipid				
site	species	ID	Fillet (Skin on)	Whole Body	ng/g dry	ng/g dry weight	WB:fillet	WB:fillet	WB:fillet		Percent tPCB found in		
Site	SP	ID	%lipid fillet	%lipid WB	X_PCB	x_PCBWB	ConvFac	Lratio	ConvFacL	% difference	%liver	%fillet	%other
Reference	White Grunt	FS-01-WG-R	23.2%	29.7%	49.37	55.87	1.13	1.28	0.88	113%	10%	54%	37%
Target	White Grunt	FS-13-WG-T	10.6%	15.2%	152.79	182.56	1.19	1.44	0.83	119%	14%	54%	32%
Target	White Grunt	FS-11-WG-T	17.4%	22.5%	150.99	170.26	1.13	1.29	0.87	113%	9%	61%	30%
Target	White Grunt	FS-10-WG-T	17.4%	24.3%	2446.64	2855.80	1.17	1.40	0.83	117%	13%	53%	34%
Target	White Grunt	FS-02-WG-T	24.7%	30.0%	5121.95	5639.22	1.10	1.22	0.91	110%	8%	63%	29%
Target	White Grunt	FS-15-WG-T	18.1%	23.1%	2261.04	2536.20	1.12	1.28	0.88	112%	9%	62%	29%
Target	White Grunt	FS-20-WG-T	12.7%	15.5%	408.60	458.02	1.12	1.22	0.92	112%	5%	54%	41%
Target	White Grunt	FS-14-WG-T	8.5%	11.5%	234.47	273.17	1.17	1.35	0.86	117%	10%	54%	36%
Target	White Grunt	FS-09-WG-T	11.7%	13.9%	1372.29	1510.88	1.10	1.19	0.92	110%	5%	63%	32%
Target	White Grunt	FS-19-WG-T	14.2%	18.2%	152.33	173.64	1.14	1.28	0.89	114%	8%	55%	36%
Target	White Grunt	FS-06-WG-T	6.2%	9.6%	193.66	241.48	1.25	1.54	0.81	125%	16%	50%	34%
Target	White Grunt	FS-08-WG-T	9.7%	12.6%	180.57	206.17	1.14	1.30	0.88	114%	9%	60%	31%
Target	White Grunt	FS-16-WG-T	18.3%	22.2%	1440.86	1612.23	1.12	1.21	0.92	112%	6%	55%	38%
Target	White Grunt	FS-05-WG-T	14.9%	20.3%	85.89	98.98	1.15	1.36	0.85	115%	11%	59%	30%
Target	White Grunt	FS-04-WG-T	19.5%	26.3%	281.20	327.09	1.16	1.35	0.86	116%	12%	51%	37%
Target	White Grunt	FS-03-WG-T	20.9%	26.5%	350.34	396.15	1.13	1.27	0.89	113%	10%	58%	32%
Target	White Grunt	FS-07-WG-T	25.3%	30.0%	136.97	149.63	1.09	1.18	0.92	109%	6%	63%	30%
Target	White Grunt	FS-12-WG-T	20.0%	25.1%	1683.17	1896.67	1.13	1.26	0.90	113%	9%	57%	34%
Target	White Grunt	FS-01-WG-T	18.4%	23.0%	269.11	300.88	1.12	1.25	0.89	112%	8%	61%	31%
Target	White Grunt	FS-18-WG-T	25.5%	30.9%	4808.36	5348.79	1.11	1.21	0.92	111%	7%	55%	38%
Target	White Grunt	FS-17-WG-T	19.0%	24.8%	645.79	735.57	1.14	1.30	0.87	114%	9%	54%	36%

site	species	ID	AXIS Analytical Services								Percent tPCB found in		
			Measured Fillet (Skin on)	Estimated Whole Body	Fillet tPCB ng/g dry	WB tPCB ng/g dry weight	tPCB WB:fillet	lipid WB:fillet	tPCB/lipid WB:fillet				
Site	SP	ID	%lipid fillet	%lipid WB	X_PCB	x_PCBWB	ConvFac	Lratio	ConvFacL	% difference	%liver	%fillet	%other
		average for all	12.9%	16.1%	234.54	264.70	1.21	1.50	0.85	121.0%	12.2%	57.1%	30.8%
		Summary for each Group		n									
		Black Seabass	all	31	70.67	86.26	1.39	2.02	0.74	139%	21%	42%	37%
		Black Seabass	Reference	20	27.31	38.96	1.52	2.37	0.68	152%	26%	34%	40%
		Black Seabass	Target	11	149.50	172.24	1.16	1.37	0.86	116%	12%	57%	31%
		Vermilion Snapper	all	42	38.12	41.08	1.08	1.14	0.94	108%	4%	71%	25%
		Vermilion Snapper	Reference	22	26.14	28.12	1.08	1.14	0.94	108%	4%	71%	25%
		Vermilion Snapper	Target	20	51.30	55.33	1.10	1.20	0.92	110%	8%	75%	17%
		White Grunt	all	40	567.77	637.79	1.19	1.44	0.84	119%	12%	52%	36%
		White Grunt	Reference	20	16.69	19.92	1.26	1.60	0.80	126%	15%	46%	39%
		White Grunt	Target	20	1118.85	1255.67	1.14	1.30	0.88	114%	9%	57%	34%

APPENDIX A4d.1 Correlation Analysis for All Fish

Summary of correlations of supplemental fish variables for all fish.

All Fish

CORRELATIONS (PEARSON)
CASES INCLUDED 113, MISSING CASES 0

		AGE	F_LPCB	F_LPCBL	F_PCB	F_PCBL	HSI	LEN	LIPIDD	LWEIGHT	WEIGHT	W_LPCB	W_LPCBL	W_PCB
Fillet Log(tPCB)	F_LPCB	0.3750												
	P-VALUE	0.0000												
Fillet Log(tPCB/ Lipid)	F_LPCBL	0.3682	0.7574											
		0.0001	0.0000											
Fillet tPCB	F_PCB	0.4848	0.6922	0.6185										
		0.0000	0.0000	0.0000										
Fillet tPCB/lipid	F_PCBL	0.4391	0.7220	0.7533	0.9575									
		0.0000	0.0000	0.0000	0.0000									
Hepatosomatic Index	HSI	0.1751	**0.5717**	**0.2601**	**0.3134**	**0.2571**								
		0.0636	0.0000	0.0054	0.0007	0.0060								
Total Length	LEN	0.9282	0.3387	0.3309	0.3943	0.3516	**0.2125**							
		0.0000	0.0002	0.0003	0.0000	0.0001	0.0239							
%Lipid Dry Weight	LIPIDD	0.0758	0.4937	-0.1417	0.2578	0.1330	**0.5440**	0.0943						
		0.4248	0.0000	0.1345	0.0058	0.1603	0.0000	0.3202						
Liver Weight	LWEIGHT	**0.6704**	**0.6405**	**0.4238**	**0.5851**	**0.5236**	**0.7664**	**0.6586**	**0.4453**					
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000					
Body Weight	WEIGHT	0.9437	0.4711	0.4200	0.5176	0.4704	**0.3447**	0.9386	0.1681	**0.8100**				
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0751	0.0000				
Whole Body Log(tPCB)	W_LPCB	0.3777	0.9956	0.8078	0.6990	0.7441	**0.5670**	0.3431	0.4349	**0.6399**	0.4752			
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000			
Whole Body Log(tPCB/lipid)	W_LPCBL	0.3465	0.6952	0.9948	0.5826	0.7279	**0.2285**	0.3134	-0.2142	**0.3886**	0.3950	0.7533		
		0.0002	0.0000	0.0000	0.0000	0.0000	0.0149	0.0007	0.0227	0.0000	0.0000	0.0000		
Whole Body tPCB	W_PCB	0.4850	0.6952	0.6246	0.9998	0.9602	**0.3172**	0.3950	0.2541	**0.5879**	0.5186	0.7027	0.5890	
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0066	0.0000	0.0000	0.0000	0.0000	
Whole Body tPCB/lipid	W_PCBL	0.4084	0.6843	0.7779	0.9143	0.9851	**0.2303**	0.3326	0.0728	**0.4890**	0.4401	0.7176	0.7647	0.9181
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0141	0.0003	0.4434	0.0000	0.0000	0.0000	0.0000	0.0000

APPENDIX A4d.2 Correlation Analysis for Vermilion Snapper

Summary of correlations of supplemental fish variables for vermilion snapper.

VERMILION SNAPPER CORRELATIONS (PEARSON)

CASES INCLUDED 42, MISSING CASES 0

		AGE	F_LPCB	F_LPCBL	F_PCB	F_PCBL	HSI	LEN	LIPIDD	LWEIGHT	WEIGHT	W_LPCB	W_LPCBL	W_PCB
Fillet Log(tPCB)	F_LPCB	0.3821												
	P-VALUE	0.0125												
Fillet Log(tPCB/ Lipid)	F_LPCBL	0.4157	0.8047											
		0.0062	0.0000											
Fillet tPCB	F_PCB	0.3755	0.9005	0.7763										
		0.0143	0.0000	0.0000										
Fillet tPCB/lipid	F_PCBL	0.3646	0.7725	0.8966	0.8866									
		0.0176	0.0000	0.0000	0.0000									
Hepatosomatic Index	HSI	0.2855	0.0770	0.0563	0.0695	-0.0612								
		0.0669	0.6278	0.7232	0.6617	0.7002								
Total Length	LEN	0.8037	0.4626	0.5073	0.4596	0.4277	**0.4874**							
		0.0000	0.0020	0.0006	0.0022	0.0047	0.0011							
%Lipid Dry Weight	LIPIDD	-0.1411	0.0784	-0.5015	0.0209	-0.3411	0.0618	-0.1900						
		0.3726	0.6215	0.0007	0.8953	0.0271	0.6976	0.2282						
Liver Weight	LWEIGHT	**0.5671**	0.2449	0.2454	0.2341	0.1299	**0.9127**	**0.7684**	-0.0244					
		0.0001	0.1180	0.1173	0.1356	0.4121	0.0000	0.0000	0.8782					
Body Weight	WEIGHT	0.7991	0.5131	0.4758	0.5351	0.4704	0.4660	0.9629	-0.0649	**0.7604**				
		0.0000	0.0005	0.0014	0.0003	0.0017	0.0019	0.0000	0.6830	0.0000				
Whole Body Log(tPCB)	W_LPCB	0.4055	0.9965	0.8366	0.9108	0.7958	0.1196	0.4937	0.0286	0.2882	0.5380			
		0.0077	0.0000	0.0000	0.0000	0.0000	0.4506	0.0009	0.8574	0.0642	0.0002			
Whole Body Log(tPCB/lipid)	W_LPCBL	0.4222	0.7676	0.9969	0.7543	0.8877	0.0915	0.5175	-0.5417	0.2749	0.4797	0.8055		
		0.0054	0.0000	0.0000	0.0000	0.0000	0.5645	0.0004	0.0002	0.0781	0.0013	0.0000		
Whole Body tPCB	W_PCB	0.3786	0.9003	0.7855	0.9997	0.8914	0.0826	0.4651	0.0061	0.2463	0.5394	0.9122	0.7648	
		0.0134	0.0000	0.0000	0.0000	0.0000	0.6029	0.0019	0.9695	0.1159	0.0002	0.0000	0.0000	
Whole Body tPCB/lipid	W_PCBL	0.3673	0.7502	0.9019	0.8709	0.9984	-0.0390	0.4336	-0.3754	0.1486	0.4705	0.7776	0.8972	0.8769
		0.0167	0.0000	0.0000	0.0000	0.0000	0.8061	0.0041	0.0143	0.3475	0.0017	0.0000	0.0000	0.0000

APPENDIX A4d.3 Correlation Analysis for White Grunt

Summary of correlations of supplemental fish variables for white grunt.

WHITE GRUNT CORRELATIONS (PEARSON)
CASES INCLUDED 40, MISSING CASES 0

		AGE	F_LPCB	F_LPCBL	F_PCB	F_PCBL	HSI	LEN	LIPIDD	LWEIGHT	WEIGHT	W_LPCB	W_LPCBL	W_PCB
Fillet Log(tPCB)	F_LPCB	0.3226												
	P-VALUE	0.0423												
Fillet Log(tPCB/ Lipid)	F_LPCBL	0.3411	0.9640											
		0.0313	0.0000											
Fillet tPCB	F_PCB	0.4791	0.7206	0.7438										
		0.0018	0.0000	0.0000										
Fillet tPCB/lipid	F_PCBL	0.4199	0.7876	0.8300	0.9708									
		0.0070	0.0000	0.0000	0.0000									
Hepatosomatic Index	HSI	0.2950	**0.6881**	**0.5468**	**0.4594**	**0.4388**								
		0.0646	0.0000	0.0003	0.0029	0.0046								
Total Length	LEN	0.9797	0.2993	0.3076	0.4482	0.3898	0.2918							
		0.0000	0.0606	0.0535	0.0037	0.0129	0.0677							
%Lipid Dry Weight	LIPIDD	0.3390	0.8257	0.6692	0.6006	0.5809	**0.8656**	0.3365						
		0.0324	0.0000	0.0000	0.0000	0.0001	0.0000	0.0337						
Liver Weight	LWEIGHT	**0.7618**	**0.6082**	**0.5206**	**0.6309**	**0.5875**	**0.7609**	**0.7394**	**0.7513**					
		0.0000	0.0000	0.0006	0.0000	0.0001	0.0000	0.0000	0.0000					
Body Weight	WEIGHT	0.9724	0.4031	0.3842	0.5200	0.4647	**0.4032**	0.9667	0.4652	**0.8531**				
		0.0000	0.0099	0.0144	0.0006	0.0025	0.0099	0.0000	0.0025	0.0000				
Whole Body Log(tPCB)	W_LPCB	0.3262	0.9998	0.9680	0.7245	0.7920	**0.6876**	0.3022	0.8201	**0.6088**	0.4047			
		0.0399	0.0000	0.0000	0.0000	0.0000	0.0000	0.0580	0.0000	0.0000	0.0096			
Whole Body Log(tPCB/lipic	W_LPCBL	0.3441	0.9553	0.9993	0.7444	0.8313	**0.5375**	0.3095	0.6513	**0.5146**	0.3829	0.9601		
		0.0297	0.0000	0.0000	0.0000	0.0000	0.0003	0.0519	0.0000	0.0007	0.0147	0.0000		
Whole Body tPCB	W_PCB	0.4791	0.7244	0.7480	0.9998	0.9726	**0.4649**	0.4490	0.6018	**0.6341**	0.5209	0.7283	0.7487	
		0.0018	0.0000	0.0000	0.0000	0.0000	0.0025	0.0037	0.0000	0.0000	0.0006	0.0000	0.0000	
Whole Body tPCB/lipid	W_PCBL	0.4187	0.7897	0.8337	0.9681	0.9997	**0.4433**	0.3893	0.5783	**0.5887**	0.4639	0.7943	0.8353	0.9703
		0.0072	0.0000	0.0000	0.0000	0.0000	0.0042	0.0130	0.0001	0.0001	0.0026	0.0000	0.0000	0.0000

APPENDIX A4d.4 Correlation Analysis for Black Sea Bass

BLACK SEA BASS

Summary of correlations of supplemental fish variables for black sea bass.

CORRELATIONS (PEARSON)
CASES INCLUDED 31, MISSING CASES 0

		AGE	F_LPCB	F_LPCBL	F_PCB	F_PCBL	HSI	LEN	LIPIDD	LWEIGHT	WEIGHT	W_LPCB	W_LPCBL	W_PCB
Fillet Log(tPCB)	F_LPCB	0.3667												
	P-VALUE	0.0425												
Fillet Log(tPCB/ Lipid)	F_LPCBL	0.1313	-0.1376											
		0.4813	0.4604											
Fillet tPCB	F_PCB	0.4667	0.9303	0.0187										
		0.0081	0.0000	0.9206										
Fillet tPCB/lipid	F_PCBL	0.0720	-0.0824	0.9108	0.0218									
		0.7005	0.6596	0.0000	0.9071									
Hepatosomatic Index	HSI	-0.0907	**0.7397**	**-0.4408**	**0.6340**	-0.2725								
		0.6275	0.0000	0.0131	0.0001	0.1380								
Total Length	LEN	0.9481	0.3692	0.1323	0.4375	0.0836	-0.0367							
		0.0000	0.0410	0.4780	0.0139	0.6548	0.8444							
%Lipid Dry Weight	LIPIDD	0.1556	0.8354	-0.5170	0.7164	-0.3834	**0.8286**	0.1725						
		0.4033	0.0000	0.0029	0.0000	0.0332	0.0000	0.3534						
Liver Weight	LWEIGHT	0.3005	**0.8463**	**-0.3486**	**0.8025**	-0.2187	**0.8793**	**0.3576**	**0.8650**					
		0.1004	0.0000	0.0546	0.0000	0.2371	0.0000	0.0483	0.0000					
Body Weight	WEIGHT	0.8938	0.5876	-0.0414	0.6302	-0.0573	0.2176	0.9343	0.4238	**0.5981**				
		0.0000	0.0005	0.8251	0.0001	0.7594	0.2396	0.0000	0.0175	0.0004				
Whole Body Log(tPCB)	W_LPCB	0.3488	0.9854	-0.0097	0.9333	0.0597	**0.7330**	0.3522	0.7889	**0.8300**	0.5625			
		0.0545	0.0000	0.9588	0.0000	0.7497	0.0000	0.0520	0.0000	0.0000	0.0010			
Whole Body Log(tPCB/lipid)	W_LPCBL	0.0283	-0.2862	0.9797	-0.1283	0.9146	**-0.4820**	0.0299	-0.6046	**-0.4351**	-0.1549	-0.1466		
		0.8799	0.1186	0.0000	0.4917	0.0000	0.0060	0.8732	0.0003	0.0144	0.4055	0.4312		
Whole Body tPCB	W_PCB	0.4507	0.9177	0.0998	0.9924	0.1080	**0.6296**	0.4256	0.6612	**0.7815**	0.6053	0.9357	-0.0432	
		0.0109	0.0000	0.5931	0.0000	0.5632	0.0001	0.0170	0.0001	0.0000	0.0003	0.0000	0.8177	
Whole Body tPCB/lipid	W_PCBL	-0.0492	-0.1847	0.8066	-0.1203	0.9636	-0.2627	-0.0310	-0.3757	-0.2587	-0.1588	-0.0382	0.8513	-0.0390
		0.7929	0.3199	0.0000	0.5193	0.0000	0.1534	0.8685	0.0372	0.1599	0.3934	0.8384	0.0000	0.8350

Table A4d-5. The results of bivariate regression analysis of supplemental fish data. The regression coefficient (r^2) and regression equation (y = mx + b) were reported for each regression equation with a slope significantly different than zero (p<=0.05).

Parameters	Grouping	Site	n	r^2	m	b	p
Body Weight v. Age							
	All Fish	all	113	0.8906	0.0055	1.8932	<0.0001
A4d-Fig. 1a	Vermilion Snapper	all	42	0.6386	0.0049	2.1909	<0.0001
	Vermilion Snapper	target	20	0.8879	0.0061	1.4759	<0.0001
	Vermilion Snapper	reference	22	0.3941	0.0079	1.2962	0.0018
A4d-Fig. 1b	White Grunt	all	40	0.9455	0.0054	2.0506	<0.0001
	White Grunt	target	20	0.9781	0.0054	1.8706	<0.0001
	White Grunt	reference	20	0.9067	0.0057	2.0831	<0.0001
A4d-Fig. 1c	Black Seabass	all	31	0.7989	0.0055	1.5736	<0.0001
	Black Seabass	target	11	0.8748	0.0062	0.5930	<0.0001
	Black Seabass	reference	20	0.8747	0.0060	1.5897	<0.0001
Body Weight v. Liver Weight							
	All Fish	all	113	0.6562	0.0216	-3.9237	<0.0001
A4d-Fig. 2a	Vermilion Snapper	all	42	0.5789	0.0184	-2.6720	<0.0001
	Vermilion Snapper	target	20				0.0651
	Vermilion Snapper	reference	22	0.6437	0.0170	-2.8202	<0.0001
A4d-Fig. 2b	White Grunt	all	40	0.7277	0.0228	-4.8562	<0.0001
	White Grunt	target	20	0.8952	0.0230	-1.8258	<0.0001
	White Grunt	reference	20	0.5513	0.0190	-5.8774	0.0002
A4d-Fig. 2c	Black Seabass	all	31	0.3577	0.0180	-1.7284	0.0004
	Black Seabass	target	11	0.4318	0.0159	5.9360	0.0280
	Black Seabass	reference	20	0.5545	0.0074	-0.0525	0.0002
Body Weight v. Lipid Content							
	All Fish	all	113				0.0751
A4d-Fig. 3a	Vermilion Snapper	all	42				NS
	Vermilion Snapper	target	20				NS
	Vermilion Snapper	reference	22				NS
A4d-Fig. 3b	White Grunt	all	40	0.2164	0.0086	5.1356	0.0025
	White Grunt	target	20	0.3789	0.0069	11.7327	0.0039
	White Grunt	reference	20	0.2847	0.0077	0.3479	0.0154
A4d-Fig. 3c	Black Seabass	all	31	0.1796	0.0167	-0.6560	0.0175
	Black Seabass	target	11				NS
	Black Seabass	reference	20	0.4335	0.0074	-1.0755	0.0016
Body Weight v. H S I							
	All Fish	all	113	0.1188	8.50E-06	0.0083	0.0002
A4d-Fig. 4a	Vermilion Snapper	all	42	0.2171	1.75E-05	0.0041	0.0019
	Vermilion Snapper	target	20				NS
	Vermilion Snapper	reference	22	0.2559	2.2E-05	0.0019	0.0163
A4d-Fig. 4b	White Grunt	all	40	0.1626	7.5E-06	0.0087	0.0099
	White Grunt	target	20				0.0931
	White Grunt	reference	20	0.3121	8.7E-06	0.0032	0.0105
A4d-Fig. 4c	Black Seabass	all	31				0.2396
	Black Seabass	target	11				NS
	Black Seabass	reference	20				NS
Body Weight v. Whole Body Log(tPCB)							
	All Fish	all	113	0.2258	0.0010	1.1664	<0.0001
A4d-Fig. 5a	Vermilion Snapper	all	42	0.2895	0.0011	1.0846	0.0013
	Vermilion Snapper	target	20				0.0961
	Vermilion Snapper	reference	22				NS
A4d-Fig. 5b	White Grunt	all	40	0.1638	0.0010	1.2522	0.0096
	White Grunt	target	20	0.4016	0.0007	2.2506	0.0027
	White Grunt	reference	20	0.4291	0.0008	0.5383	0.0017
A4d-Fig. 5c	Black Seabass	all	31	0.3164	0.0009	1.2631	0.0010
	Black Seabass	target	11				0.1243
	Black Seabass	reference	20	0.2962	0.0005	1.2822	0.0131

Parameters	Grouping	Site	n	r^2	m	b	P
Body Weight v. Whole Body Log(tPCB/Lipid)							
	All Fish	all	113	0.1560	0.0008	2.3427	<0.0001
A4d-Fig. 6a	Vermilion Snapper	all	42	0.2301	0.0011	1.8467	0.0013
	Vermilion Snapper	target	20	0.2220	0.0010	1.90552	0.0360
	Vermilion Snapper	reference	22				NS
A4d-Fig. 6b	White Grunt	all	40	0.1466	0.0007	2.5529	0.0147
	White Grunt	target	20	0.2500	0.0005	3.1997	0.0248
	White Grunt	reference	20	0.2518	0.0005	2.1120	0.0242
A4d-Fig. 6c	Black Seabass	all	31				NS
	Black Seabass	target	11				NS
	Black Seabass	reference	20				NS
Lipid Weight v. Whole Body Log(tPCB/Lipid)							
	All Fish	all	113	0.0459	-0.0153	2.9723	0.0227
A4d-Fig. 7a	Vermilion Snapper	all	42	0.2934	-0.0279	2.8059	0.0002
	Vermilion Snapper	target	20				0.2291
	Vermilion Snapper	reference	22	0.6292	-0.0336	2.8023	<0.0001
A4d-Fig. 7b	White Grunt	all	40	0.4243	0.0603	2.3353	<0.0001
	White Grunt	target	20	n			NS
	White Grunt	reference	20	n			NS
A4d-Fig. 7c	Black Seabass	all	31	0.3655	-0.0213	3.3160	0.0003
	Black Seabass	target	11				0.0891
	Black Seabass	reference	20				0.0745
Lipid Weight v. H S I							
	All Fish	all	113	0.2959	0.0003	0.0067	<0.0001
A4d-Fig. 8a	Vermilion Snapper	all	42	n			NS
	Vermilion Snapper	target	20	n			NS
	Vermilion Snapper	reference	22	0.1978	0.0001	0.0054	0.0381
A4d-Fig. 8b	White Grunt	all	40	0.7492	0.0009	0.0042	<0.0001
	White Grunt	target	20	0.4100	0.0008	0.0060	0.0024
	White Grunt	reference	20	0.8189	0.0010	0.0036	<0.0001
A4d-A4d-Fig.	Black Seabass	all	31	0.6866	0.0007	0.0066	<0.0001
	Black Seabass	target	11				NS
	Black Seabass	reference	20				NS
Whole Body Log(tPCB/Lipid) v H S I							
	All Fish	all	113	0.0522	0.0028	0.0051	0.0149
A4d-Fig. 9a	Vermilion Snapper	all	42				NS
	Vermilion Snapper	target	20				NS
	Vermilion Snapper	reference	22	0.2742	-0.0048	0.0190	0.0124
A4d-Fig. 9b	White Grunt	all	40	0.2889	0.0058	-0.0038	0.0003
	White Grunt	target	20				NS
	White Grunt	reference	20				NS
A4d-Fig. 9c	Black Seabass	all	31	0.2324	-0.0144	0.0589	0.0060
	Black Seabass	target	11				NS
	Black Seabass	reference	20				NS

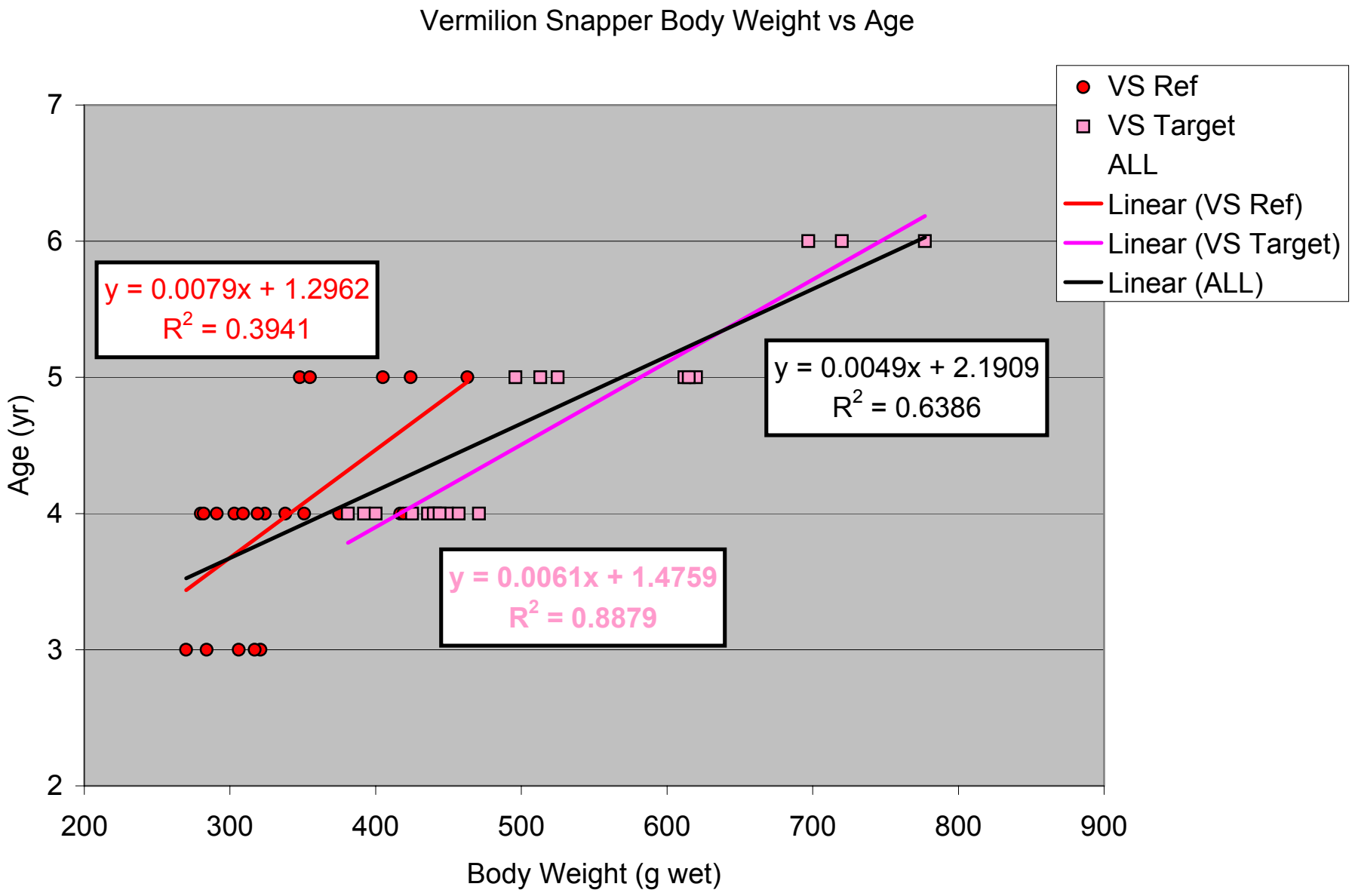


Fig. A4d-1a. Outlined boxes indicate regression equations with slopes significantly greater than zero.

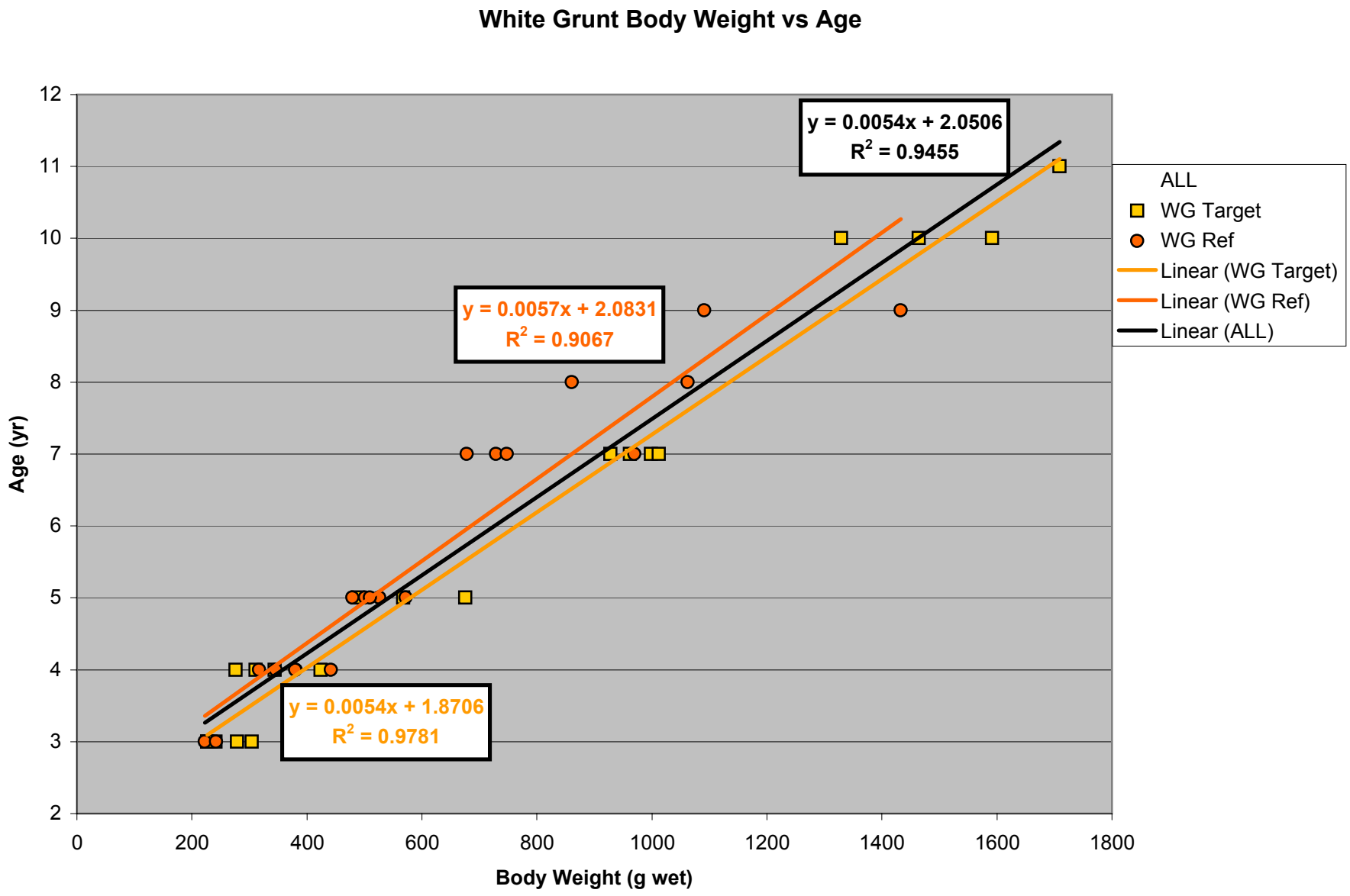


Fig. A4d-1b. Outlined boxes indicate regression equations with slopes significantly greater than zero.

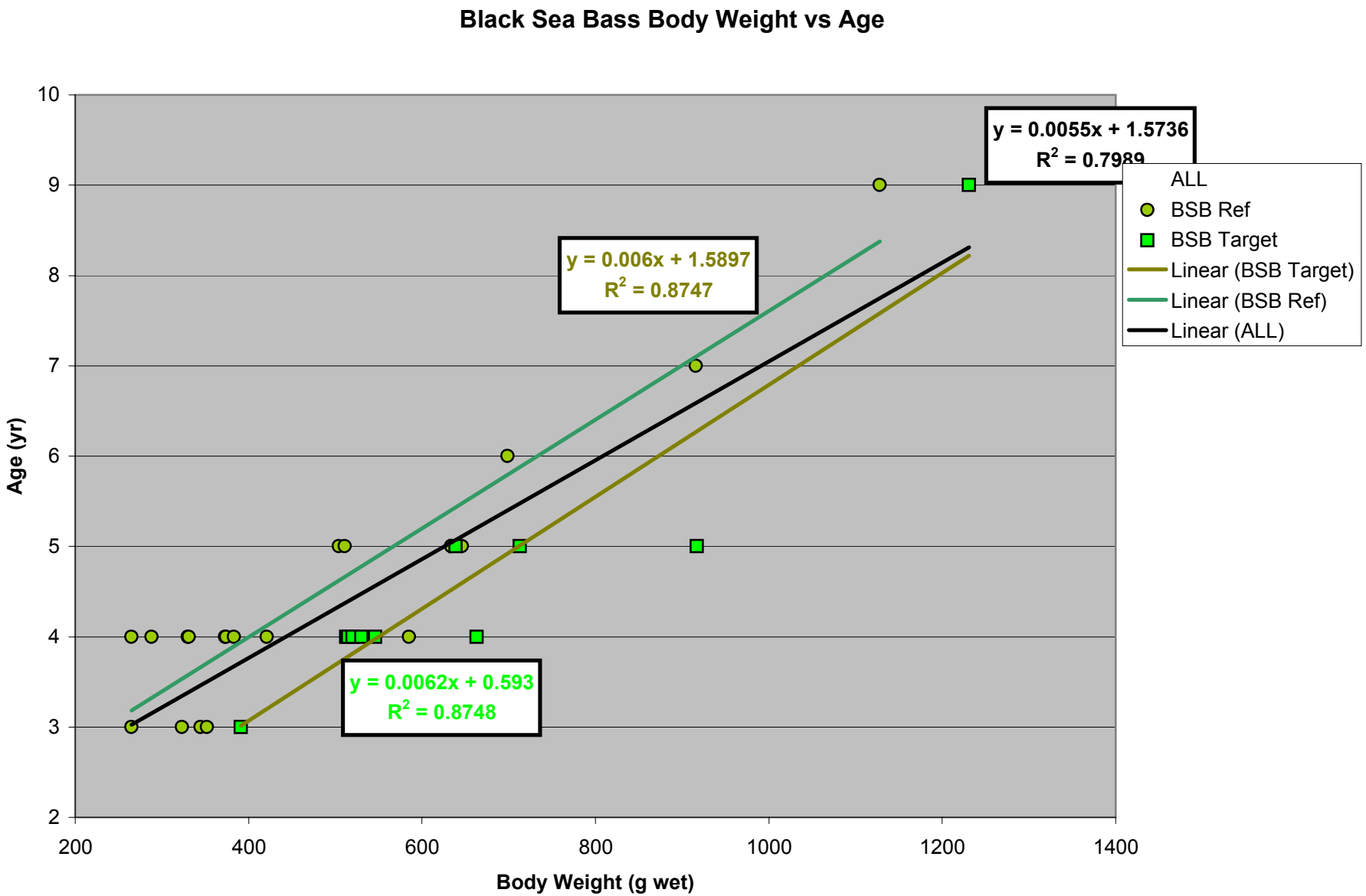


Fig. A4d-1c. Outlined boxes indicate regression equations with slopes significantly greater than zero.

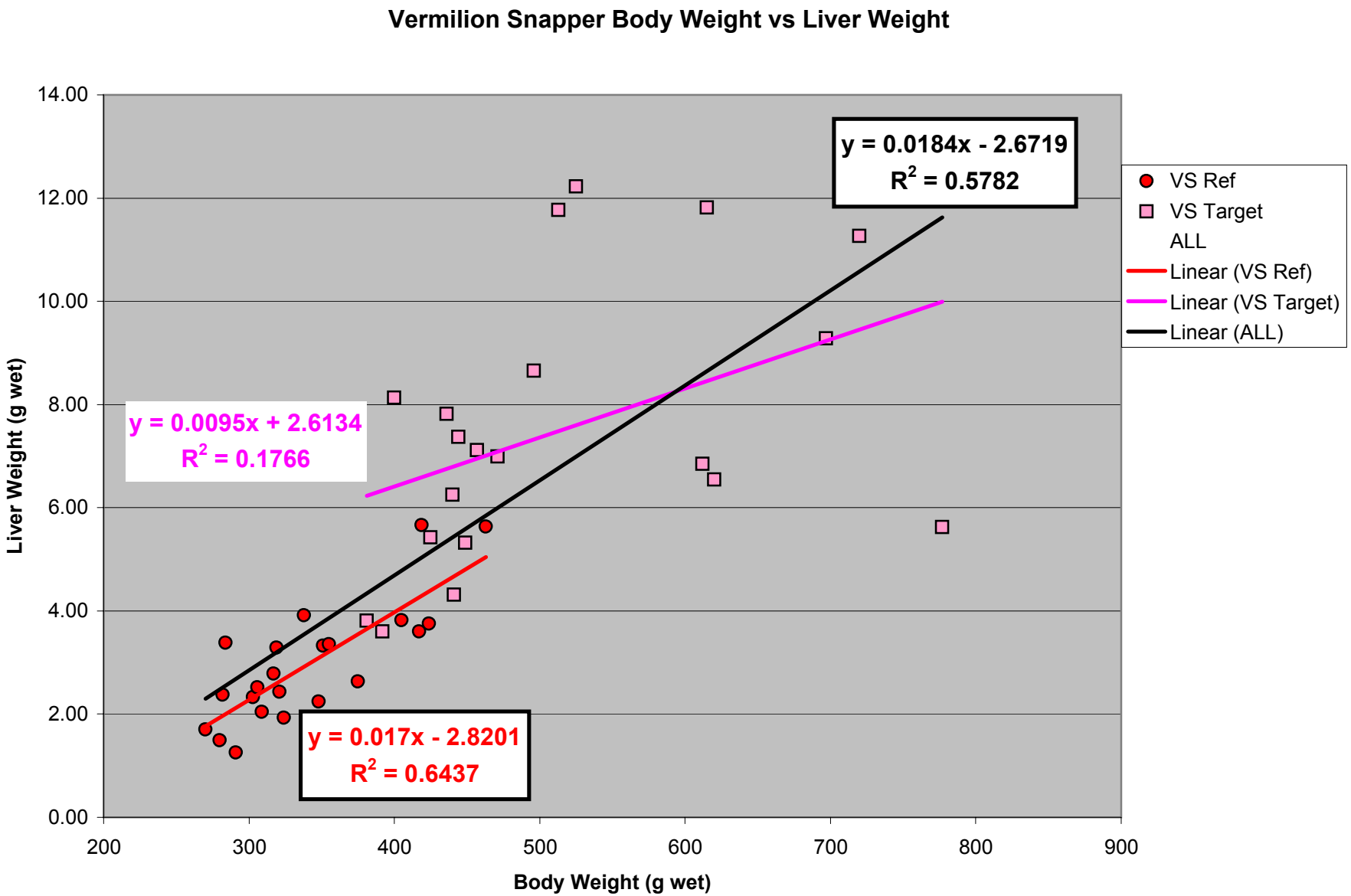


Fig. A4d-2a. Outlined boxes indicate regression equations with slopes significantly greater than zero.

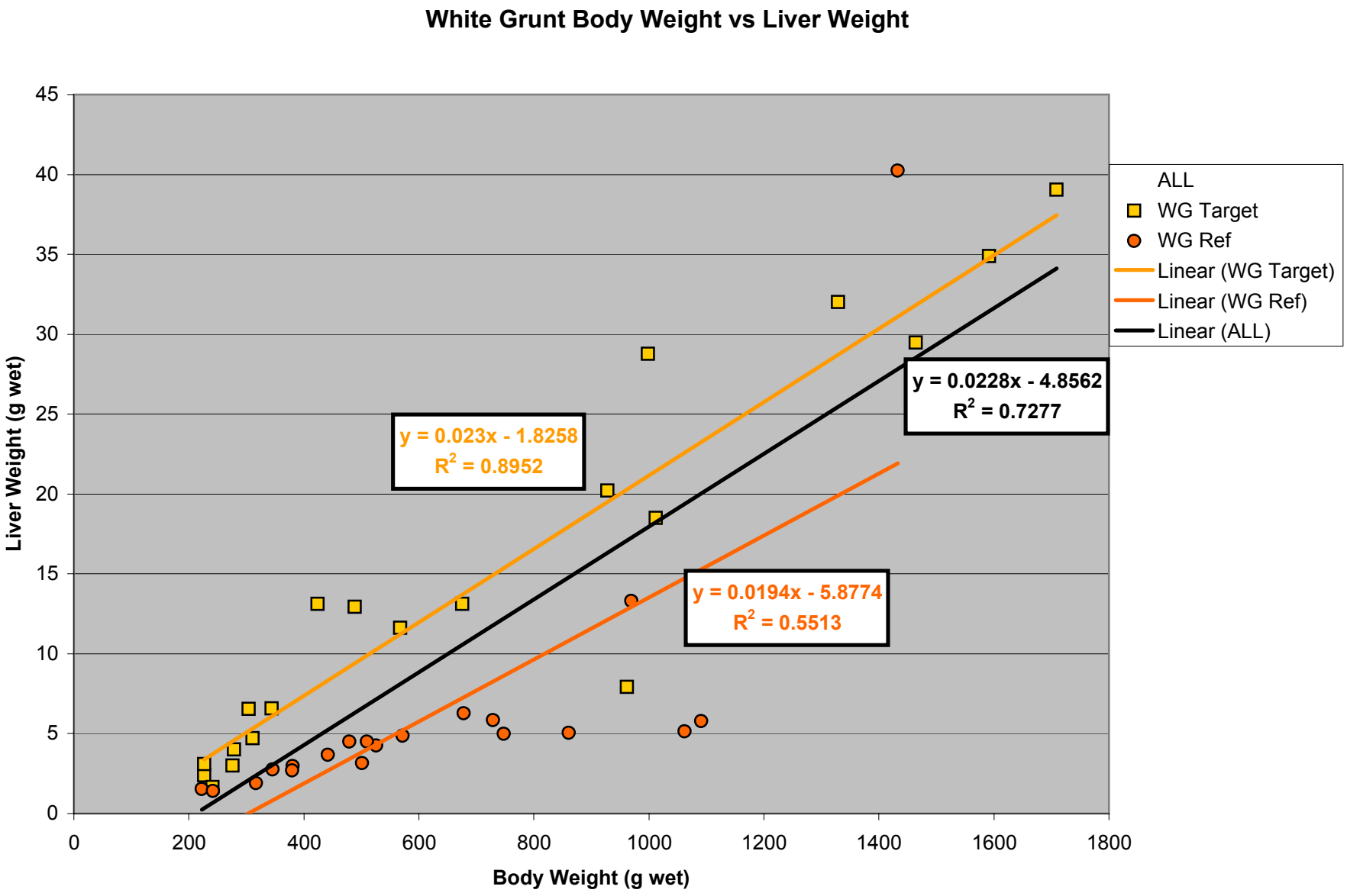


Fig. A4d-2b. Outlined boxes indicate regression equations with slopes significantly greater than zero.

Fig. A4d-2c. Outlined boxes indicate regression equations with slopes significantly greater than zero.

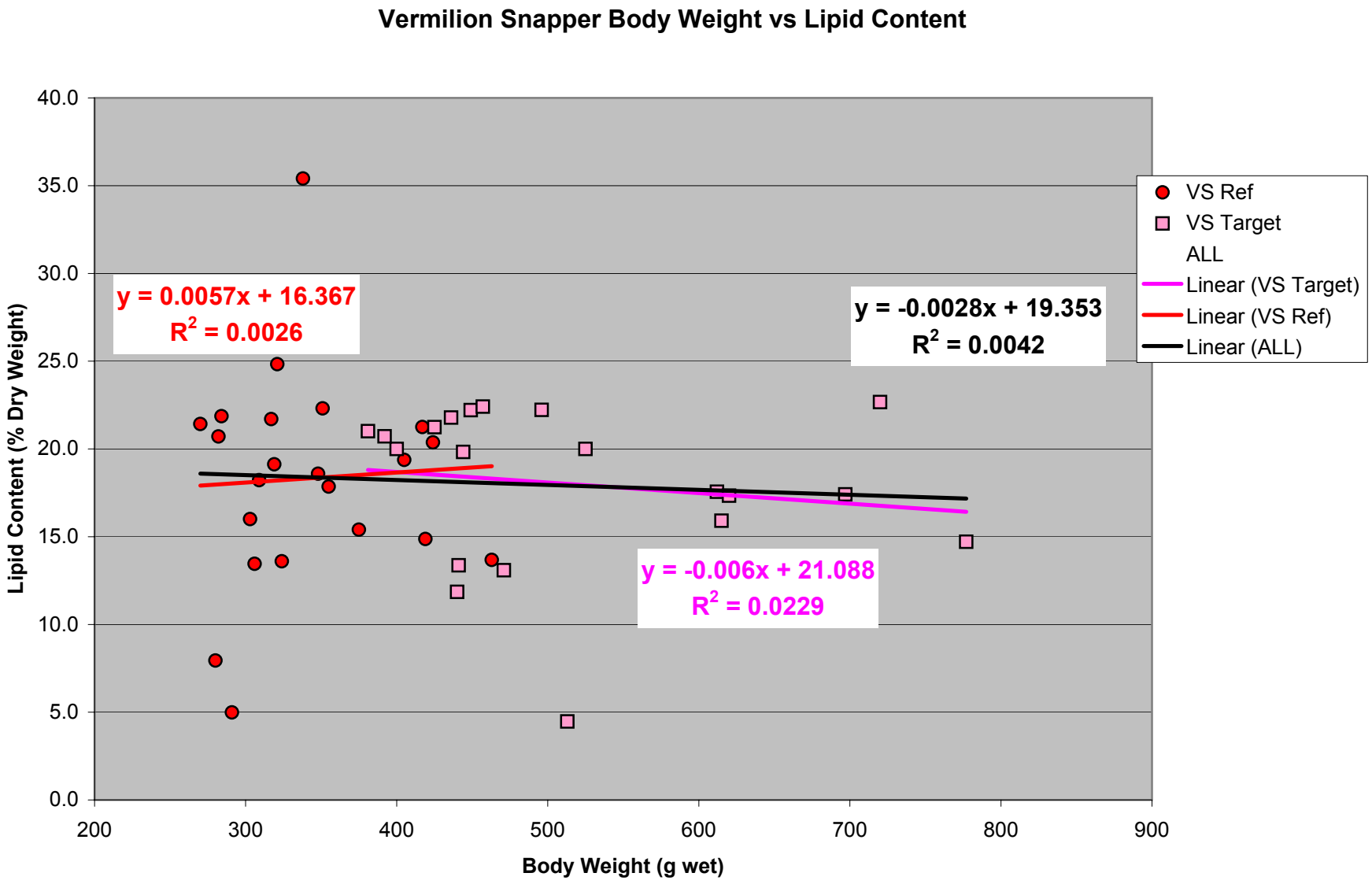


Fig. A4d-3a. Outlined boxes indicate regression equations with slopes significantly greater than zero.

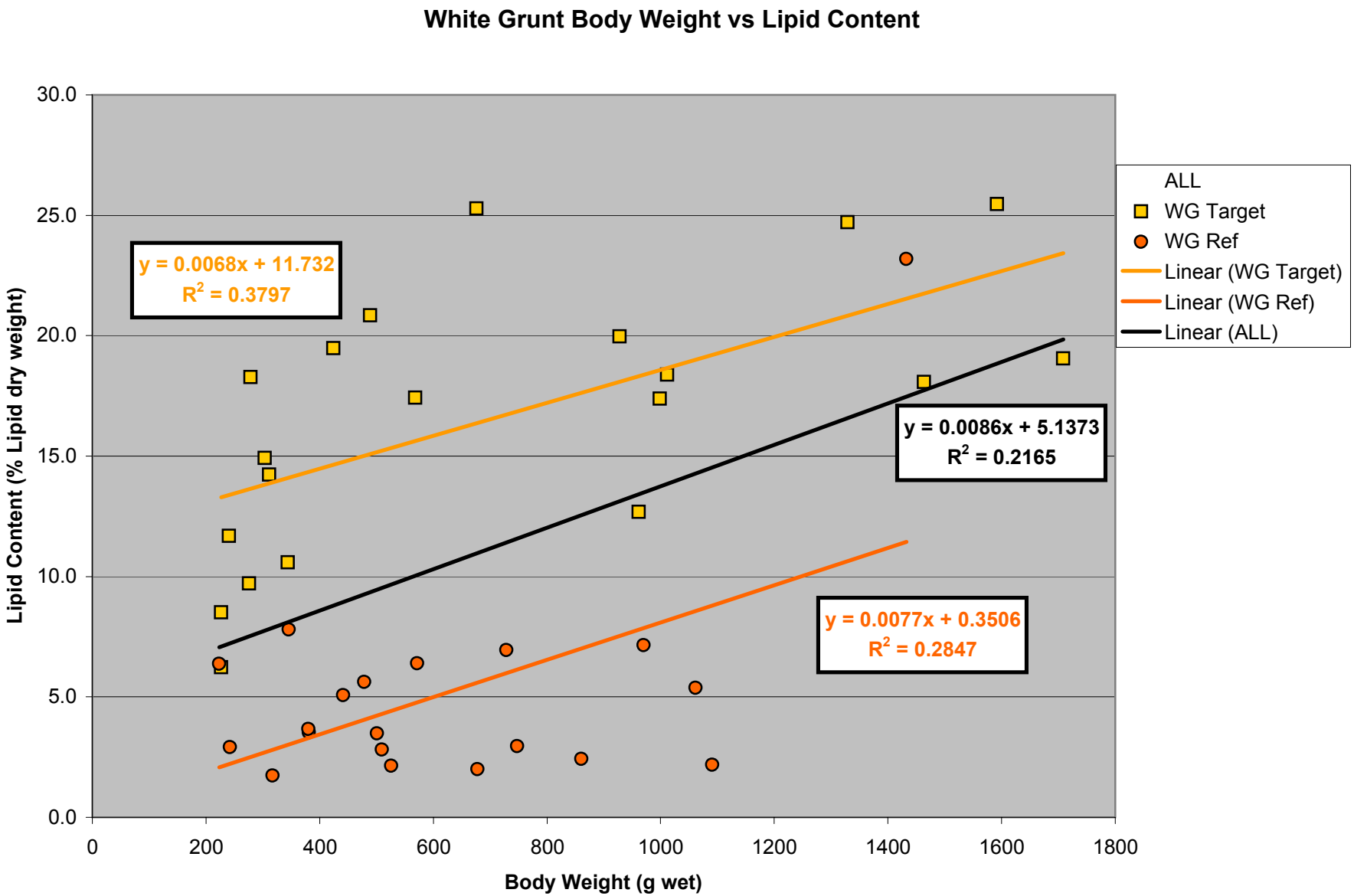


Fig. A4d-3b. Outlined boxes indicate regression equations with slopes significantly greater than zero.

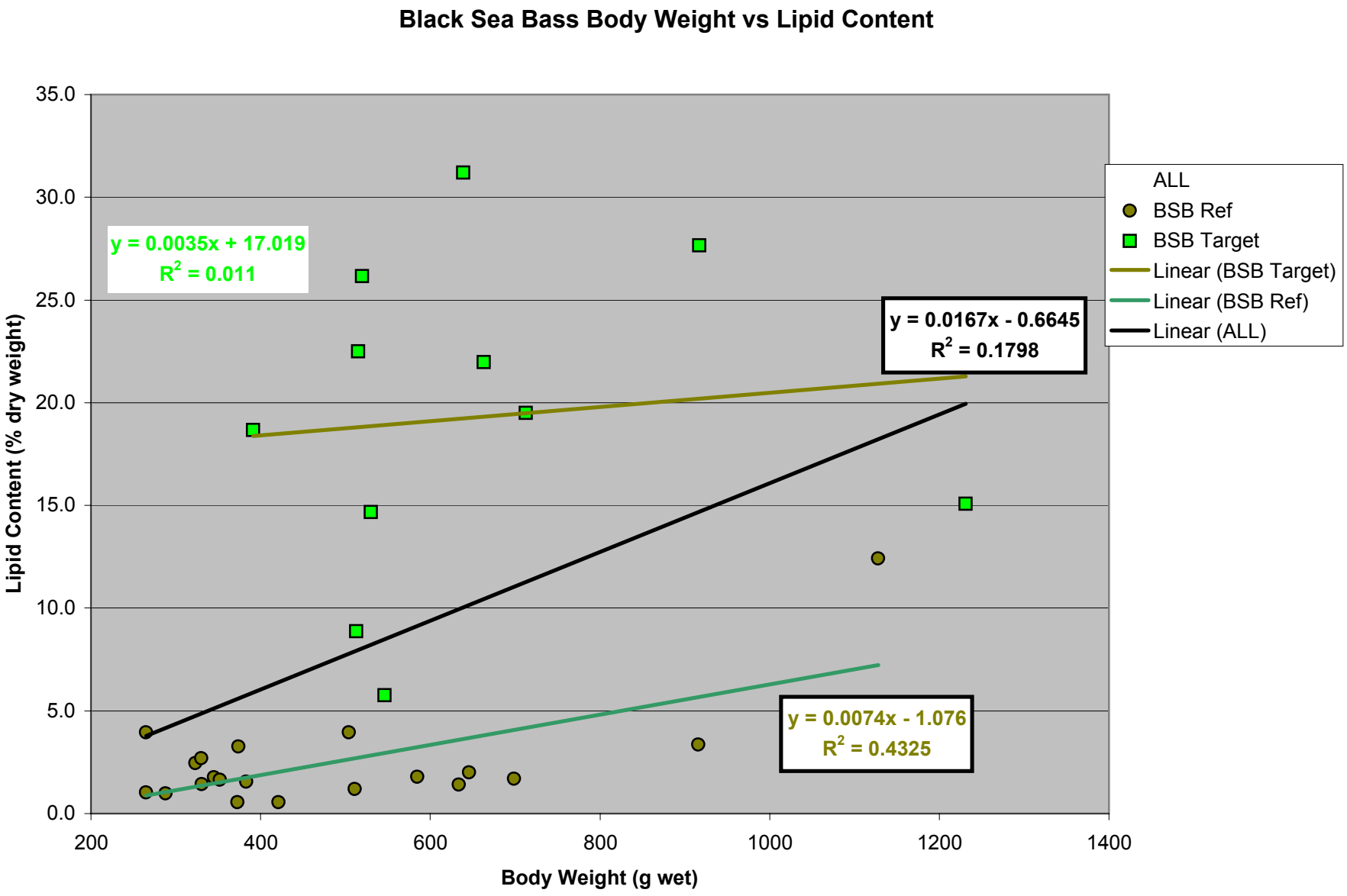


Fig. A4d-3c. Outlined boxes indicate regression equations with slopes significantly greater than zero.

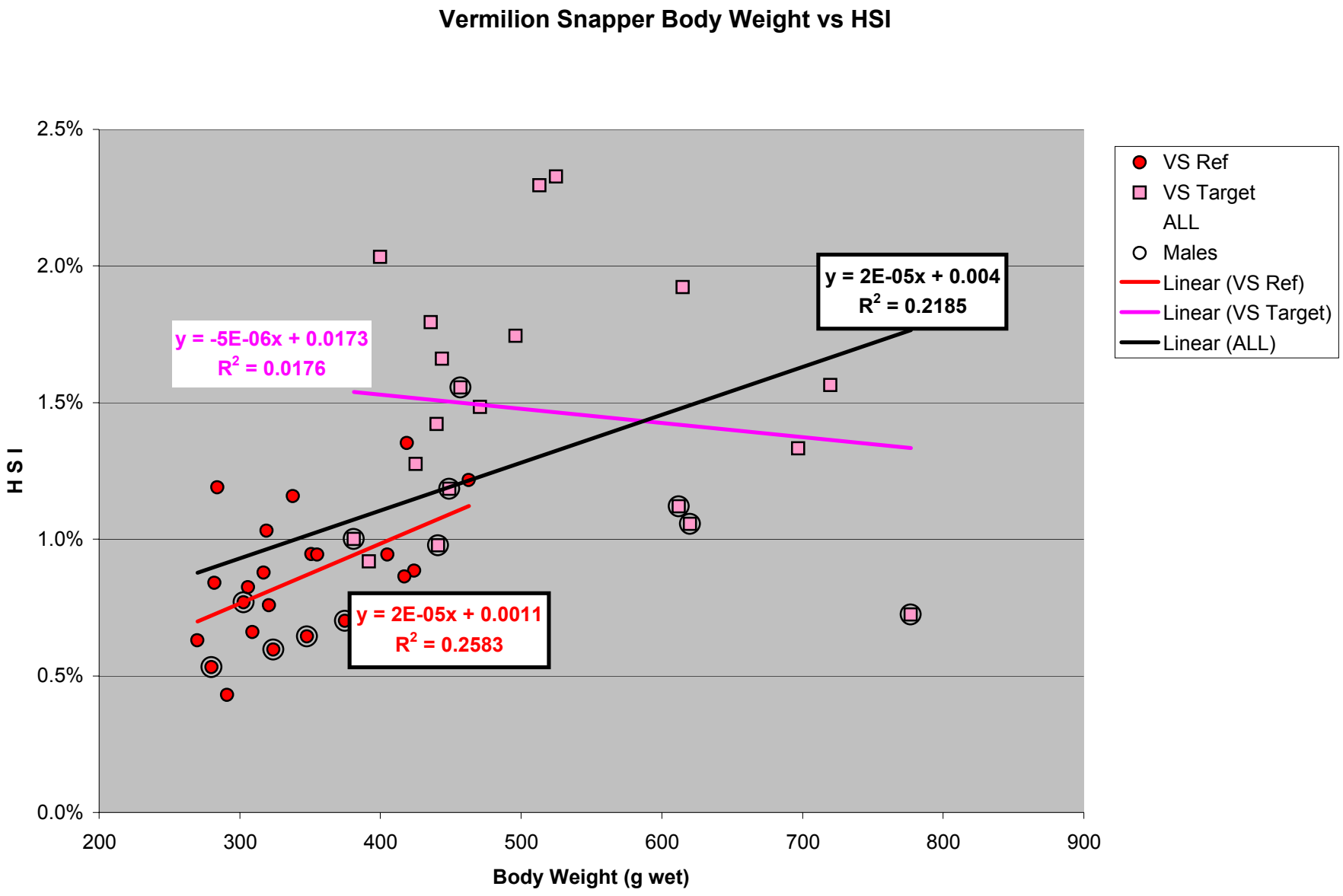


Fig. A4d-4a. Outlined boxes indicate regression equations with slopes significantly greater than zero.

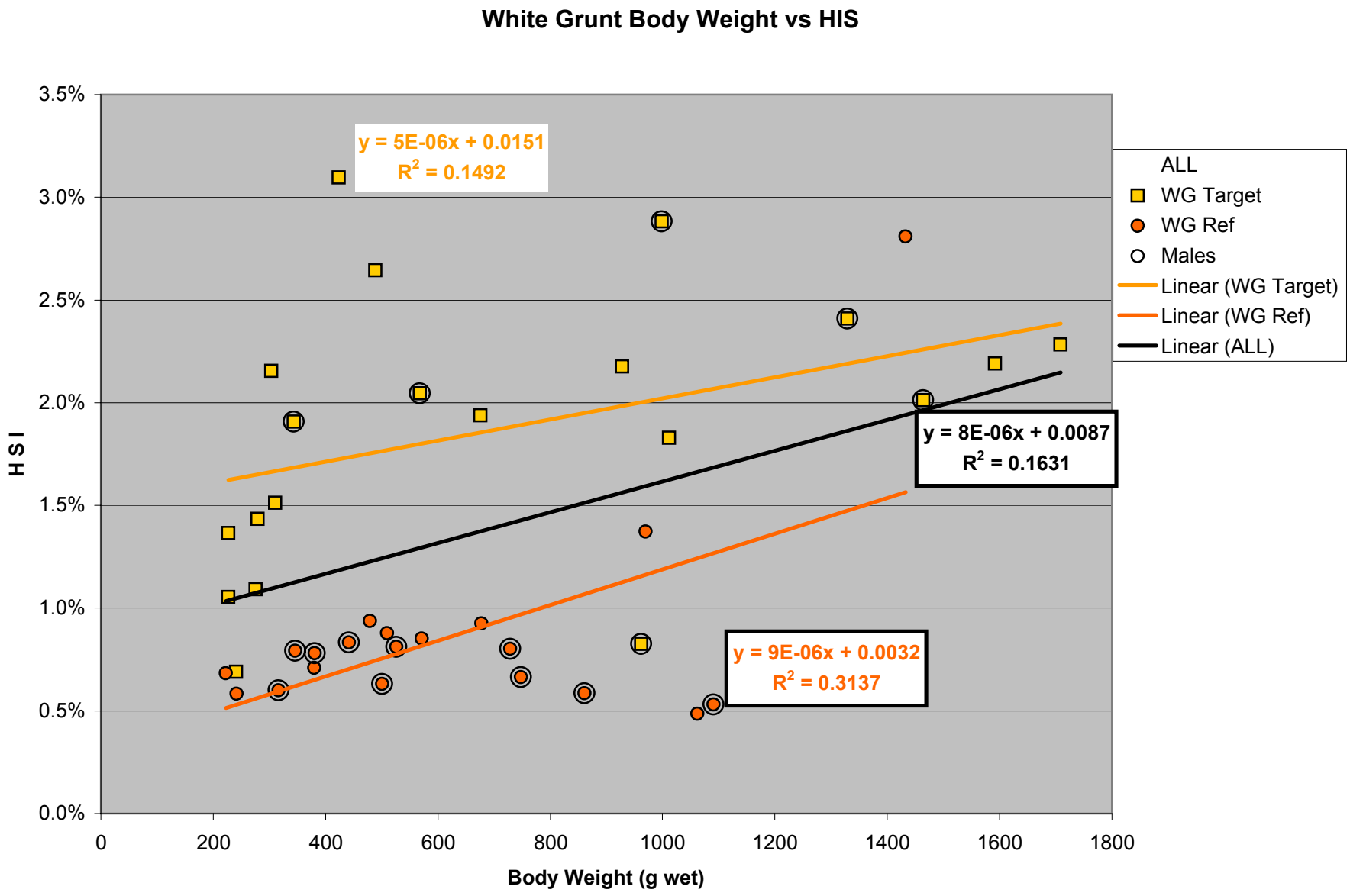


Fig. A4d-4b. Outlined boxes indicate regression equations with slopes significantly greater than zero.

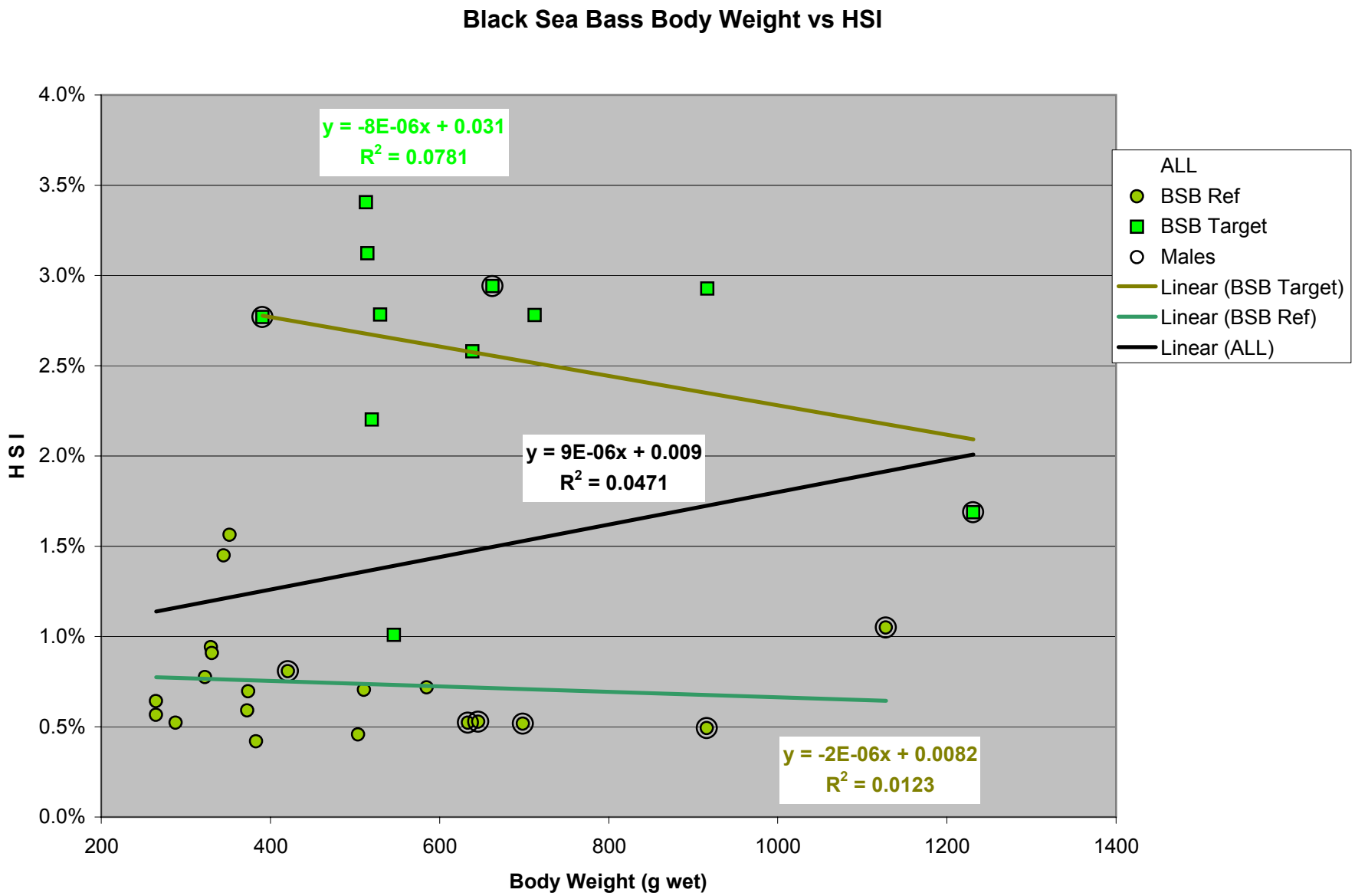


Fig. A4d-4c. Outlined boxes indicate regression equations with slopes significantly greater than zero.

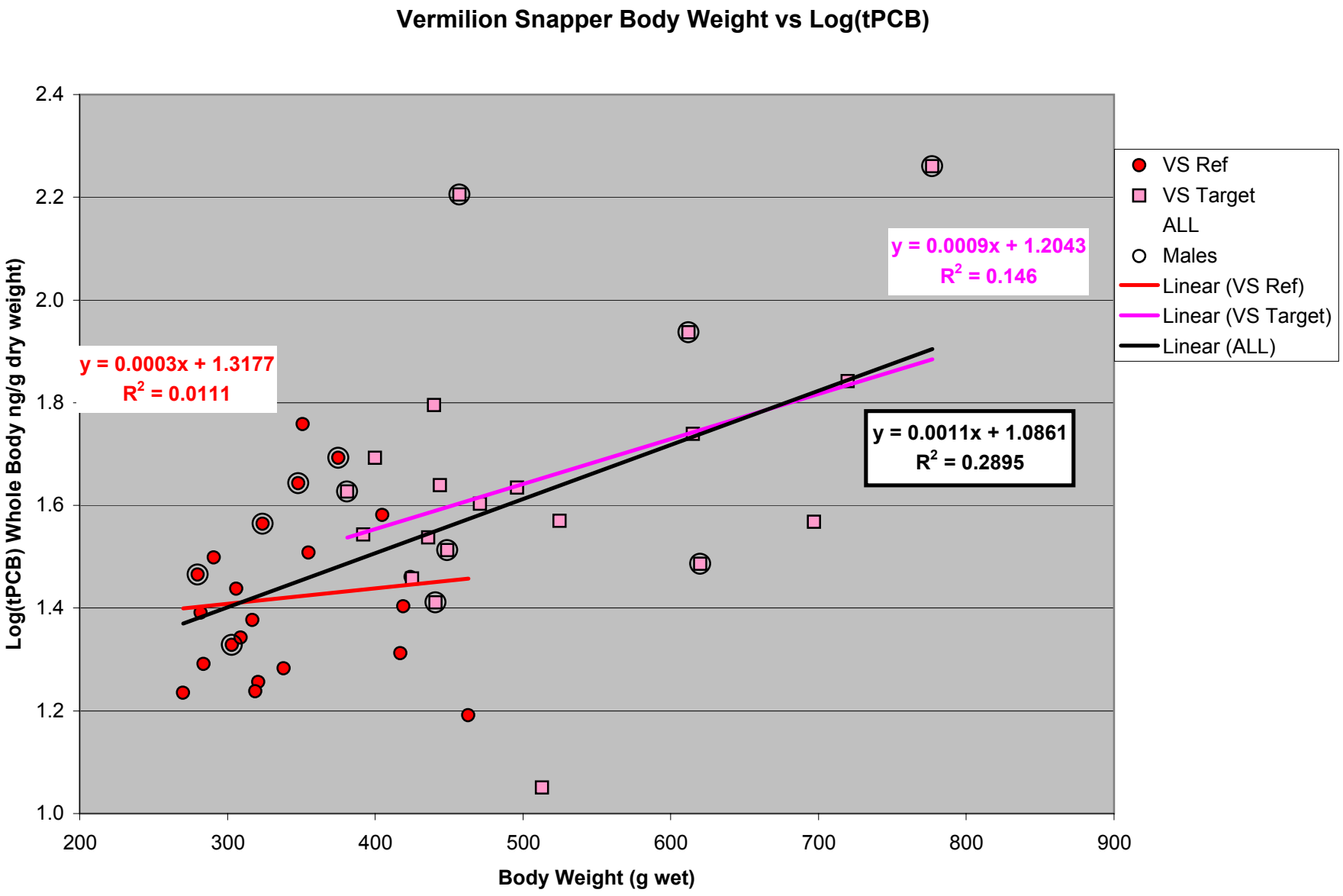


Fig. A4d-5a. Outlined boxes indicate regression equations with slopes significantly greater than zero.

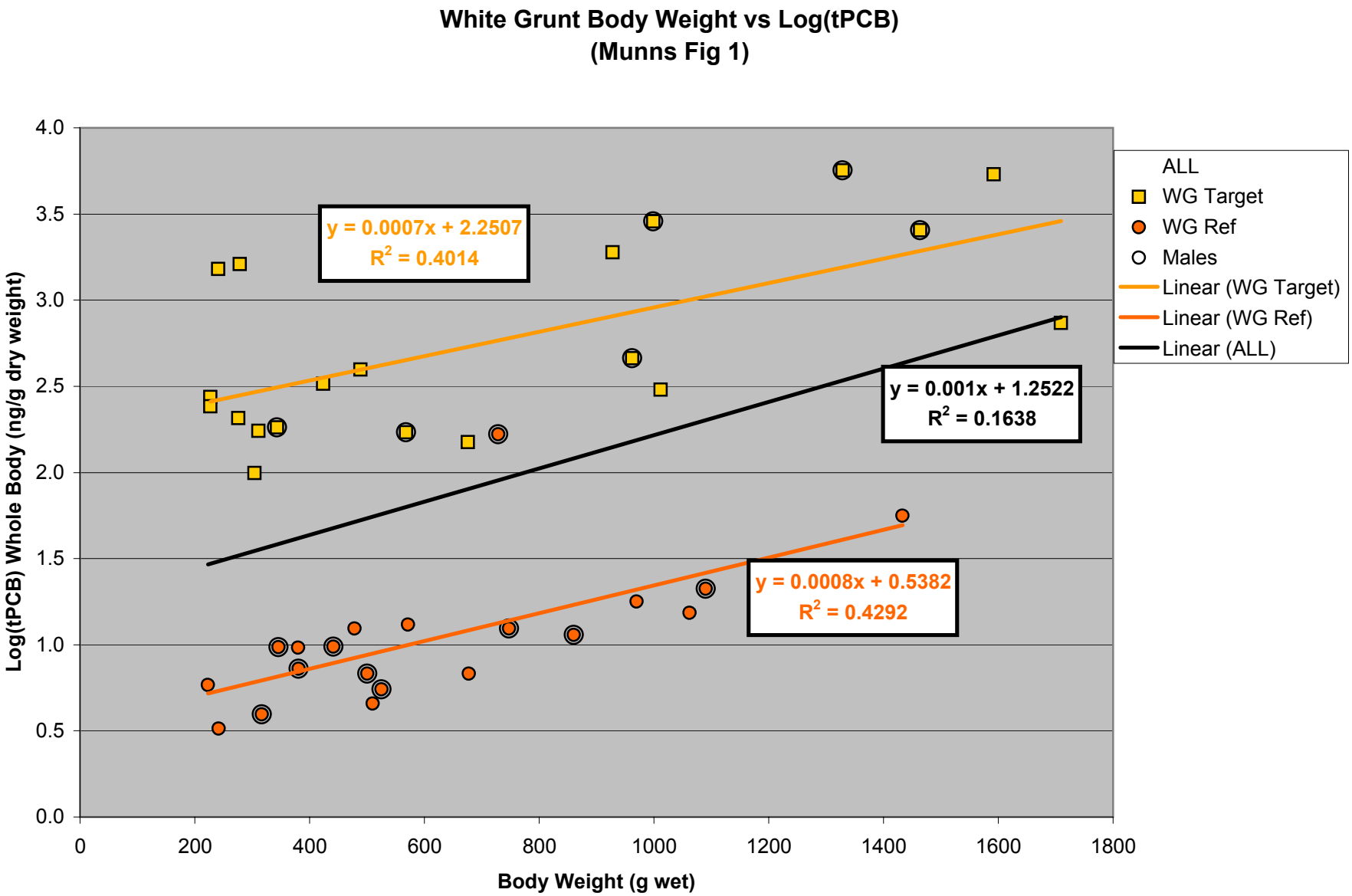


Fig. A4d-5b. Outlined boxes indicate regression equations with slopes significantly greater than zero.

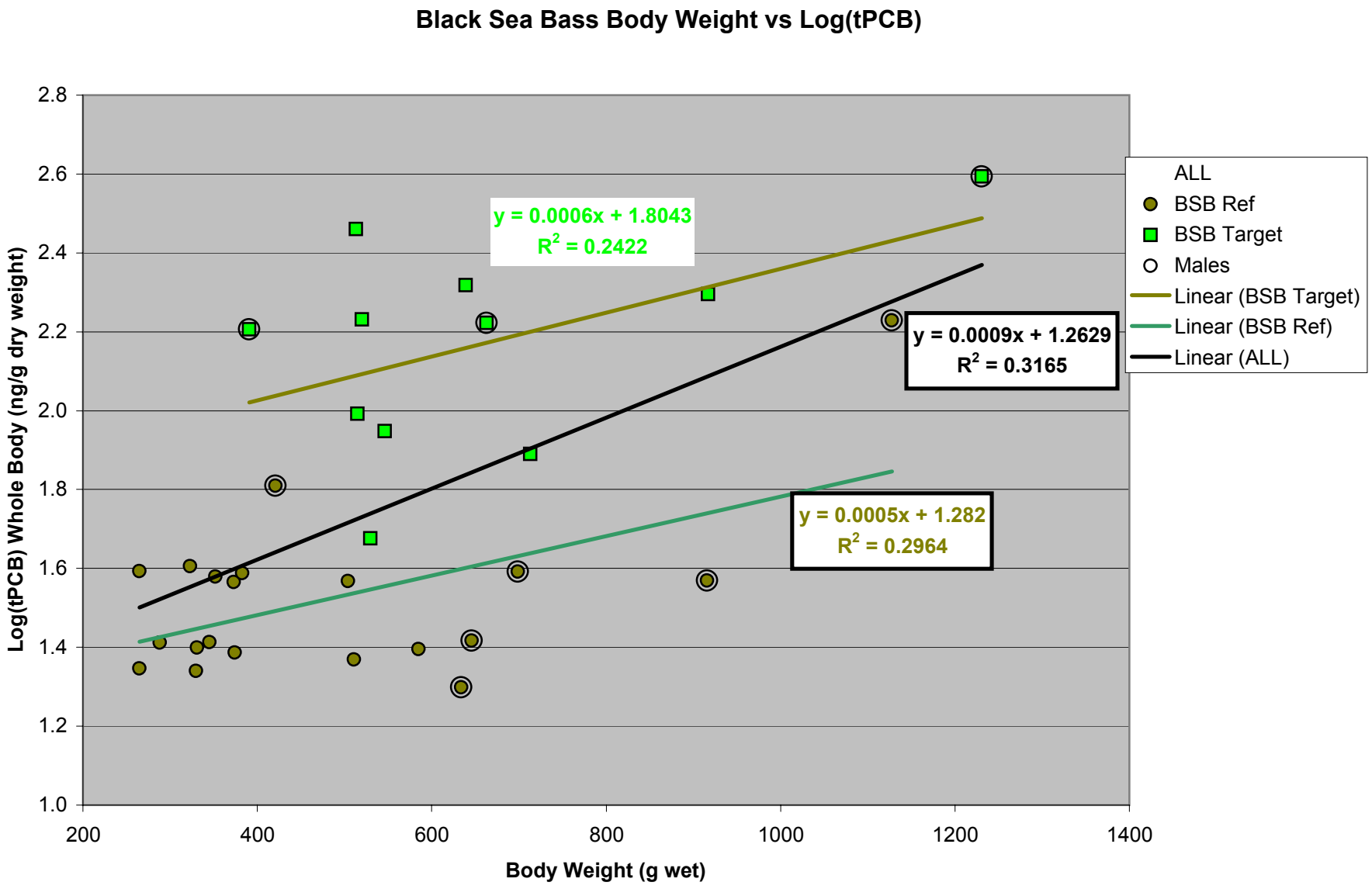


Fig. A4d-5c. Outlined boxes indicate regression equations with slopes significantly greater than zero.

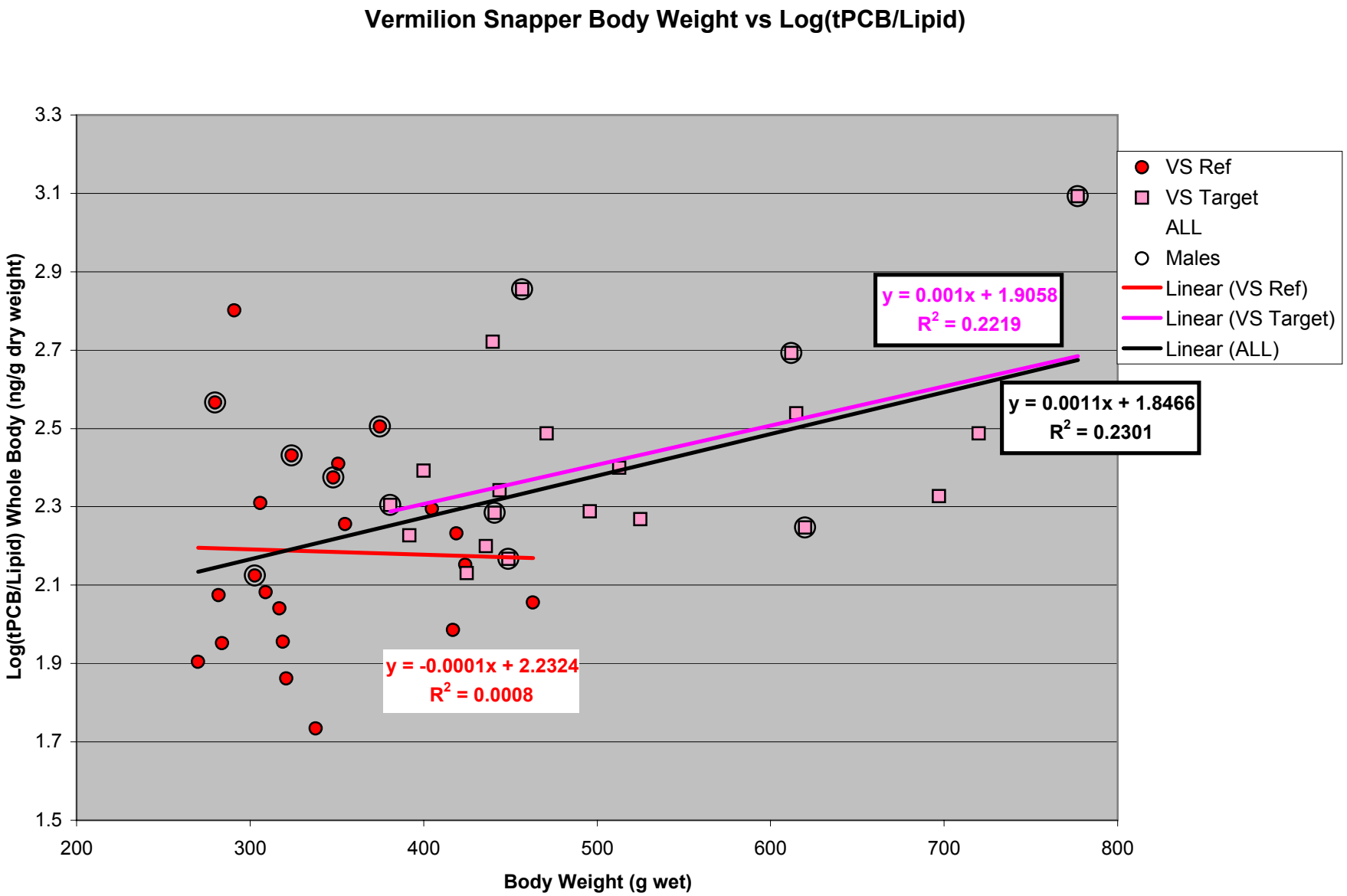


Fig. A4d-6a. Outlined boxes indicate regression equations with slopes significantly greater than zero.

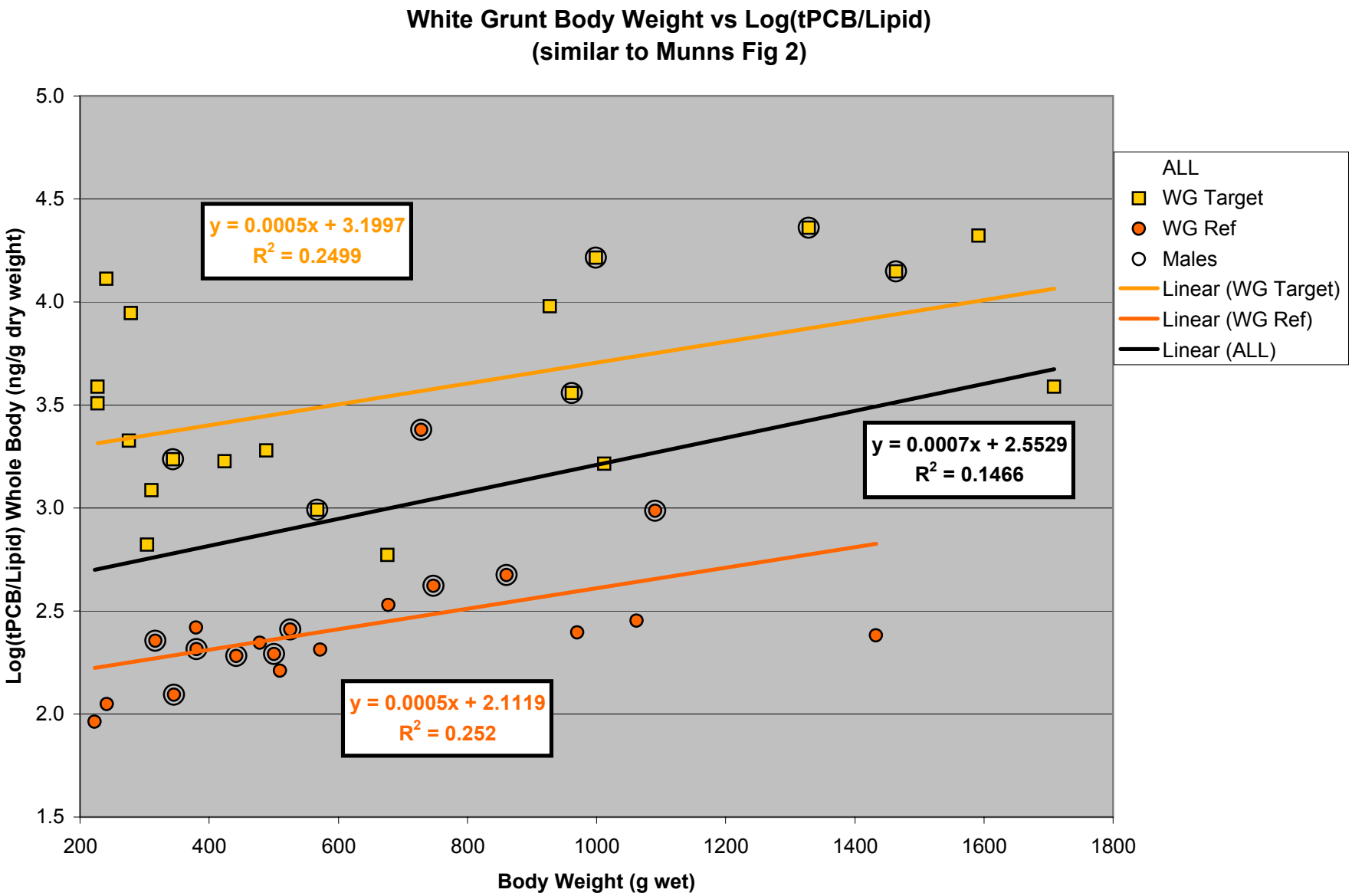


Fig. A4d-6b. Outlined boxes indicate regression equations with slopes significantly greater than zero.

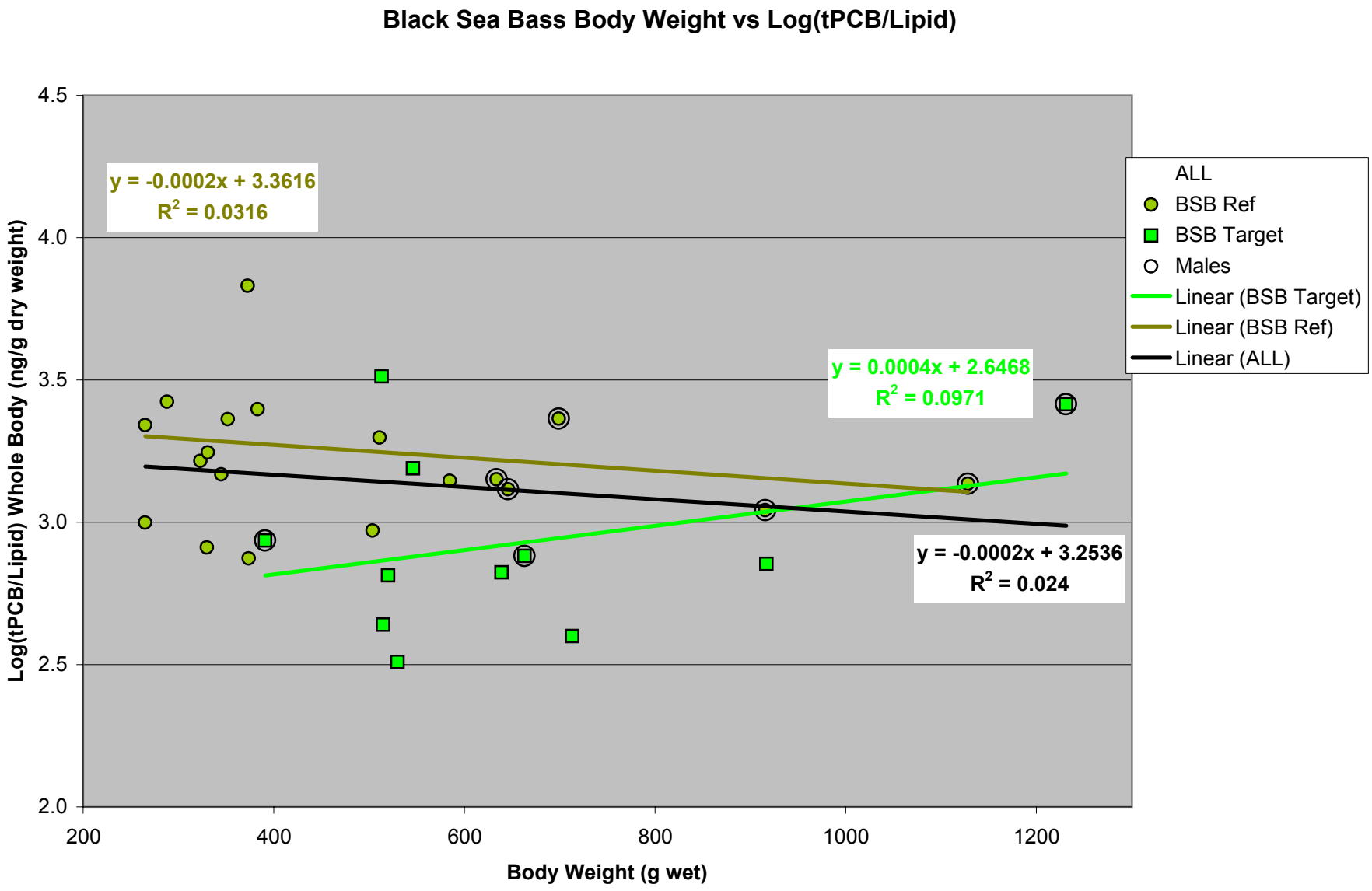


Fig. A4d-6c. Outlined boxes indicate regression equations with slopes significantly greater than zero.

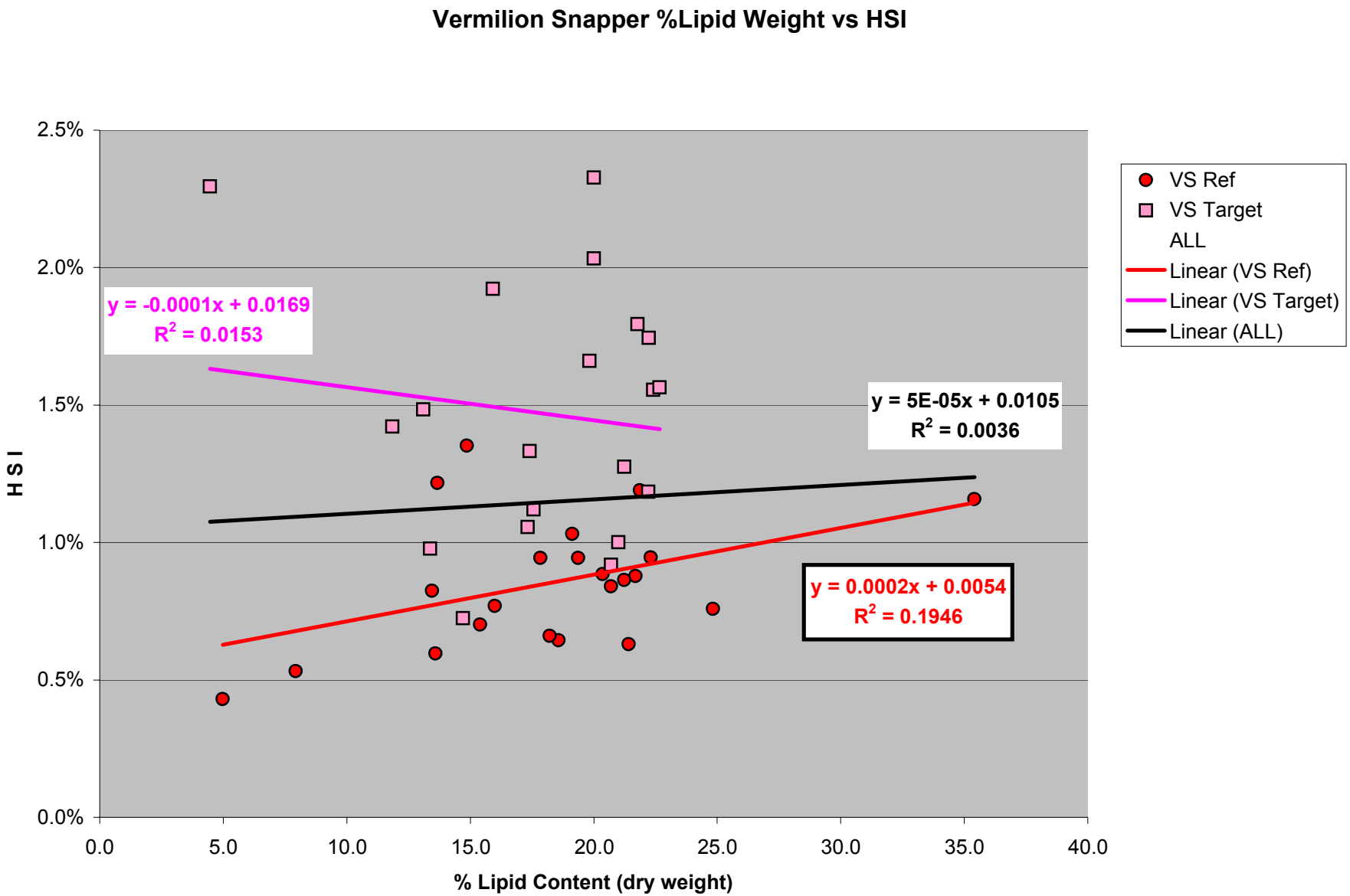


Fig. A4d-7a. Outlined boxes indicate regression equations with slopes significantly greater than zero.

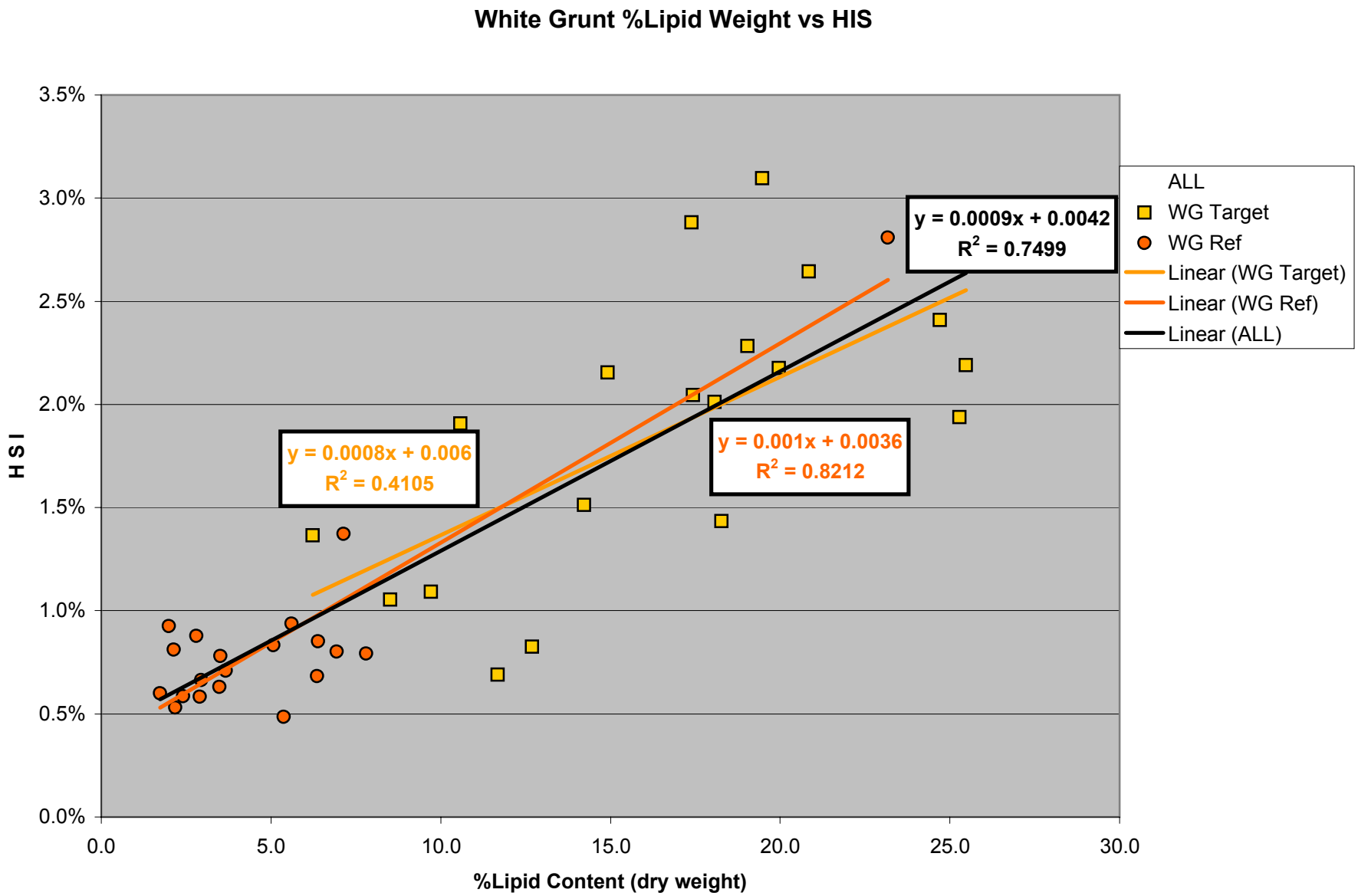


Fig. A4d-7b. Outlined boxes indicate regression equations with slopes significantly greater than zero.

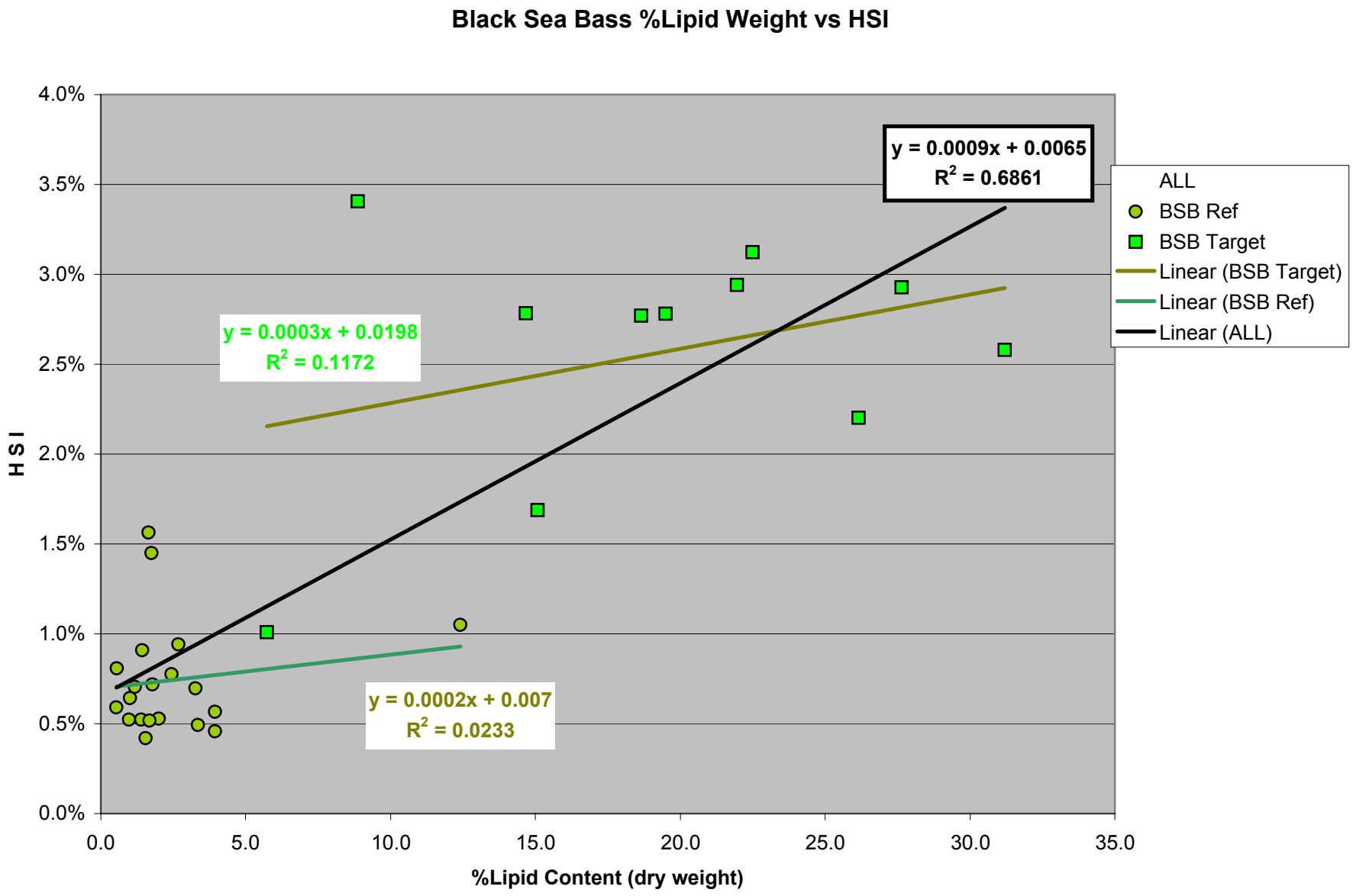


Fig. A4d-7c. Outlined boxes indicate regression equations with slopes significantly greater than zero.

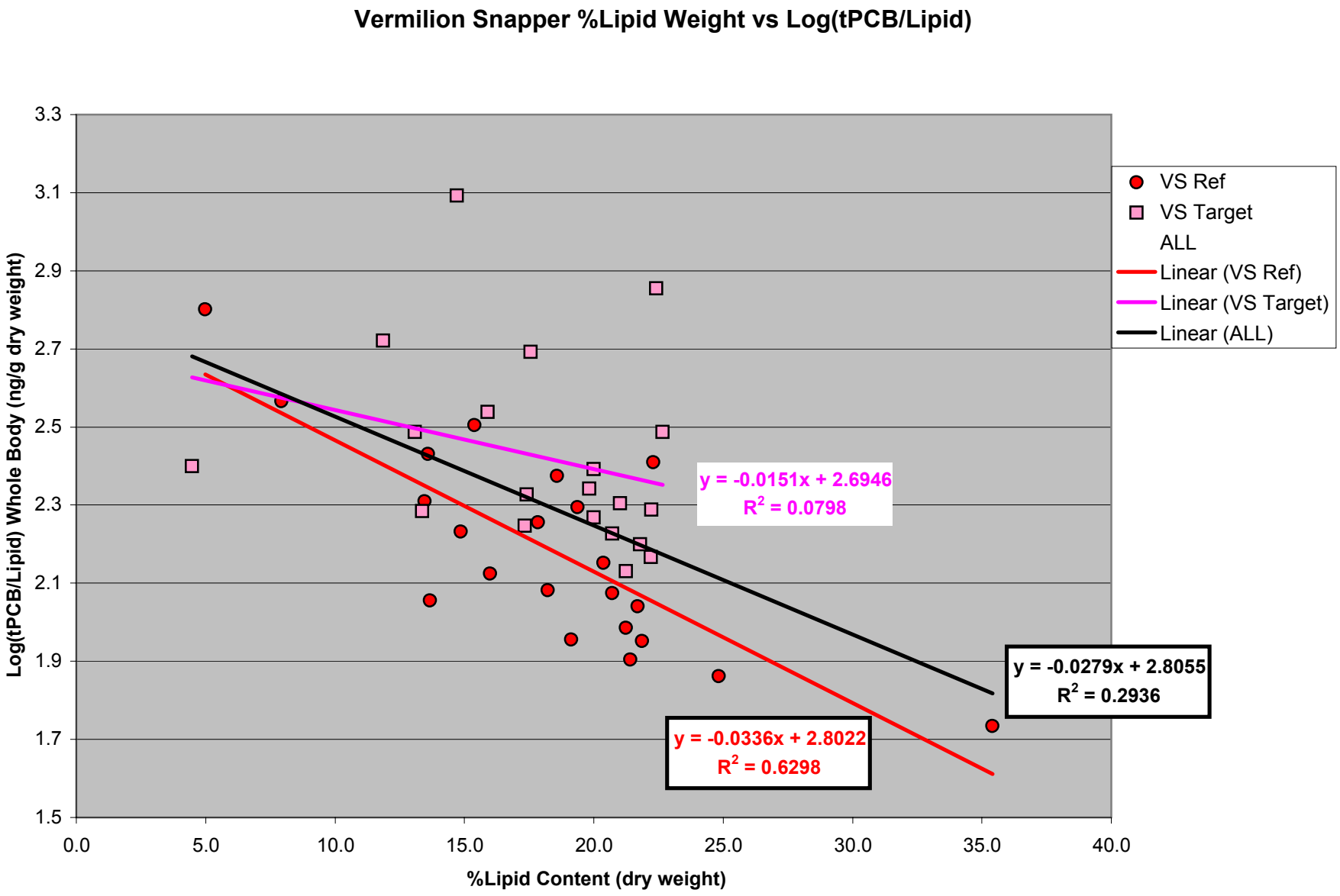


Fig. A4d-8a. Outlined boxes indicate regression equations with slopes significantly greater than zero.

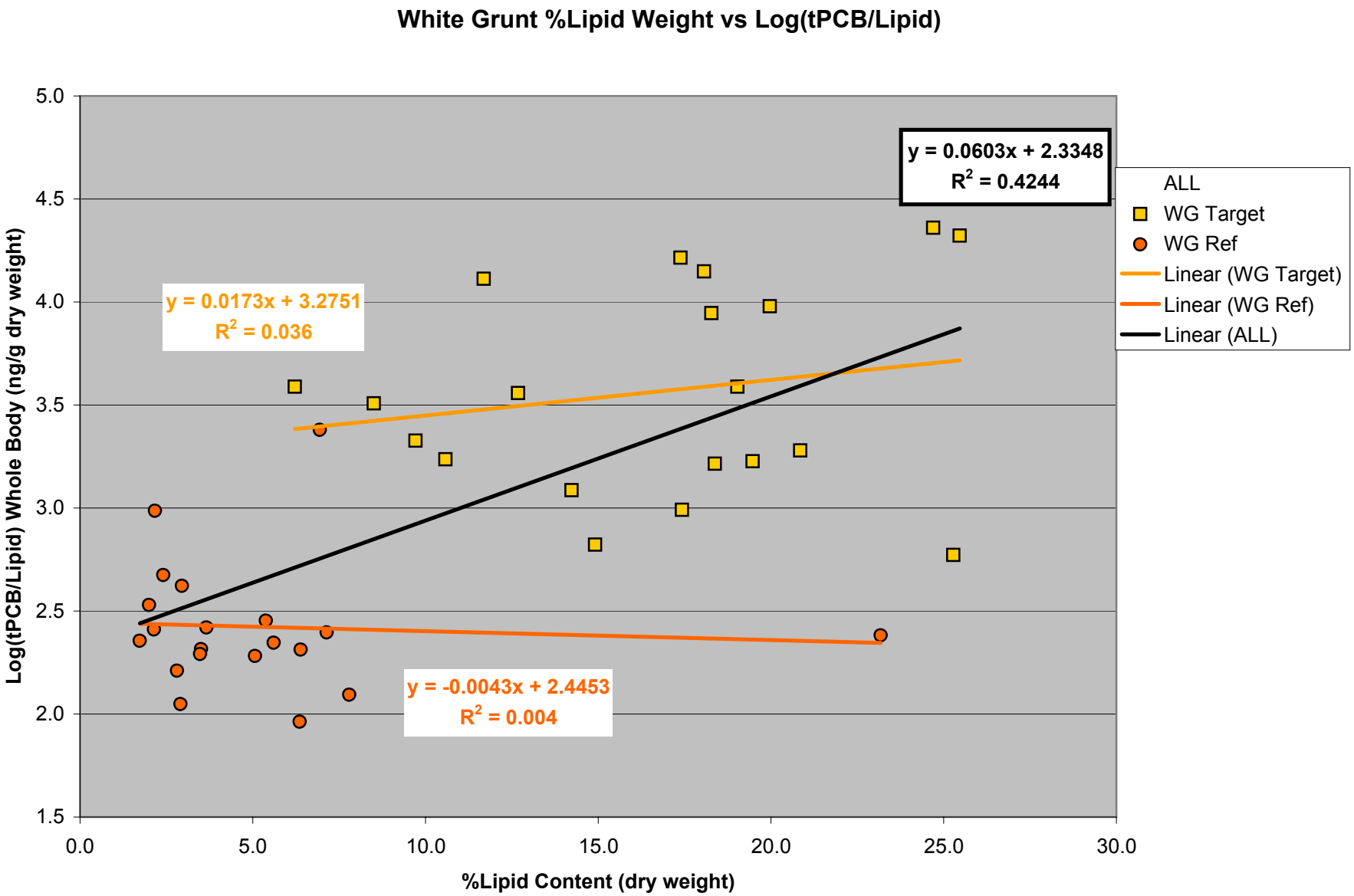


Fig. A4d-8b. Outlined boxes indicate regression equations with slopes significantly greater than zero.

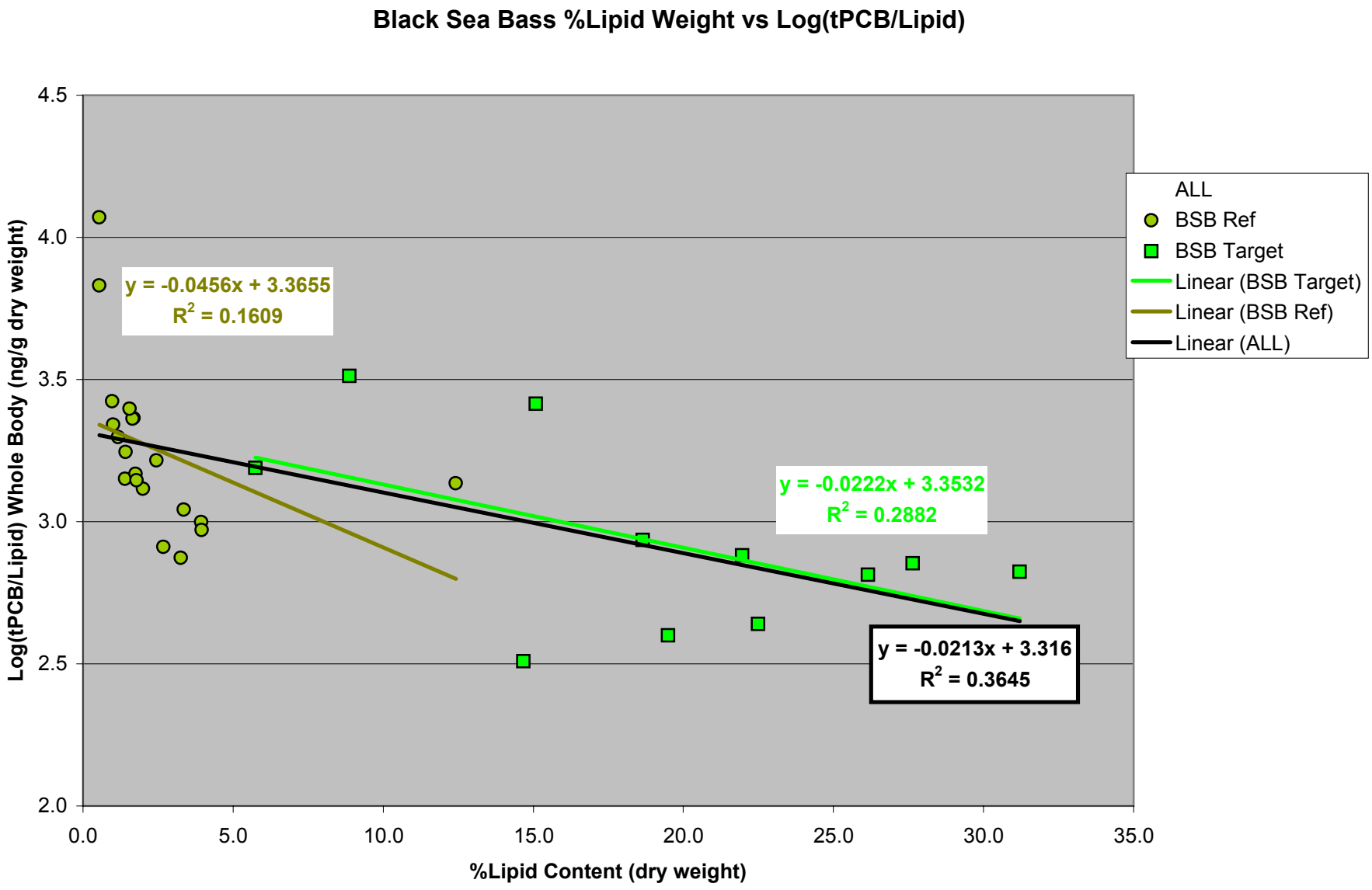


Fig. A4d-8c. Outlined boxes indicate regression equations with slopes significantly greater than zero.

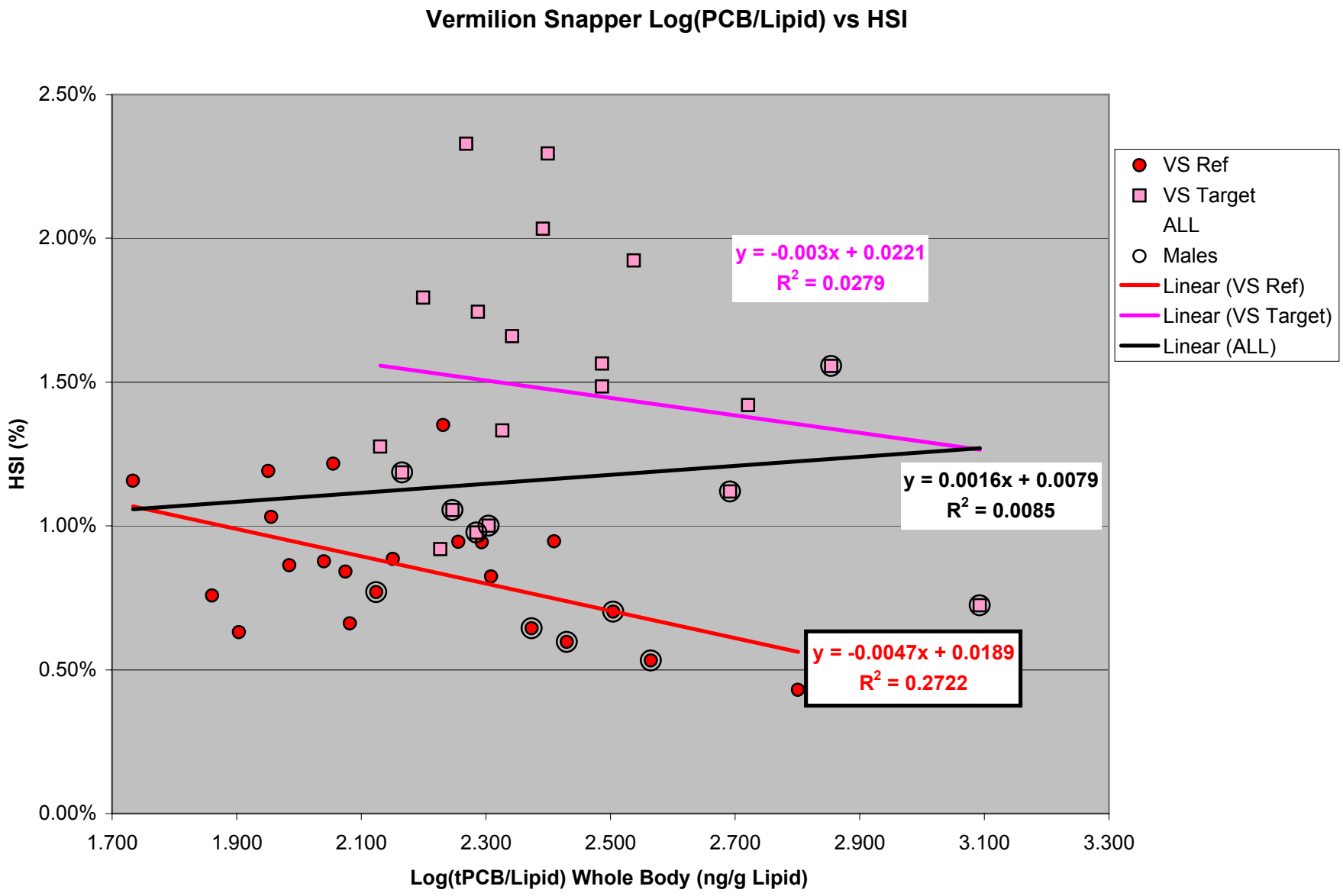


Fig. A4d-9a. Outlined boxes indicate regression equations with slopes significantly greater than zero.

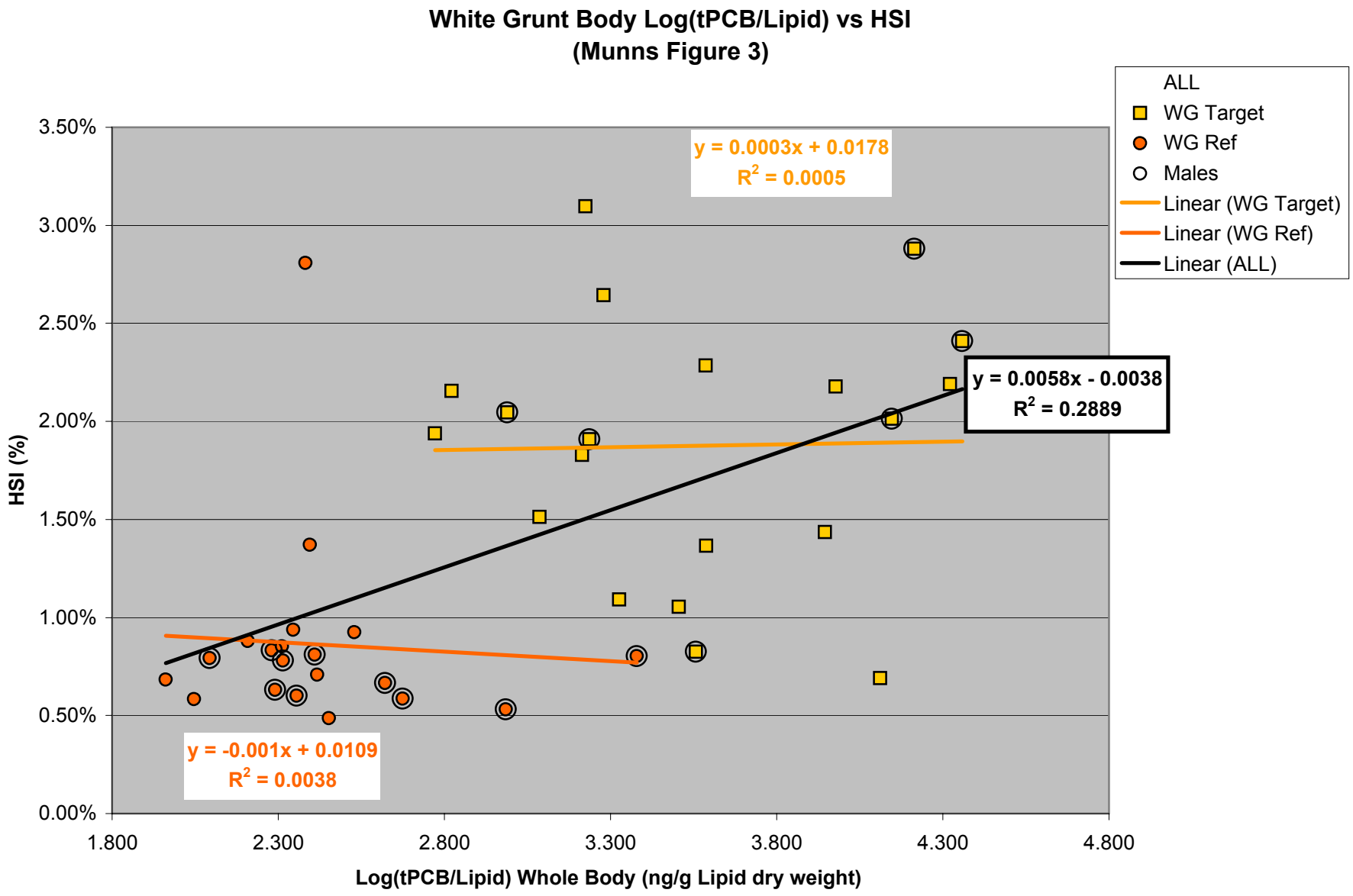


Fig. A4d-9b. Outlined boxes indicate regression equations with slopes significantly greater than zero.

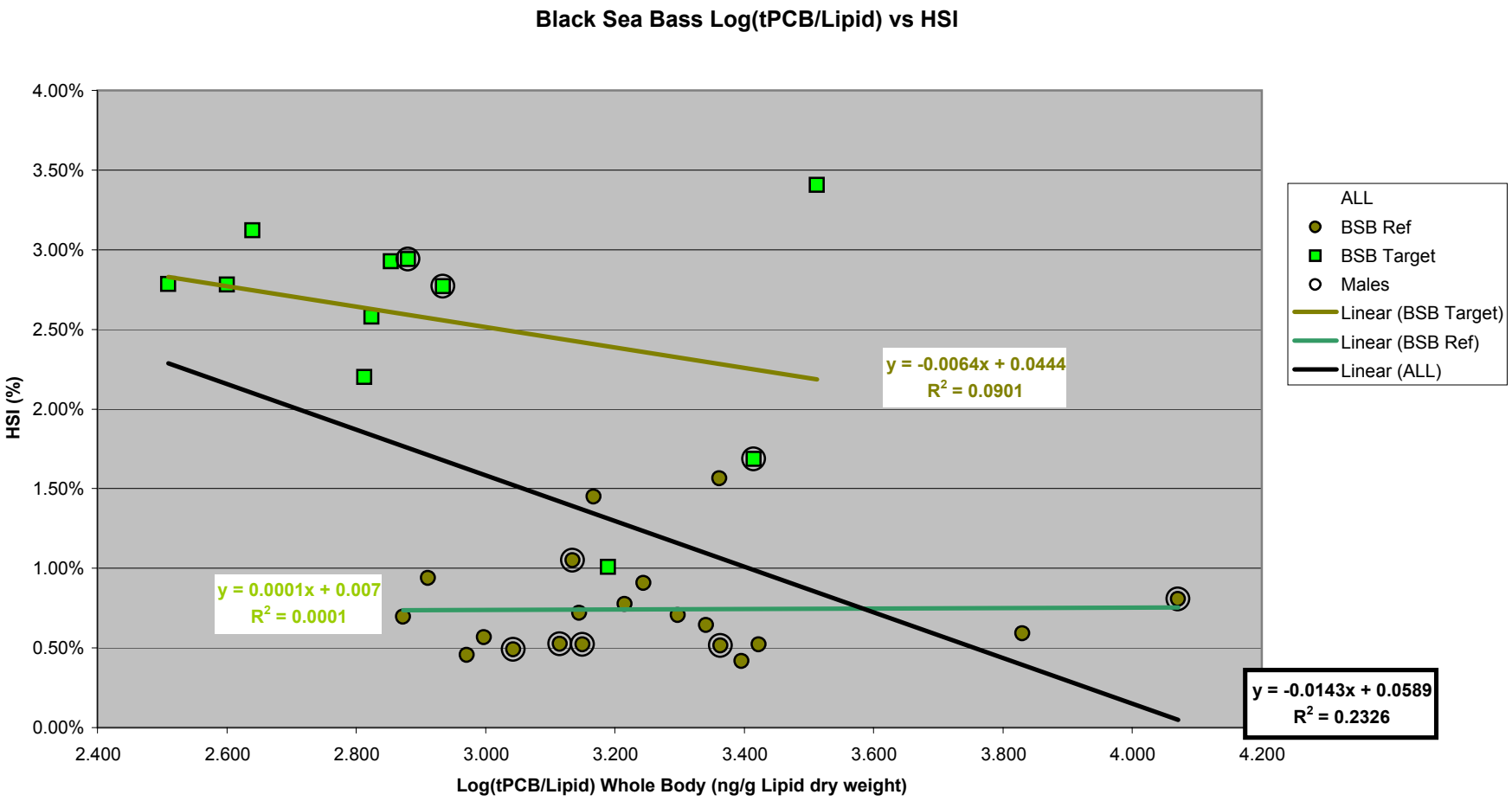


Fig. A4d-9c. Outlined boxes indicate regression equations with slopes significantly greater than zero.

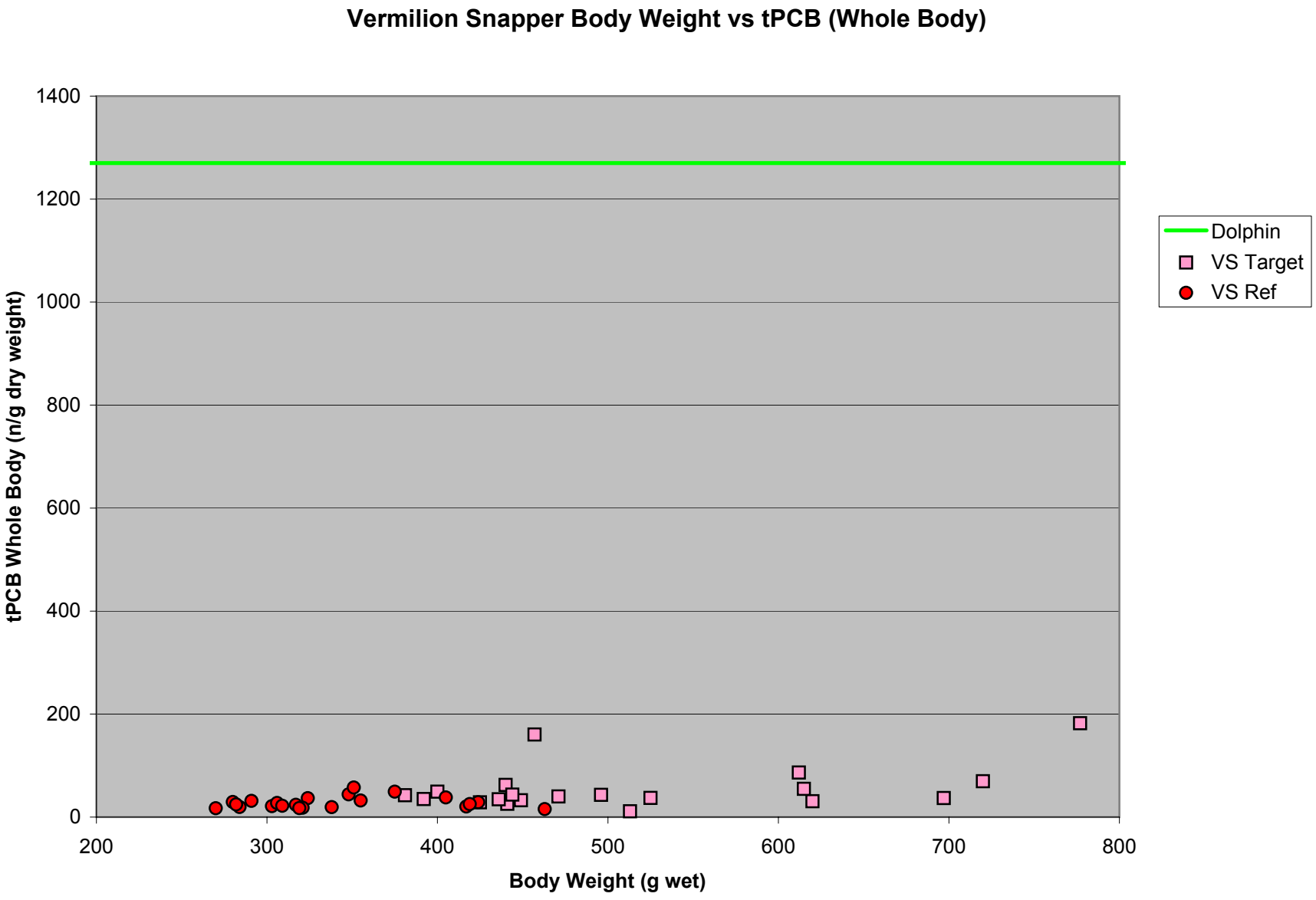


Fig. A4d-10a Whole body tPCB and ecorisk benchmarks.

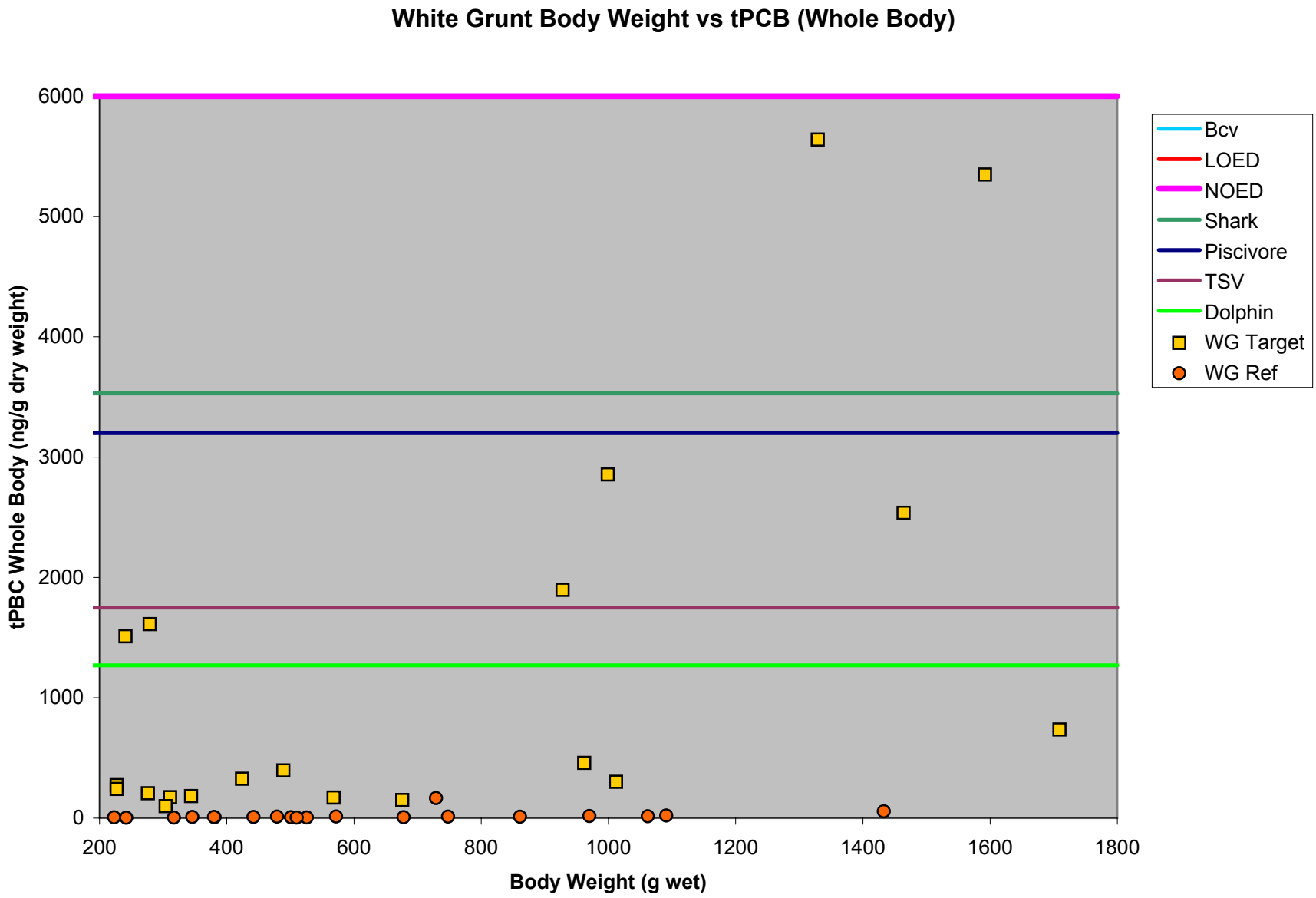


Fig. A4d-10b Whole body tPCB and ecorisk benchmarks.

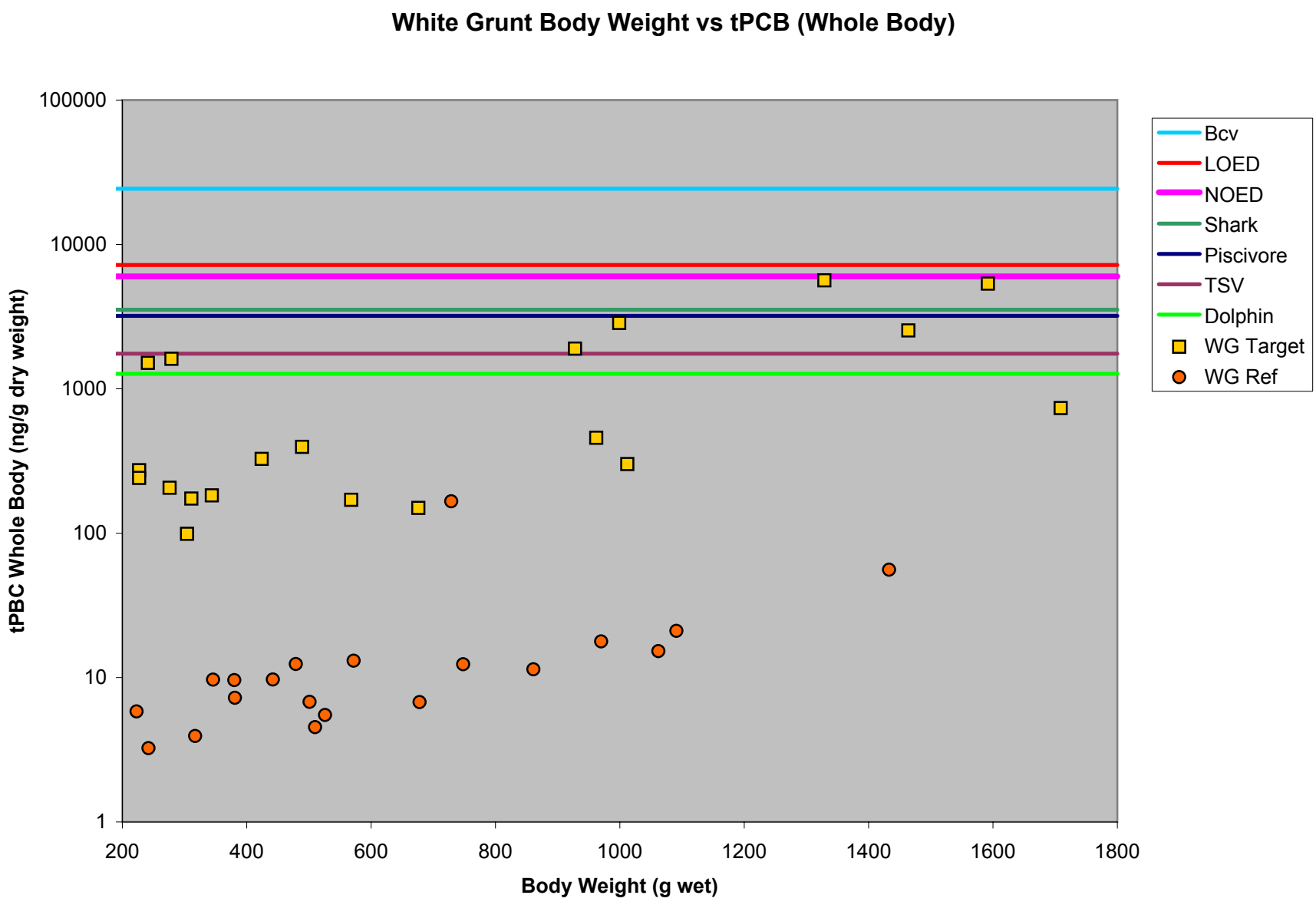


Fig. A4d-10b_log Whole body tPCB and ecorisk benchmarks.

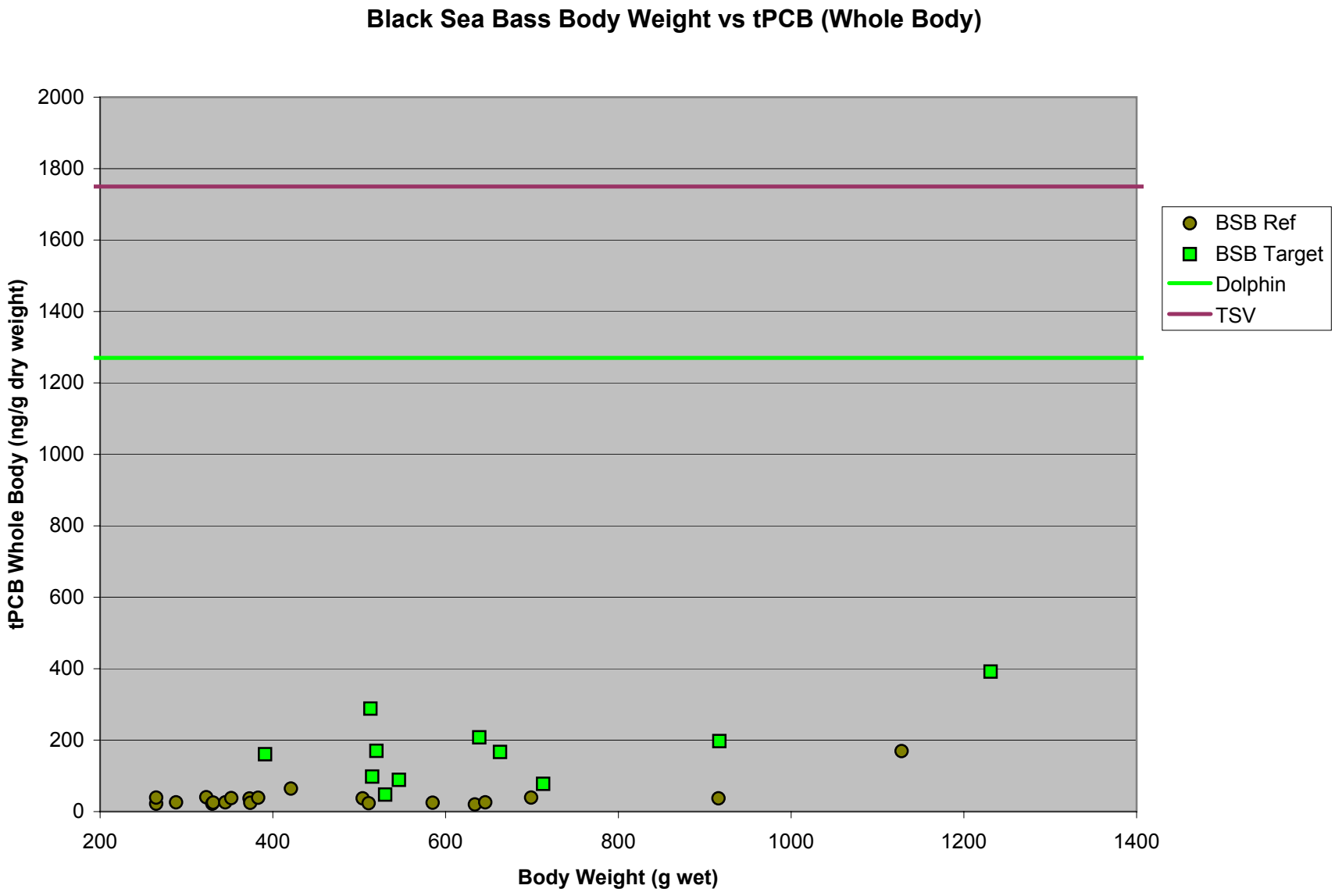


Fig. A4d-10c Whole body tPCB and ecorisk benchmarks.

A4E.1 Variables

Listing of the variable names used in this appendix.		units (unless otherwise specified)
code	analyte/description	
PCB008	8 - 2,4'-Dichlorobiphenyl	pg/g wet
PCB018	18 - 2,2',5-Trichlorobiphenyl	pg/g wet
PCB028	28 - 2,4,4'-Trichlorobiphenyl	pg/g wet
PCB044	44 - 2,2',3,5'-Tetrachlorobiphenyl	pg/g wet
PCB049	49 - 2,2',4,5' - Tetrachlorobiphenyl	pg/g wet
PCB052	52 - 2,2',5,5'-Tetrachlorobiphenyl	pg/g wet
PCB066	66 - 2,3',4,4'-Tetrachlorobiphenyl	pg/g wet
PCB077	77 - 3,3',4,4'-Tetrachlorobiphenyl	pg/g wet
PCB087	87 - 2,2',3,4,5 - Pentachlorobiphenyl	pg/g wet
ePCB081	81 - 3,4,4',5-Tetrachlorobiphenyl (estimated concn.)	pg/g wet
PCB101	101 - 2,2',4,5,5'-Pentachlorobiphenyl	pg/g wet
PCB105	105 - 2,3,3',4,4'-Pentachlorobiphenyl	pg/g wet
PCB114	114 - 2,3,4,4',5-Pentachlorobiphenyl	pg/g wet
PCB118	118 - 2,3',4,4',5-Pentachlorobiphenyl	pg/g wet
PCB123	123 - 2',3,4,4',5-Pentachlorobiphenyl	pg/g wet
PCB126	126 - 3,3',4,4',5-Pentachlorobiphenyl	pg/g wet
PCB128	128 - 2,2',3,3',4,4'-Hexachlorobiphenyl	pg/g wet
PCB138	138 - 2,2',3,4,4',5'-Hexachlorobiphenyl	pg/g wet
PCB153	153 - 2,2',4,4',5,5'-Hexachlorobiphenyl	pg/g wet
PCB156e	156 2,3,3',4,4',5-Hexachlorobiphenyl (NR values estimated based on PCB169 concn.)	pg/g wet
PCB157e	157 2,3,3',4,4',5'-Hexachlorobiphenyl (NR values estimated based on PCB169 concn.)	pg/g wet
PCB167	167 - 2,3',4,4',5,5'-Hexachlorobiphenyl	pg/g wet
PCB169	169 - 3,3',4,4',5,5'-Hexachlorobiphenyl	pg/g wet
PCB170	170 - 2,2',3,3',4,4',5-Heptachlorobiphenyl	pg/g wet
PCB180	180 - 2,2',3,4,4',5,5'-Heptachlorobiphenyl	pg/g wet
PCB183	183 - 2,2',3,4,4',5',6 - Heptachlorobiphenyl	pg/g wet
PCB184	184 - 2,2',3,4,4',6,6' - Heptachlorobiphenyl	pg/g wet
PCB187	187 - 2,2',3,4',5,5',6-Heptachlorobiphenyl	pg/g wet
PCB189	189 - 2,3,3',4,4',5,5'-Heptachlorobiphenyl	pg/g wet
PCB195	195 - 2,2',3,3',4,4',5,6-Octachlorobiphenyl	pg/g wet
PCB206	206 - 2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	pg/g wet
PCB209	209 - Decachlorobiphenyl	pg/g wet
Homo_CL1	Total Monochlorobiphenyl	pg/g wet
Homo_CL2	Total Dichlorobiphenyls	pg/g wet
Homo_CL3	Total Trichlorobiphenyls	pg/g wet
Homo_CL4	Total Tetrachlorobiphenyls	pg/g wet
Homo_CL5	Total Pentachlorobiphenyls	pg/g wet
Homo_CL6	Total Hexachlorobiphenyls	pg/g wet
Homo_CL7	Total Heptachlorobiphenyls	pg/g wet
Homo_CL8	Total Octachlorobiphenyls	pg/g wet
Homo_CL9	Total Nonachlorobiphenyls	pg/g wet
tPCB	TOTAL Polychlorinated Biphenyls	pg/g wet
ID_to_use	Field sample id	
Lab ID	Laboratory sample id	
Species	Species of fish sample	
Site	Site fish collected from Reference = natural reef; Target = ex-VERMILION reef	
LEN	Total Length (mm)	mm

A4E.1 Variables

Listing of the variable names used in this appendix.		units (unless otherwise specified)
code	analyte/description	
WEIGHT	Total Weight (g)	g
FWEIGHT	Filet Weight (g)	g
LWEIGHT	Liver Weight (g)	g
SEX	Sex	
AGE	Estimated Age	yr
W-D	Percent (wet or dry)	%
DRY	Percent Dry Weight	%
LIPIDW	Percent Lipid (wet weight basis)	%
LIPIDD	f_Lipid (Dryweight)	mass fraction
tPCBw	total PCB wet weight basis	pg/g wet
tPCBd	total PCB dry weight basis	ng/g dry
X_PCB	total PCB ng/g Fillet dry weight reported by Axys and used in Appendix 4c	ng/g
x_PCBWB	total PCB whole body ng/g dry weight	ng/g
ConvFac	conversion factor to convert fillet PCB to whole body PCB (see Appendix 4c)	g PCB wb /gPCB fillet
TECF077	Fish dioxin toxicity equivalent concentration for PCB077	pg/g wet
TECF081	Fish dioxin toxicity equivalent concentration for PCB081	pg/g wet
TECF105	Fish dioxin toxicity equivalent concentration for PCB105	pg/g wet
TECF114	Fish dioxin toxicity equivalent concentration for PCB114	pg/g wet
TECF118	Fish dioxin toxicity equivalent concentration for PCB118	pg/g wet
TECF123	Fish dioxin toxicity equivalent concentration for PCB123	pg/g wet
TECF126	Fish dioxin toxicity equivalent concentration for PCB126	pg/g wet
TECF156	Fish dioxin toxicity equivalent concentration for PCB156	pg/g wet
TECF157	Fish dioxin toxicity equivalent concentration for PCB157	pg/g wet
TECF167	Fish dioxin toxicity equivalent concentration for PCB167	pg/g wet
TECF169	Fish dioxin toxicity equivalent concentration for PCB169	pg/g wet
TECF189	Fish dioxin toxicity equivalent concentration for PCB189	pg/g wet
FTEQ_W	Fish TEQ whole body wet weight basis	pg/g wet
FTEQ_L	Fish TEQ whole body lipid basis (wet)	pg/g wet
LFTEQ_W	Log (Fish TEQ whole body wet weight basis)	pg/g wet
LFTEQ_L	Log (Fish TEQ whole body lipid basis (wet))	pg/g wet
TEGG077	Fish Egg dioxin toxicity equivalent concentration for PCB077	pg/g wet
TEGG081	Fish Egg dioxin toxicity equivalent concentration for PCB081	pg/g wet
TEGG105	Fish Egg dioxin toxicity equivalent concentration for PCB105	pg/g wet
TEGG114	Fish Egg dioxin toxicity equivalent concentration for PCB114	pg/g wet
TEGG118	Fish Egg dioxin toxicity equivalent concentration for PCB118	pg/g wet
TEGG123	Fish Egg dioxin toxicity equivalent concentration for PCB123	pg/g wet
TEGG126	Fish Egg dioxin toxicity equivalent concentration for PCB126	pg/g wet
TEGG156	Fish Egg dioxin toxicity equivalent concentration for PCB156	pg/g wet
TEGG157	Fish Egg dioxin toxicity equivalent concentration for PCB157	pg/g wet
TEGG167	Fish Egg dioxin toxicity equivalent concentration for PCB167	pg/g wet
TEGG169	Fish Egg dioxin toxicity equivalent concentration for PCB169	pg/g wet
TEGG189	Fish Egg dioxin toxicity equivalent concentration for PCB189	pg/g wet
TEQ_EGGL	Fish TEQ whole body lipid basis (wet) The egg:female transfer ratio is lipid normalized, whole body concentration is assumed to be proportional to lipid	pg/g wet

A4E.1 Variables

Listing of the variable names used in this appendix.		units (unless otherwise specified)
code	analyte/description	
TEQ_EGGw	Fish Egg TEQ whole body wet weight basis. Uses the average fraction of lipid:wet tissue reported for egss by Cook et al. 2003, and Debruyn et al. 2004	pg/g wet
TEQ_EGGx	This assumes that the lipid:wet weight ratio is the sampe as the female, probably not correct.	pg/g wet
est%Mort	estimated egg mortality based on equ (4) in Cook et al. 2004	%
TECB077	Avian dioxin toxicity equivalent concentration for PCB077	pg/g wet
TECB081	Avian dioxin toxicity equivalent concentration for PCB081	pg/g wet
TECB105	Avian dioxin toxicity equivalent concentration for PCB105	pg/g wet
TECB114	Avian dioxin toxicity equivalent concentration for PCB114	pg/g wet
TECB118	Avian dioxin toxicity equivalent concentration for PCB118	pg/g wet
TECB123	Avian dioxin toxicity equivalent concentration for PCB123	pg/g wet
TECB126	Avian dioxin toxicity equivalent concentration for PCB126	pg/g wet
TECB156	Avian dioxin toxicity equivalent concentration for PCB156	pg/g wet
TECB157	Avian dioxin toxicity equivalent concentration for PCB157	pg/g wet
TECB167	Avian dioxin toxicity equivalent concentration for PCB167	pg/g wet
TECB169	Avian dioxin toxicity equivalent concentration for PCB169	pg/g wet
TECB189	Avian dioxin toxicity equivalent concentration for PCB189	pg/g wet
BTEQ_W	Avian TEQ in fish tissue whole body wet weight basis	pg/g wet
BTEQ_L	Avian TEQ in fish tissue whole body lipid basis (wet)	pg/g wet
LBTEQW	Log(Avian TEQ in fish tissue whole body wet weight basis)	pg/g wet
LBTEQL	Log(Avian TEQ in fish tissue whole body lipid basis (wet))	pg/g wet
		pg/g wet
TECM077	Mammal dioxin toxicity equivalent concentration for PCB077	pg/g wet
TECM081	Mammal dioxin toxicity equivalent concentration for PCB081	pg/g wet
TECM105	Mammal dioxin toxicity equivalent concentration for PCB105	pg/g wet
TECM114	Mammal dioxin toxicity equivalent concentration for PCB114	pg/g wet
TECM118	Mammal dioxin toxicity equivalent concentration for PCB118	pg/g wet
TECM123	Mammal dioxin toxicity equivalent concentration for PCB123	pg/g wet
TECM126	Mammal dioxin toxicity equivalent concentration for PCB126	pg/g wet
TECM156	Mammal dioxin toxicity equivalent concentration for PCB156	pg/g wet
TECM157	Mammal dioxin toxicity equivalent concentration for PCB157	pg/g wet
TECM167	Mammal dioxin toxicity equivalent concentration for PCB167	pg/g wet
TECM169	Mammal dioxin toxicity equivalent concentration for PCB169	pg/g wet
TECM189	Mammal dioxin toxicity equivalent concentration for PCB189	pg/g wet
MTEQ_W	Mammal TEQ in fish tissue whole body wet weight basis	pg/g wet
MTEQ_L	Mammal TEQ in fish tissue whole body lipid basis (wet)	pg/g wet
LMTEQW	Log(Mammalian TEQ in fish tissue whole body wet weight basis)	pg/g wet
LMTEQL	Log(Mammalian TEQ in fish tissue whole body lipid basis (wet))	pg/g wet
ZHOMO_CL1	log transformed HOMO_CL1	pg/g wet
ZHOMO_CL2	log transformed HOMO_CL2	pg/g wet
ZHOMO_CL3	log transformed HOMO_CL3	pg/g wet
ZHOMO_CL4	log transformed HOMO_CL4	pg/g wet
ZHOMO_CL5	log transformed HOMO_CL5	pg/g wet
ZHOMO_CL6	log transformed HOMO_CL6	pg/g wet
ZHOMO_CL7	log transformed HOMO_CL7	pg/g wet
ZHOMO_CL8	log transformed HOMO_CL8	pg/g wet

A4E.1 Variables

Listing of the variable names used in this appendix.		units (unless otherwise specified)
code	analyte/description	
ZHOMO_CL9	log transformed HOMO_CL9	pg/g wet
ZPCB008	log transformed PCB008	pg/g wet
ZPCB018	log transformed PCB018	pg/g wet
ZPCB028	log transformed PCB028	pg/g wet
ZPCB044	log transformed PCB044	pg/g wet
ZPCB049	log transformed PCB049	pg/g wet
ZPCB052	log transformed PCB052	pg/g wet
ZPCB066	log transformed PCB066	pg/g wet
ZPCB077	log transformed PCB077	pg/g wet
ZPCB081E	log transformed PCB081E	pg/g wet
ZPCB087	log transformed PCB087	pg/g wet
ZPCB101	log transformed PCB101	pg/g wet
ZPCB105	log transformed PCB105	pg/g wet
ZPCB114	log transformed PCB114	pg/g wet
ZPCB118	log transformed PCB118	pg/g wet
ZPCB123	log transformed PCB123	pg/g wet
ZPCB126	log transformed PCB126	pg/g wet
ZPCB128	log transformed PCB128	pg/g wet
ZPCB138	log transformed PCB138	pg/g wet
ZPCB153	log transformed PCB153	pg/g wet
ZPCB156	log transformed PCB156	pg/g wet
ZPCB157	log transformed PCB157	pg/g wet
ZPCB167	log transformed PCB167	pg/g wet
ZPCB169	log transformed PCB169	pg/g wet
ZPCB170	log transformed PCB170	pg/g wet
ZPCB180	log transformed PCB180	pg/g wet
ZPCB183	log transformed PCB183	pg/g wet
ZPCB184	log transformed PCB184	pg/g wet
ZPCB187	log transformed PCB187	pg/g wet
ZPCB189	log transformed PCB189	pg/g wet
ZPCB195	log transformed PCB195	pg/g wet
ZPCB206	log transformed PCB206	pg/g wet
ZPCB209	log transformed PCB209	pg/g wet
ZTPCBW	log transformed TPCBW	pg/g wet

Raw results for PCB homolog and congener analysis (EPA Method 1668). The sample method detection limit is reported for non dectected values

						fillet	fillet	fillet	fillet	fillet	fillet	fillet	fillet
				Sex	%Lipid(wet)	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet
ID_to_use	**Lab ID**	**Species**	**Site**	**SEX**	**LIPIDW**	**Homo_CL1**	**Homo_CL2**	**Homo_CL3**	**Homo_CL4**	**Homo_CL5**	**Homo_CL6**	**Homo_CL7**	**Homo_CL8**
NEHC-0005	L3606-5	Black Seabass	Referer	F	0.85	0.465	2.63	16.1	192	1190	3090	1580	639
NEHC-0024	L3606-24	Black Seabass	Referer	F	0.52	0.732	2.05	16.3	214	1160	2460	1250	652
NEHC-0048	L3606-48R	Black Seabass	Referer	F	0.33	0.754	1.87	4.45	60.5	486	1620	974	547
NEHC-0007	L3606-7	Black Seabass	Referer	F	0.36	1.15	1.7	7.71	87.9	587	1210	592	281
NEHC-0023	L3606-23	Black Seabass	Referer	F	0.76	0.212	2.45	12	124	783	1890	946	408
NEHC-0002	L3606-2 i	Black Seabass	Referer	F	0.20	0.377	1.6	2.72	37	318	926	680	428
NEHC-0034	L3606-34	Black Seabass	Referer	F	0.32	0.28	2.99	5.84	53.7	503	1390	840	397
NEHC-0004	L3606-4	Black Seabass	Referer	F	0.21	0.12	2.35	4.58	50.2	522	1550	908	358
NEHC-0042	L3606-42R	Black Seabass	Referer	F	0.57	2.02	2.45	6.84	61.8	552	1540	738	321
NEHC-0016	L3606-16	Black Seabass	Referer	F	7.46	0.175	2.35	5.66	90.6	683	1580	798	304
NEHC-0017	L3606-17	Black Seabass	Referer	M	7.46	0.133	2.19	6.03	50.8	657	2340	1540	720
NEHC-0011	L3606-11 i	Black Seabass	Referer	F	0.28	0.751	1.71	8.81	127	905	2310	1290	443
NEHC-0033	L3606-33 i	Black Seabass	Referer	F	0.40	0.397	3.6	9.34	92.9	671	1560	802	355
NEHC-0044	L3606-44R	Black Seabass	Referer	F	0.83	0.301	2.28	23.9	204	1080	2510	1430	864
NEHC-0003	L3606-3	Black Seabass	Referer	F	0.25	0.496	1.36	5.42	73.3	482	1260	756	297
NEHC-0046	L3606-46R	Black Seabass	Referer	M	0.28	1.38	1.69	3.83	29	353	1190	734	348
NEHC-0026	L3606-26	Black Seabass	Referer	M	0.42	0.665	0.879	7.36	44.8	474	1600	993	524
NEHC-0049	L3606-49R	Black Seabass	Referer	M	0.36	1.04	3.96	14.7	93.8	659	2200	1550	900
NEHC-0041	L3606-41R	Black Seabass	Referer	M	0.74	1.33	3.71	13.4	203	1390	2720	1300	588
NEHC-0010	L3606-10 i	Black Seabass	Referer	M	2.83	0.992	7.43	46.8	422	3470	13900	10400	3110
NEHC-0043	L3606-43R	Black Seabass	Target	M	5.04	1.41	26.9	224	2470	12100	16600	4990	1360
NEHC-0027	L3606-27	Black Seabass	Target	F	7.78	1.83	19.1	210	2940	14100	19500	6910	2260
NEHC-0036	L3606-36R	Black Seabass	Target	F	6.30	1.82	16.6	156	2150	9570	9090	2340	638
NEHC-0053	L3606-53R	Black Seabass	Target	F	3.67	0.914	13.1	104	884	3590	3820	1140	352
NEHC-0021	L3606-21	Black Seabass	Target	Immature	2.16	2.01	8.86	75.5	3120	22400	20600	4190	859
NEHC-0006	L3606-6	Black Seabass	Target	F	1.24	0.684	5.81	61.7	996	4590	5900	2210	698
NEHC-0047	L3606-47R	Black Seabass	Target	M	5.93	1.8	17.2	197	3460	16300	16300	3240	803
NEHC-0050	L3606-50R	Black Seabass	Target	F	9.05	2.44	28.8	318	4120	17900	21400	7560	3240
NEHC-0031	L3606-31	Black Seabass	Target	F	5.34	3.54	51.5	368	2430	7390	6070	1650	525
NEHC-0013	L3606-13	Black Seabass	Target	F	7.46	2.17	25.3	356	5190	20400	17600	3820	1090
NEHC-0022	L3606-22	Black Seabass	Target	M	3.85	2.72	34.8	511	8400	36000	32600	7850	2600
FS-13-VS-R	L2767-8	Vermilion Snap	Referer	F	7.20	0.794	17.1	87.2	357	1430	2000	614	221
FS-17-VS-R	L2767-12	Vermilion Snap	Referer	F	5.78	1.43	14.5	68.3	304	1650	1960	544	203
NEHC-0009	L3606-9 i	Vermilion Snap	Referer	F	5.92	1.14	15.2	91.5	349	1400	1730	632	216
FS-21-VS-R	L2767-14	Vermilion Snap	Referer	F	3.32	1.67	9.88	62.2	303	1670	2670	909	351
NEHC-0015	L3606-15	Vermilion Snap	Referer	F	6.49	1.44	17.7	89.2	374	1890	2740	1090	338
FS-05-VS-R	L2767-3	Vermilion Snap	Referer	F	4.92	0.821	13.5	74.6	392	1640	2370	732	297
FS-14-VS-R	L2767-9	Vermilion Snap	Referer	F	10.63	1.8	19.7	88.5	364	1750	2230	675	271

A4E.2 Result

ID_to_use	Lab ID	Species	Site	SEX	LIPIDW	Homo_CL1	Homo_CL2	Homo_CL3	Homo_CL4	Homo_CL5	Homo_CL6	Homo_CL7	Homo_CL8
NEHC-0035	L3606-35	Vermilion Snap	Referer	F	5.92	1.09	15.1	76	353	1820	2810	1060	360
FS-07-VS-R	L2767-4	Vermilion Snap	Referer	M	4.00	0.283	9.58	50.4	258	1320	2290	684	263
FS-18-VS-R	L2767-13	Vermilion Snap	Referer	F	5.04	0.983	10.5	54.2	253	1350	1760	539	207
NEHC-0040	L3606-40R	Vermilion Snap	Referer	M	1.99	0.802	5.19	43.3	290	1710	3070	1040	336
FS-22-VS-R	L2767-15	Vermilion Snap	Referer	F	1.12	0.42	2.36	23.6	421	2530	2410	654	221
FS-02-VS-R	L2767-2	Vermilion Snap	Referer	F	5.80	0.728	13.9	167	1260	4040	5740	2100	458
FS-15-VS-R	L2767-10	Vermilion Snap	Referer	M	4.83	0.935	12.1	63.9	422	2970	5070	1350	489
FS-11-VS-R	L2767-7	Vermilion Snap	Referer	M	3.40	0.849	8.43	53.7	348	2150	4120	1160	463
NEHC-0018	L3606-18	Vermilion Snap	Referer	F	5.59	0.952	20.6	104	504	2900	4530	1500	508
FS-10-VS-R	L2767-6	Vermilion Snap	Referer	F	5.50	0.195	15.4	74.3	389	1970	3320	929	347
FS-16-VS-R	L2767-11	Vermilion Snap	Referer	F	4.56	0.959	10.5	58.4	351	2280	3400	1040	375
NEHC-0030	L3606-30	Vermilion Snap	Referer	M	4.21	3.5	24.5	97	452	3240	5870	2130	665
FS-01-VS-R	L2767-1	Vermilion Snap	Referer	F	5.90	0.617	15.3	69.4	323	1490	2300	803	345
NEHC-0019	L3606-19	Vermilion Snap	Referer	F	4.09	0.822	12.4	60.6	280	1570	2700	1070	416
FS-09-VS-R	L2767-5	Vermilion Snap	Referer	F	3.48	0.392	10.2	51.6	231	1090	1500	472	194
FS-17-VS-T	L2767-28	Vermilion Snap	Target	F	5.60	1.67	24.4	190	1450	5550	4240	834	251
NEHC-0052	L3606-52R	Vermilion Snap	Target	M	5.88	1.71	16	146	1290	4280	4090	1010	281
FS-18-VS-T	L2767-29	Vermilion Snap	Target	F	5.80	1.28	16.2	128	986	4020	3220	678	211
FS-03-VS-T	L2767-18	Vermilion Snap	Target	F	6.37	1.77	19.8	139	946	3440	2640	601	193
FS-16-VS-T	L2767-27	Vermilion Snap	Target	F	6.10	1.88	19.3	140	1020	3930	3050	666	200
NEHC-0008	L3606-8	Vermilion Snap	Target	F	3.05	1.1	19.5	173	1270	5750	5380	1370	339
FS-07-VS-T	L2767-21	Vermilion Snap	Target	M	5.75	1.63	15.5	129	977	3870	3900	997	297
FS-11-VS-T	L2767-23	Vermilion Snap	Target	M	6.50	1.27	20.7	181	3600	21700	15700	1990	384
FS-01-VS-T	L2767-16	Vermilion Snap	Target	F	5.55	1.63	20.6	167	1290	4750	3710	805	258
FS-02-VS-T	L2767-17	Vermilion Snap	Target	M	6.44	1.53	15.1	132	986	3590	3020	860	277
NEHC-0037	L3606-37R	Vermilion Snap	Target	F	3.80	1.89	20.5	158	1210	4270	3620	869	251
FS-13-VS-T	L2767-25	Vermilion Snap	Target	F	5.80	1.72	18.9	155	1180	4380	3150	681	205
NEHC-0029	L3606-29	Vermilion Snap	Target	F	6.85	2.69	25.4	212	1550	5410	3870	993	291
FS-12-VS-T	L2767-24 i	Vermilion Snap	Target	F	1.70	0.567	5.39	36.7	239	1150	1070	268	103
FS-04-VS-T	L2767-19	Vermilion Snap	Target	F	4.30	1.46	17.6	153	1400	5700	4440	1010	325
FS-06-VS-T	L2767-20	Vermilion Snap	Target	M	4.86	1.33	11.5	91.9	792	3240	2980	695	210
FS-09-VS-T	L2767-22	Vermilion Snap	Target	M	4.92	1.3	11.7	131	2160	9360	7960	2090	785
NEHC-0038	L3606-38R	Vermilion Snap	Target	M	4.27	1.26	14.6	173	3030	16500	20000	7370	2170
FS-15-VS-T	L2767-26 (	Vermilion Snap	Target	F	7.00	1.65	24.6	218	2080	8700	6430	1420	480
FS-20-VS-T	L2767-30	Vermilion Snap	Target	F	4.70	1.14	15.3	117	852	3710	3330	865	286
FS-20-WG-R	L2767-45	White Grunt	Referer	Immature	1.40	0.22	1.9	11.7	49.9	324	480	132	52
FS-18-WG-R	L2767-43	White Grunt	Referer	Immature	0.64	0.263	0.831	5.95	27.4	163	253	62.4	28.2
NEHC-0051	L3606-51R	White Grunt	Referer	M	1.87	0.528	12.8	53.3	111	489	851	297	127
FS-17-WG-R	L2767-42	White Grunt	Referer	M	0.40	0.467	1.54	8.38	32.9	188	279	77.5	37.1
FS-16-WG-R	L2767-41	White Grunt	Referer	F	0.77	0.334	1.34	13.3	76	443	676	216	118
FS-08-WG-R	L2767-35	White Grunt	Referer	M	0.77	0.313	3.12	13.1	52.1	324	535	171	95.4
NEHC-0028	L3606-28	White Grunt	Referer	M	1.26	1.44	6.82	24.5	73.8	336	711	375	213
FS-09-WG-R	L2767-36	White Grunt	Referer	F	0.61	0.543	2.29	7.53	26	189	335	94.1	48.3

A4E.2 Result

ID_to_use	Lab ID	Species	Site	SEX	LIPIDW	Homo_CL1	Homo_CL2	Homo_CL3	Homo_CL4	Homo_CL5	Homo_CL6	Homo_CL7	Homo_CL8
FS-10-WG-R	L2767-37	White Grunt	Referer	M	0.74	0.609	2.91	12.7	46.6	303	515	160	78.2
NEHC-0039	L3606-39R	White Grunt	Referer	F	1.29	0.718	5.36	20.5	71.5	586	1120	345	130
FS-06-WG-R	L2767-34	White Grunt	Referer	M	0.46	0.223	1.52	9.43	32.3	211	363	111	53.4
NEHC-0025	L3606-25R	White Grunt	Referer	F	1.49	1.07	6.54	22.2	86.4	652	1160	402	162
FS-14-WG-R	L2767-40	White Grunt	Referer	F	0.37	0.268	0.92	5.09	30.8	231	381	110	49.6
NEHC-0001	L3606-1	White Grunt	Referer	M	1.73	0.78	6.38	73.7	2390	16700	13800	2240	371
FS-19-WG-R	L2767-44	White Grunt	Referer	M	0.62	0.156	1.88	13.7	59.9	476	879	305	165
FS-03-WG-R	L2767-33	White Grunt	Referer	F	1.63	0.545	4.19	21.2	103	815	1500	496	227
FS-12-WG-R	L2767-38	White Grunt	Referer	M	0.51	0.4	0.92	5.78	40.8	423	966	264	106
FS-02-WG-R	L2767-32	White Grunt	Referer	F	1.21	0.613	3.9	19.3	94	676	1370	416	212
FS-13-WG-R	L2767-39 (A	White Grunt	Referer	M	0.56	0.192	0.753	10.2	69.4	1020	1920	424	138
FS-01-WG-R	L2767-31	White Grunt	Referer	F	6.12	1.83	8.61	62.4	393	3540	6020	1640	742
NEHC-0045	L3606-45R	White Grunt	Target	F	1.56	0.522	7.57	139	2630	20100	19600	4700	1050
FS-14-WG-T	L2767-56	White Grunt	Target	Immature	2.00	0.353	8.59	89	1410	10000	22400	14600	5850
FS-09-WG-T	L2767-53	White Grunt	Target	Immature	2.70	1.49	101	1590	23000	95300	121000	56500	18300
FS-16-WG-T	L2767-58	White Grunt	Target	F	5.10	2.54	75.6	1450	28800	148000	177000	36800	9120
FS-05-WG-T	L2767-50	White Grunt	Target	F	3.70	0.566	10	77.6	1460	9630	8210	1430	416
NEHC-0014	L3606-14	White Grunt	Target	Immature	3.68	1.47	33.6	441	2740	9080	10100	9660	6200
FS-08-WG-T	L2767-52	White Grunt	Target	F	2.40	0.483	15.7	169	2270	16500	19100	4780	1540
FS-04-WG-T	L2767-49	White Grunt	Target	F	5.44	1.54	52.6	2410	14800	29900	22400	6510	3310
NEHC-0012	L3606-12	White Grunt	Target	M	2.68	1.08	14.8	140	3210	14600	14000	4920	1530
FS-03-WG-T	L2767-48	White Grunt	Target	F	6.13	1.96	38.8	523	4310	20000	38200	27700	10600
FS-11-WG-T	L2767-55	White Grunt	Target	M	4.41	1.4	36.9	637	4680	16300	12900	2510	912
FS-07-WG-T	L2767-51	White Grunt	Target	F	7.18	2.02	19.4	209	3290	15500	14900	3520	1190
NEHC-0020	L3606-20	White Grunt	Target	F	5.61	1.93	178	7980	66500	196000	163000	31500	6380
FS-01-WG-T	L2767-46	White Grunt	Target	F	4.76	1.4	39.2	590	6120	25700	25300	6660	4080
NEHC-0032	L3606-32	White Grunt	Target		3.01	1.5	27.5	316	7230	33600	34600	14900	5340
FS-10-WG-T	L2767-54	White Grunt	Target	M	4.40	3.77	308	3590	47200	200000	210000	82600	62200
FS-02-WG-T	L2767-47	White Grunt	Target	M	7.09	18	1050	14900	146000	496000	581000	156000	61300
FS-15-WG-T	L2767-57	White Grunt	Target	M	4.50	3.74	242	3060	37900	203000	251000	51000	14800
FS-18-WG-T	L2767-60	White Grunt	Target	F	7.31	3.1	138	7900	163000	538000	566000	81100	21600
FS-17-WG-T	L2767-59	White Grunt	Target	F	4.98	0.599	14.8	277	9390	61400	70100	16900	7000
NR = Not Reported													

A4E.2 Result

Raw results f															
	fillet	fillet	fillet	fillet	fillet	fillet	fillet	fillet	fillet	fillet	fillet	fillet	fillet	fillet	fillet
	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet
ID_to_use	**Homo_CL9**	**PCB008**	**PCB018**	**PCB028**	**PCB044**	**PCB049**	**PCB052**	**PCB066**	**PCB077**	**PCB087**	**PCB101**	**PCB105**	**PCB114**	**PCB118**	**PCB123**
NEHC-0005	285	0.852	0.718	8.99	26.2	12.3	40.9	40.5	4.04	57.5	184	127	7.28	408	4.42
NEHC-0024	363	0.875	0.898	8.42	26.6	13.5	35.6	51.4	1.44	64	186	126	6.43	370	2.64
NEHC-0048	203	0.856	1.02	3.43	8.95	4.82	11.3	15.7	1.12	19.5	72.2	56.2	3.07	192	1.56
NEHC-0007	134	0.621	0.427	4.16	11.8	5.41	19.9	17.3	0.866	30.5	97.4	66	3.69	188	1.95
NEHC-0023	154	0.983	0.789	5.7	16.9	7.57	29	27.2	0.886	38	119	84.9	5.15	264	2.48
NEHC-0002	230	0.659	0.571	1.83	4.6	1.65	7.66	9.78	0.432	9.49	45.7	45.7	1.88	138	0.635
NEHC-0034	157	0.866	0.565	3.03	4.99	1.83	10.3	14	0.638	13.4	75.1	69.6	4.39	217	1.83
NEHC-0004	150	0.619	0.481	2.34	7.25	2.63	9.17	14.6	0.366	15.5	76.8	74.3	3.91	233	1.47
NEHC-0042	135	1.06	0.788	3.7	7.65	3.13	13.6	16.1	1.18	20.2	74.9	77.2	3.09	234	3.39
NEHC-0016	136	0.451	0.453	4.08	12.3	5.85	18.8	22.9	0.989	31.3	112	83	4.15	240	2.26
NEHC-0017	331	0.627	0.589	2.46	7.61	2.68	10.8	11.5	0.474	17.1	83.3	92.1	5.07	319	1.46
NEHC-0011	194	0.495	0.462	5.39	15.9	5.08	22.1	36.5	0.924	36.1	119	113	5.55	340	3.91
NEHC-0033	153	0.931	0.791	3.69	10.7	6.31	15.1	23.4	0.58	34.4	102	76.9	4.25	223	2.46
NEHC-0044	418	1.23	1.02	11.6	25.7	15.3	45.9	43.9	1.94	55.9	185	116	7.5	346	6.64
NEHC-0003	171	0.566	0.453	2.93	9.79	3.82	15	17.6	0.583	20.9	97.3	57.1	3.03	172	1.71
NEHC-0046	116	1.06	1.03	1.8	4.02	1.9	6.7	6.07	0.481	9.58	48.6	51	3.77	158	1.2
NEHC-0026	258	0.879	0.976	2.47	5.51	3.01	9.58	10.5	0.312	12.8	64.7	68.1	3.83	216	1.24
NEHC-0049	353	1.29	1.4	5.57	13	5.56	20.2	18.9	0.855	24.6	93	89.6	4.63	263	1.66
NEHC-0041	223	1.64	1.26	8	21.3	14.9	50.3	35.8	1.87	79.3	224	156	10.8	446	6.63
NEHC-0010	957	2.63	1.99	21.2	52.1	29	92.2	75.6	4.04	153	488	417	22.1	1400	8.64
NEHC-0043	343	4.7	34.5	29.8	261	184	787	341	5.68	724	2140	1410	79.4	3710	53.6
NEHC-0027	622	5.55	17.8	65.2	331	236	841	439	13	1060	2670	1140	70.7	3660	38.2
NEHC-0036	162	4.94	14.5	41.3	237	186	695	251	7.68	728	1730	826	49.3	2460	34.3
NEHC-0053	101	2.73	20.1	14	97.6	74.4	281	102	1.69	251	610	339	21.7	950	10.7
NEHC-0021	221	2.29	6.66	13.2	278	233	999	368	4.75	1880	4270	2060	119	5530	69.5
NEHC-0006	300	1.83	3.67	22.3	122	74.7	301	144	4.1	301	813	407	19	1280	16.4
NEHC-0047	264	5.18	15.6	47.8	325	274	1170	422	7.96	1050	3260	1620	92.5	4490	57.4
NEHC-0050	1110	7.82	27.1	87.8	451	316	1230	541	16.3	1290	3070	1510	89.5	4430	70
NEHC-0031	169	6.62	66.7	28.9	270	203	818	215	4.17	588	1190	617	39.7	1790	20.2
NEHC-0013	301	5.41	35.9	67.7	452	488	2000	569	15.7	1330	4480	1360	62.2	5720	37.3
NEHC-0022	575	9.89	27.6	128	872	548	2840	814	21.9	2640	6780	2060	188	9390	98.6
FS-13-VS-R	100	5.01	9.33	22	45.8	30.4	66.4	39.9	6.65	135	245	115	5.65	305	6.16
FS-17-VS-R	62.9	4.63	8	16.4	35.2	24	53.8	34.1	6.37	134	270	168	9.95	417	6.02
NEHC-0009	64.8	4.31	8.44	27.3	39.1	30.5	69	41.5	6.46	121	254	108	5.46	265	5.69
FS-21-VS-R	118	2.98	6.57	16	36.6	27.2	55	35.1	5.94	139	280	142	8.21	407	6
NEHC-0015	105	4.9	9.72	24.5	39.4	33.6	75.3	44.2	7.36	148	349	147	8.01	401	7.55
FS-05-VS-R	98.8	3.54	7.69	19	49.7	34.7	74.1	47.1	6.62	149	296	130	7.19	345	7
FS-14-VS-R	95.6	5.69	9.7	21.9	46	29.6	67.8	39.1	8.65	166	307	148	8.01	378	6.99

A4E.2 Result

ID_to_use	Homo_CL9	PCB008	PCB018	PCB028	PCB044	PCB049	PCB052	PCB066	PCB077	PCB087	PCB101	PCB105	PCB114	PCB118	PCB123
NEHC-0035	115	4.18	7.59	21	37.2	29.8	67.1	45.8	6.83	142	328	148	9.4	409	7.51
FS-07-VS-R	96.1	2.97	4.7	15.6	37.5	22.7	50.1	28.9	5.36	116	222	116	5.7	322	6.16
FS-18-VS-R	62.8	3.34	5.65	14.2	29.2	21.1	48.2	30.3	5.31	120	238	119	6.39	320	4.95
NEHC-0040	112	1.52	2.28	16.6	28.1	25.7	64	43.1	4.48	126	319	149	7.2	403	8.29
FS-22-VS-R	87.9	0.835	1.3	7.77	32.6	28.6	90.5	53	4.33	209	465	246	13.1	649	9.43
FS-02-VS-R	193	4.69	12.5	48	161	122	204	176	15.6	365	785	240	11.3	758	13.7
FS-15-VS-R	182	2.96	4.76	18.9	48.6	35.1	73.1	62.3	9.61	217	510	271	13.8	826	14.4
FS-11-VS-R	188	2.24	3.73	16.9	45.4	33.2	64.4	45.6	6.81	161	356	187	9.73	561	8.3
NEHC-0018	157	6.01	11.5	27.3	49.4	46.1	93.9	66.4	8.54	211	527	232	13.3	682	10.6
FS-10-VS-R	133	4.38	7.06	20.7	45.7	32.8	69.2	51.8	6.6	169	330	170	9.45	466	8.08
FS-16-VS-R	132	3.63	6.26	15.1	37.7	30.6	63.5	46.9	6.65	170	373	182	12.1	661	8.56
NEHC-0030	220	4.34	4.74	32.1	49.1	40.4	81.2	76.4	6.68	207	560	266	17	862	13.2
FS-01-VS-R	111	4.55	7.85	19.3	42.8	28.9	57.1	40.2	6.03	140	256	115	5.52	318	6.46
NEHC-0019	181	3.66	6.58	18.4	30.8	24.9	50.8	38.6	4.72	113	272	130	7.27	368	5.95
FS-09-VS-R	68.6	3.23	5.54	12.7	27.9	19	44.6	26	4.21	92.8	187	94.5	4.93	257	4.68
FS-17-VS-T	61.9	5.15	38.3	26.2	157	126	409	128	6.57	564	985	404	21	1120	14.5
NEHC-0052	64.4	3.59	21.8	28.3	144	117	412	124	5.68	431	818	328	18.4	858	12.9
FS-18-VS-T	54	3.78	22.9	20.1	110	82	276	92.4	5.6	410	668	292	14.8	801	11
FS-03-VS-T	46.7	4.78	21.5	25	114	79.8	256	82.1	6.19	370	579	227	12.2	628	7.46
FS-16-VS-T	52	4.88	26	20	123	86.1	281	90.8	5.81	414	659	273	14.6	755	10.8
NEHC-0008	75.4	3.77	34	21.8	116	122	390	111	4.29	446	1010	493	31.4	1360	18.5
FS-07-VS-T	85.1	3.94	18.9	25.5	123	88.5	257	90.9	6.77	380	645	274	14.7	795	11.6
FS-11-VS-T	66.9	4.94	29.9	28.8	228	258	798	460	14.5	1860	4280	1980	110	5060	81.9
FS-01-VS-T	67.5	4.87	27.1	27.9	142	114	354	117	7.11	508	818	324	16.9	904	9.71
FS-02-VS-T	67.6	3.41	21.6	21.7	121	87	284	82	6.25	389	598	233	12.6	643	8.39
NEHC-0037	67.5	4.5	23	30.2	152	99	325	122	5.46	391	767	294	17	814	13.3
FS-13-VS-T	57.1	4.23	27.6	25	130	97.1	337	101	6.19	478	731	293	15.8	793	10.3
NEHC-0029	69.2	7.07	33.2	37.4	153	134	456	140	5.01	514	938	371	22.3	972	12.4
FS-12-VS-T	33.1	1.51	6.19	6.91	26.6	20	59.7	23.6	2.47	112	205	86.7	5	234	3.35
FS-04-VS-T	97.2	4.39	28.1	23.4	150	125	389	126	6.23	589	968	401	22.4	1140	12.9
FS-06-VS-T	57.2	2.82	13	18.6	99.8	67.1	208	73.2	5.52	321	566	245	12.9	660	9.3
FS-09-VS-T	198	2.75	14.4	30.5	208	191	647	206	9.37	969	1690	615	37.6	1810	22.9
NEHC-0038	419	4.08	20.2	42	255	280	942	335	13	1330	3060	1290	82.1	3890	56.1
FS-15-VS-T	146	5.82	40.9	33.1	205	178	598	190	9.6	943	1500	602	32.8	1660	20.4
FS-20-VS-T	81	4.17	21.8	18.5	95.8	72.3	229	77.6	5.47	390	632	261	13.1	735	9.53
FS-20-WG-R	36.7	1.04	0.932	4.32	9.12	3.36	7.37	9.44	0.674	13.3	32.7	38.5	2.36	112	1.16
FS-18-WG-R	19.1	0.595	0.697	2.39	4.67	1.96	4.4	4.96	0.499	6.85	15	19	1.09	61.4	0.567
NEHC-0051	49.9	3.63	3.49	18.9	12.4	7.24	16.3	23.8	1.74	21.9	59.7	63.3	2.95	184	2.2
FS-17-WG-R	19.2	0.71	0.924	2.68	4.99	2.57	5.46	5.89	0.323	8.88	21.5	20.7	1.28	60.8	0.775
FS-16-WG-R	67.8	0.702	0.948	5.25	8.67	5.26	11.2	13.6	0.946	25.7	49	47.7	2.45	142	1.96
FS-08-WG-R	46	1.41	1.28	4.11	7.71	4.18	8.22	9.17	0.538	19.9	42.9	40.1	2.54	116	1.1
NEHC-0028	132	2.27	2.03	6.8	9.62	5.8	11.1	14	0.46	19.1	51.4	35.6	1.93	102	0.642
FS-09-WG-R	23.2	0.962	0.947	2.22	4.27	1.58	3.19	4.92	0.195	9.92	20.7	23.8	1.31	71.5	0.553

A4E.2 Result

ID_to_use	Homo_CL9	PCB008	PCB018	PCB028	PCB044	PCB049	PCB052	PCB066	PCB077	PCB087	PCB101	PCB105	PCB114	PCB118	PCB123
FS-10-WG-R	40.4	1.22	1.31	3.58	7.23	2.99	4.86	8.91	0.444	15.2	39.5	38.3	2.03	113	1.17
NEHC-0039	63.5	1.48	1.5	6.91	8.5	4.98	10.9	15.4	0.821	24.7	53.7	77.6	4.38	235	2.53
FS-06-WG-R	43.1	0.95	0.994	3.08	5.11	2.3	3.05	6.31	0.123	8.18	23.8	29	2.15	85.2	0.976
NEHC-0025	63.2	2.19	1.83	6.79	10.6	6.63	14.8	18.3	0.675	31.2	74.2	79.1	5.04	235	2.43
FS-14-WG-R	24.2	0.515	0.395	1.78	3.93	1.75	2.88	5.76	0.331	11.9	27.2	30.6	1.92	92.7	0.73
NEHC-0001	103	2.8	2.95	23	144	155	446	378	7.87	1170	2850	1810	113	4970	56.4
FS-19-WG-R	114	1.08	1.46	4.22	9.22	4.3	7.18	14.1	0.743	17.2	51	48.8	2.65	162	1.39
FS-03-WG-R	92.1	1.96	1.41	6.36	15	7.16	13.4	19.1	0.704	39.7	96.5	98	6.38	310	1.53
FS-12-WG-R	37.8	0.55	0.488	1.79	7.16	2.73	5.86	5.57	0.277	19.2	53	53.9	3.2	176	0.568
FS-02-WG-R	134	1.49	1.21	6.32	19.2	5.11	9.16	16.2	1.07	26.6	48.2	95.2	6.28	305	2.76
FS-13-WG-R	58	0.808	0.695	3.48	9.57	1.98	3.04	18.9	0.767	16.4	46	146	8.99	526	2.91
FS-01-WG-R	330	3.8	1.91	24.6	46.1	18.8	36.2	83.5	4.35	126	298	486	28.9	1520	12.8
NEHC-0045	143	2.95	6.1	27.7	163	145	421	634	10.1	1100	2760	2540	160	6870	88.4
FS-14-WG-T	737	2.57	6.27	26.3	109	83.7	281	256	6.94	655	1490	1230	69.9	3350	32.2
FS-09-WG-T	1350	16.2	191	215	2120	2170	5330	3480	68.8	8010	17700	8480	534	27600	279
FS-16-WG-T	884	26	75.1	264	2380	2320	7790	3470	59.9	16000	23800	15300	902	35500	446
FS-05-WG-T	79.9	3.76	6.55	19.7	113	93.5	342	210	3.65	745	1480	1160	62.7	3070	23.1
NEHC-0014	1140	8.76	70.6	37.4	189	506	757	275	7.98	615	1740	796	50	2530	27.6
FS-08-WG-T	184	4.26	18.2	22.3	222	177	513	310	5.69	771	1700	1920	137	6800	26.9
FS-04-WG-T	753	17.1	49.2	146	1940	2790	4290	1130	19.2	2500	5260	2200	145	7370	69.8
NEHC-0012	285	5.02	13.4	35.4	224	358	702	473	7.26	1000	2420	1550	103	4300	45.1
FS-03-WG-T	1530	8.61	38.1	59	348	317	917	664	15	1460	3600	2150	121	6100	69.1
FS-11-WG-T	176	8.1	58.1	65.6	385	474	1310	597	14.4	1230	2950	1570	85.1	4670	52.9
FS-07-WG-T	230	6.76	13.1	52.3	338	270	693	501	8.58	1240	2350	1590	93.2	4690	50.9
NEHC-0020	911	35.2	105	604	4390	9060	22100	8190	72.1	9530	43600	15300	977	50100	565
FS-01-WG-T	1110	11.1	34.5	64.2	476	657	1380	772	20.5	2150	4470	2460	144	7620	78.4
NEHC-0032	806	13.5	13.7	82	622	642	1860	807	13.1	3250	5580	2820	184	7990	87
FS-10-WG-T	12600	144	461	500	3220	5030	10700	6270	149	18600	43600	19600	1050	48300	637
FS-02-WG-T	10800	280	1580	1460	11900	14400	35000	20400	389	40000	88600	46000	3050	144000	1400
FS-15-WG-T	2400	107	308	367	3020	4050	8490	5060	159	19500	38000	21900	1110	51900	648
FS-18-WG-T	3040	47.1	123	911	12000	17600	41000	22700	148	49200	92200	50200	3880	156000	1800
FS-17-WG-T	1680	5.73	8.59	84	372	382	923	1980	23.7	2260	5090	8770	602	27400	270
NR = Not Rep															

A4E.2 Result

Raw results f																
	fillet	fillet	fillet	fillet			fillet	fillet	fillet	fillet	fillet	fillet	fillet	fillet	fillet	fillet
	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet	pg/g wet
ID_to_use	**PCB126**	**PCB128**	**PCB138**	**PCB153**	**PCB156**	**PCB157**	**PCB167**	**PCB169**	**PCB170**	**PCB180**	**PCB183**	**PCB184**	**PCB187**	**PCB189**	**PCB195**	**PCB206**
NEHC-0005	2.84	107	872	1270	64.9	19.3	31.7	1.13	145	395	151	1.3	518	7.13	17.1	179
NEHC-0024	2.34	96	645	986	46.6	16	25.6	0.602	106	288	122	0.503	446	4.38	18.7	229
NEHC-0048	1.49	55.1	400	770	38.4	11.9	17.4	1.68	94.2	280	96.5	0.605	330	3.96	16.7	126
NEHC-0007	0.828	48.7	334	470	31.7	8.97	12.9	0.82	56.4	150	54.8	0.573	188	2.73	8.06	83.8
NEHC-0023	1.45	67.3	518	789	45.6	12	21.3	0.504	91.8	264	93.4	0.684	308	3.71	13	98.8
NEHC-0002	2.39	36.3	202	459	27.8	8.37	9.82	0.636	58.3	178	67.7	0.0886	250	3.11	11	152
NEHC-0034	1.07	64.5	336	624	42.9	10.9	16.7	0.451	80.9	220	77.9	0.0308	285	3.95	11	95.9
NEHC-0004	0.726	62.7	344	725	50.8	13	17.7	0.531	90.9	245	84.7	0.0919	297	3.97	10.7	95.1
NEHC-0042	3.27	63.6	429	710	45.8	13.4	17.2	1.15	81.6	230	79.4	0.375	208	3.98	10.2	90.9
NEHC-0016	1.27	60.7	440	639	45.9	12.9	18.8	0.794	82.1	218	74	0.456	246	4.68	9.93	85.8
NEHC-0017	1.33	93.5	498	1170	68.5	20.6	31.1	0.973	155	418	140	0.158	529	6.46	19.2	211
NEHC-0011	1.23	85	644	932	53.4	14.7	24.5	0.756	130	333	121	0.455	404	4.5	15.7	123
NEHC-0033	1.51	66.9	439	590	34.8	10.4	15.8	0.693	72.8	203	72.2	0.638	258	3.32	12.1	96
NEHC-0044	2.56	95.7	626	1030	62.4	18.7	29	1.17	129	399	141	0.791	447	6.57	19.7	274
NEHC-0003	0.994	46.9	291	536	29.6	8.6	13.7	0.392	67.7	186	67.7	0.128	240	3.09	10.1	103
NEHC-0046	2.59	55.9	255	578	37.1	9.73	11	0.904	75	209	71.7	0.276	235	3.02	9.28	71.9
NEHC-0026	1.51	74.3	377	759	49.3	13.3	17	0.847	94.1	276	96.9	0.117	321	4.8	14.9	165
NEHC-0049	1.54	75	508	1050	48.3	16.8	22.7	1.78	137	397	138	0.495	558	5.81	22.6	215
NEHC-0041	6.38	120	745	1060	76.5	21.4	32.1	1.64	137	371	133	1.01	398	6.18	16.5	145
NEHC-0010	4.21	325	2780	7830	372	92.1	131	0.507	1100	3610	1040	3.52	3250	42.2	138	637
NEHC-0043	29.1	829	4390	6580	510	139	212	4.13	646	1440	525	1.59	1390	21.8	49.8	209
NEHC-0027	14.7	818	5520	6880	466	127	225	2.3	652	1730	645	4.44	2110	25.6	89.4	390
NEHC-0036	5.64	419	2620	2970	293	77.4	115	1.43	302	654	225	1.67	639	13.1	24.9	104
NEHC-0053	6.54	177	1090	1350	115	30.3	43.9	1.63	127	311	110	0.815	331	5.28	12.1	62.8
NEHC-0021	2.55	1210	6420	6040	937	204	311	2.42	752	1420	426	1.01	715	31.3	57.7	151
NEHC-0006	2.2	242	1590	2240	150	46.3	74.3	0.881	233	588	211	1.34	640	10.4	29	183
NEHC-0047	5.49	769	4670	5630	528	140	201	3.2	458	961	308	2.83	719	14.6	31.2	160
NEHC-0050	4.5	816	6210	7490	524	138	232	11.2	725	1990	744	7.86	2250	30.9	89.7	700
NEHC-0031	10.4	289	1690	2000	200	45.6	72.5	1.52	204	451	155	1.24	456	7.8	19.4	108
NEHC-0013	3.69	794	4820	6510	415	96.1	221	1.24	387	1020	351	3.01	1020	15.2	46.2	191
NEHC-0022	31.2	1350	8420	10400	1050	253	446	4.99	763	2160	759	5.42	2230	34.8	124	369
FS-13-VS-R	2.66	86.8	552	621	NR	NR	21.5	0.454	49.3	145	62.9	2.13	143	3.67	5.46	63.4
FS-17-VS-R	2.4	91.6	562	603	NR	NR	24.4	0.483	50.3	147	54.2	1.73	128	3.32	5.14	39.8
NEHC-0009	2.42	68.1	464	502	45.6	14.2	20	0.526	62.2	146	53.9	2.15	177	3.2	5.19	38.9
FS-21-VS-R	2.68	110	736	919	NR	NR	32.6	0.914	88.3	263	94.9	2.85	214	5.55	11.1	78.9
NEHC-0015	3.08	109	751	905	75.4	21.2	32.8	0.751	116	301	102	3.48	296	5.5	9.91	69.3
FS-05-VS-R	2.36	87.6	620	773	57.8	16.8	24.4	0.519	57.2	195	77.7	2.51	181	4.17	6.96	62.6
FS-14-VS-R	3.18	98.8	600	682	NR	NR	26.8	0.71	60.4	177	63.7	2.22	165	3.99	6.59	62.7

A4E.2 Result

ID_to_use	PCB126	PCB128	PCB138	PCB153	PCB156	PCB157	PCB167	PCB169	PCB170	PCB180	PCB183	PCB184	PCB187	PCB189	PCB195	PCB206
NEHC-0035	3.78	118	763	951	74.3	22	34.2	0.77	115	297	103	3.24	298	5.72	10.7	75
FS-07-VS-R	2.42	98.1	623	849	NR	NR	31.6	0.814	77.8	237	89.8	2.37	108	4.72	9.05	69.4
FS-18-VS-R	2.3	75.4	485	569	NR	NR	21.7	0.407	46.7	145	56	1.95	135	3.32	5.61	40
NEHC-0040	5.13	119	818	1160	85.7	24.4	39.3	1.66	136	356	119	3.62	217	6.17	12	80.8
FS-22-VS-R	2.02	116	737	703	NR	NR	33.2	0.397	74.9	204	72	1.82	134	4.66	7.91	59.1
FS-02-VS-R	3.75	184	1450	2000	NR	NR	52.3	1.49	179	643	239	4.07	451	9.66	23.5	130
FS-15-VS-R	4.44	218	1450	1960	NR	NR	65.4	0.668	154	465	174	4.34	272	8.54	16.9	131
FS-11-VS-R	2.7	182	1150	1640	NR	NR	52	0.628	143	416	162	4.94	181	7.68	18.3	135
NEHC-0018	4.06	179	1240	1580	116	32.3	52.6	1.17	158	421	151	4.39	419	7.84	17.1	102
FS-10-VS-R	3.52	139	978	1130	NR	NR	34.5	0.735	84.8	252	100	3.46	233	5.82	9.91	86.9
FS-16-VS-R	3.5	135	921	1240	NR	NR	46.8	1.25	105	317	108	2.81	267	6.49	11.6	90
NEHC-0030	4.88	243	1590	2220	162	45.4	78.1	1.29	261	688	229	6.08	537	10.9	23.8	151
FS-01-VS-R	2.37	97	610	738	NR	NR	24.5	0.88	65.4	197	76.6	3.28	208	4.62	7.47	70.4
NEHC-0019	2.9	107	752	959	71.9	21.1	33	0.838	110	318	107	2.91	306	6	13	127
FS-09-VS-R	1.79	62	417	512	NR	NR	18.3	0.825	43.3	134	49.5	1.89	118	2.99	5.5	45.1
FS-17-VS-T	3.78	184	1220	1160	NR	NR	45.9	0.641	80	219	87	2.11	196	4.25	6.97	39.5
NEHC-0052	8.23	182	1140	1150	101	25.9	41.2	1.6	111	270	95.2	2.3	264	4.37	8.4	40.6
FS-18-VS-T	2.74	170	909	922	NR	NR	37.9	0.334	73.5	195	74.2	1.81	145	3.65	6.62	36.3
FS-03-VS-T	3	122	749	696	NR	NR	27.8	0.592	56.6	154	59.7	1.81	137	3.09	5.15	29.1
FS-16-VS-T	2.53	151	860	832	NR	NR	32.1	0.48	67.1	179	68.8	1.78	151	3.3	6.36	32.9
NEHC-0008	1.92	238	1580	1730	204	44.2	76.4	0.846	173	439	130	2.23	315	6.98	15.1	48.7
FS-07-VS-T	3.06	177	1110	1110	NR	NR	45.2	0.546	103	268	103	2.21	219	4.94	10.8	51.8
FS-11-VS-T	14.1	768	5030	3900	NR	NR	207	1.63	274	616	213	1.83	305	14.3	19.2	44.8
FS-01-VS-T	3.08	163	1050	1020	NR	NR	38.6	0.547	77.4	211	83.5	2	187	4.02	7.42	42.4
FS-02-VS-T	2.39	130	834	856	NR	NR	30.3	0.694	80.1	234	90.4	2.27	200	4.02	8.55	42.1
NEHC-0037	5.37	158	988	1050	94.2	23.7	36.1	1.47	90.5	231	81	2.15	230	3.91	7.66	42
FS-13-VS-T	2.22	144	907	847	NR	NR	32.1	0.554	65.9	179	71.8	1.92	158	3.46	5.88	36.2
NEHC-0029	5.59	180	1050	1040	111	26.7	41.5	1.05	106	246	86.5	2.63	261	4.4	9.1	42.7
FS-12-VS-T	0.861	50.5	298	305	NR	NR	12.6	0.249	26.9	71.6	27.9	0.9	62.3	1.69	2.91	21
FS-04-VS-T	3.76	201	1320	1230	NR	NR	47.5	0.568	103	280	109	2.48	230	4.89	9.82	64.1
FS-06-VS-T	2.34	139	844	852	NR	NR	33.6	0.425	67.9	187	74	1.94	163	3.78	6.03	36.4
FS-09-VS-T	6.05	356	2240	2340	NR	NR	82.3	0.71	196	577	219	3.99	493	9.23	26.2	131
NEHC-0038	24.3	824	5430	7150	557	129	229	4.3	751	2460	633	8.22	2030	25.9	91.1	283
FS-15-VS-T	4.65	303	1840	1810	NR	NR	67.9	0.704	145	391	150	3.46	335	7.17	14.2	95.3
FS-20-VS-T	2.49	150	941	960	NR	NR	35.8	0.641	85.1	236	96.1	2.07	200	4.46	8.97	53.7
FS-20-WG-R	0.514	24.8	149	211	NR	NR	7.86	0.125	18.3	49	14.5	0.242	33.9	1.07	2.11	24
FS-18-WG-R	0.271	13	75	118	NR	NR	3.77	0.139	9.9	23.3	7.51	0.101	15	0.604	1.1	12.5
NEHC-0051	2.8	40.9	260	373	26.6	8.86	13.3	0.443	38.4	94.4	29.2	0.479	93.4	1.92	4.35	29.2
FS-17-WG-R	0.325	14	80.3	123	NR	NR	4.04	0.222	10.7	29.6	8.98	0.182	15.5	0.659	1.7	11.4
FS-16-WG-R	0.636	31.3	198	289	NR	NR	9.83	0.211	23.9	74.3	24.5	0.516	55.9	1.75	3.74	42.5
FS-08-WG-R	0.353	25.7	150	232	NR	NR	8.52	0.164	21.1	62.3	20.5	0.597	43.1	1.58	3.69	27.9
NEHC-0028	0.734	28	196	317	17.25	5.455	9.07	0.192	44.5	120	36.4	0.836	122	2.3	7.36	82.4
FS-09-WG-R	0.258	17.1	102	147	NR	NR	4.06	0.092	14.7	35.5	11.9	0.227	22.9	0.831	2.22	14.9

A4E.2 Result

ID_to_use	PCB126	PCB128	PCB138	PCB153	PCB156	PCB157	PCB167	PCB169	PCB170	PCB180	PCB183	PCB184	PCB187	PCB189	PCB195	PCB206
FS-10-WG-R	0.371	27	156	221	NR	NR	6.86	0.126	20.8	56.5	18.3	0.361	40.3	1.31	3.16	25.5
NEHC-0039	3.07	52.3	331	512	28.1	10.5	13.9	0.291	55	120	36.3	0.728	89.8	2.72	4.6	42.1
FS-06-WG-R	0.296	18	107	159	NR	NR	5.67	0.075	15.3	42.8	12.4	0.356	26.5	1.21	2.74	28.3
NEHC-0025	1.85	55.3	362	503	36.5	11.6	17	0.551	54.8	138	39.9	0.721	115	2.46	5.67	37.1
FS-14-WG-R	0.447	20.2	116	167	NR	NR	5.82	0.0744	20	46.1	15.7	0.394	15.2	1.6	2.85	15.8
NEHC-0001	2.28	795	4710	4170	669	157	231	0.782	437	801	228	0.944	319	20.4	29.4	68.9
FS-19-WG-R	0.605	38.8	245	427	NR	NR	12.8	0.0951	38.2	118	41.1	0.704	62.2	2.5	6.56	77.9
FS-03-WG-R	0.855	72.2	452	663	NR	NR	19.5	0.43	62	180	55.2	1.07	119	4.05	7.56	57.3
FS-12-WG-R	0.445	50.6	300	462	NR	NR	6.32	0.0877	52.8	108	35.9	0.73	32.9	1.79	5.09	22.5
FS-02-WG-R	1.12	61.3	422	621	NR	NR	21.9	0.325	58.2	159	45.3	0.91	96.6	4.96	6.9	90.8
FS-13-WG-R	1.2	110	631	892	NR	NR	28.7	0.113	79.2	193	61.6	0.553	39.2	3.86	7.72	39.8
FS-01-WG-R	3.78	298	1870	2630	NR	NR	84.9	1.58	219	615	203	3.01	353	13.1	29.1	203
NEHC-0045	32.8	1240	6750	6670	797	195	280	4.47	710	1840	443	0.561	962	24.8	87.5	99.6
FS-14-WG-T	9.92	887	5920	9710	505	106	184	4.89	1000	5450	1590	1.11	3840	32.1	334	513
FS-09-WG-T	51.9	5160	33500	44400	4010	722	1380	12.1	5800	20400	6520	2.58	11200	219	1260	964
FS-16-WG-T	75.1	11700	60400	48000	6680	1310	1880	14.6	4370	10400	2870	5.14	9320	191	584	577
FS-05-WG-T	6.72	537	2870	2380	316	71.5	112	0.703	201	483	155	0.775	271	8.84	23.1	53.7
NEHC-0014	1.61	384	2530	3880	343	77	123	1.37	713	3590	1120	0.885	2570	23.1	417	833
FS-08-WG-T	4.66	963	5540	8570	588	140	214	1.48	645	2050	586	0.993	668	23.6	115	129
FS-04-WG-T	15.3	1030	5870	7560	730	166	284	2.1	509	2100	807	2.25	1690	26.6	175	474
NEHC-0012	1.71	627	4150	4710	587	130	200	1.2	596	1650	499	1.05	1140	23.1	108	199
FS-03-WG-T	12	1430	11000	15700	903	163	308	1.75	2370	10800	3190	1.85	5950	81.1	662	1080
FS-11-WG-T	6.85	677	4050	4610	480	103	187	5.06	313	907	290	1.33	450	19.1	53.1	120
FS-07-WG-T	5.88	775	4670	5120	539	115	211	1.59	415	1240	434	2.28	672	23.3	64.2	153
NEHC-0020	5	8110	53900	50600	6800	1600	2520	6.39	5210	10400	2710	6.15	6370	246	432	637
FS-01-WG-T	15.6	1410	7860	8940	856	207	362	2.5	709	2390	702	3.73	1540	35.6	176	785
NEHC-0032	7.62	1600	10100	10600	1220	277	425	2.07	1710	4770	1480	3.71	3310	58.9	337	570
FS-10-WG-T	104	10200	56800	75900	7720	1470	2670	18.8	6110	32300	13000	17.1	17000	313	2560	9330
FS-02-WG-T	65.4	26200	179000	212000	19100	3660	7750	36.1	15000	55800	19600	12.9	31500	826	3750	7840
FS-15-WG-T	99.2	14100	82100	76000	10700	1960	3660	28.3	6950	16600	6360	7.99	8950	388	881	1760
FS-18-WG-T	128	24400	169000	203000	22800	4390	7970	89	12600		11100	16.5	12100	768	1250	2120
FS-17-WG-T	49	3530	22000	29100	3390	695.5	1340	7.2	2340	8180	2120	4.36	2210	150	407	1260
NR = Not Rep																

A4E.2 Result

Raw results f							
	fillet	fillet	fillet	fillet	Wbody	Wbody	
	pg/g wet	pg/g wet	ng/g dry	ng/g	ng/g	g PCB wb /gPCB fillet	
ID_to_use	**PCB209**	**tPCBw**	**tPCBd**	**X_PCB**	**x_PCBWB**	**ConvFac**	
NEHC-0005	47.8	7040	32.6	32.62	39.16	1.2	
NEHC-0024	101	6220	29.2	29.21	40.28	1.38	
NEHC-0048	43.4	3940	19.7	19.7	37.93	1.93	
NEHC-0007	23.1	2930	14.3	14.31	25.85	1.81	
NEHC-0023	29.3	4350	20.2	19.14	24.35	1.27	
NEHC-0002	37.2	2660	13.5	13.48	22.22	1.65	
NEHC-0034	27.3	3380	15.3	15.27	25.08	1.64	
NEHC-0004	29.1	3570	16.6	16.6	25.83	1.56	
NEHC-0042	30.9	3390	16.0	15.98	21.87	1.37	
NEHC-0016	31.9	3630	13.5	17.93	36.72	2.05	
NEHC-0017	53.5	5700	21.1	26.73	64.5	2.41	
NEHC-0011	38	5320	29.6	29.56	38.74	1.31	
NEHC-0033	41.3	3690	17.1	17.16	24.88	1.45	
NEHC-0044	54.1	6590	31.4	31.38	36.99	1.18	
NEHC-0003	53.5	3100	14.6	14.62	23.4	1.6	
NEHC-0046	14.5	2790	14.0	13.95	19.89	1.43	
NEHC-0026	38.2	3940	18.9	18.9	26.06	1.38	
NEHC-0049	59	5830	27.8	27.76	39.06	1.41	
NEHC-0041	35.2	6480	29.3	29.32	37.1	1.27	
NEHC-0010	152	32500	142.7	142.65	169.37	1.19	
NEHC-0043	69.8	38200	141.5	141.48	160.44	1.13	
NEHC-0027	102	46700	157.1	157.12	170.04	1.08	
NEHC-0036	20.8	24100	86.1	86.07	98.09	1.14	
NEHC-0053	18.8	10000	40.0	40	47.45	1.19	
NEHC-0021	29.1	51500	211.9	211.88	288.41	1.36	
NEHC-0006	92.4	14900	69.0	69.01	88.77	1.29	
NEHC-0047	58.4	40600	150.4	150.37	166.75	1.11	
NEHC-0050	148	55800	192.4	192.41	207.95	1.08	
NEHC-0031	30.3	18700	68.3	68.34	77.68	1.14	
NEHC-0013	38.2	48800	180.8	180.85	197.33	1.09	
NEHC-0022	52.1	88600	347.0	346.98	391.74	1.13	
FS-13-VS-R	9.63	4840	16.7	16.69	18.02	1.08	
FS-17-VS-R	5.83	4810	18.2	18.2	19.53	1.07	
NEHC-0009	5.86	4510	16.3	16.32	17.17	1.05	
FS-21-VS-R	11.1	6110	24.8	24.77	27.4	1.11	
NEHC-0015	9.75	6660	22.3	22.27	23.83	1.07	
FS-05-VS-R	10.5	5630	20.9	20.85	21.99	1.05	
FS-14-VS-R	10.5	5510	18.4	18.35	19.17	1.04	

A4E.2 Result

ID_to_use	PCB209	tPCBw	tPCBd	X_PCB	x_PCBWB	ConvFac	
NEHC-0035	10.7	6620	23.2	23.15	24.59	1.06	
FS-07-VS-R	9.59	4980	19.9	19.92	21.3	1.07	
FS-18-VS-R	5.74	4240	16.1	16.09	17.28	1.07	
NEHC-0040	13	6620	26.4	26.42	29.19	1.11	
FS-22-VS-R	8.19	6360	28.3	28.32	31.53	1.11	
FS-02-VS-R	41.3	14000	53.8	53.85	57.32	1.06	
FS-15-VS-R	17.7	10600	40.8	40.78	43.96	1.08	
FS-11-VS-R	28.1	8520	34.1	34.08	36.61	1.07	
NEHC-0018	17.7	10200	35.3	35.33	38.13	1.08	
FS-10-VS-R	16.6	7190	26.6	26.63	28.86	1.08	
FS-16-VS-R	13.4	7660	30.0	29.99	32.2	1.07	
NEHC-0030	27.5	12700	46.5	46.48	49.25	1.06	
FS-01-VS-R	9.54	5470	19.5	19.36	20.53	1.06	
NEHC-0019	21.6	6310	22.9	22.93	25.34	1.1	
FS-09-VS-R	7.05	3620	14.2	14.23	15.54	1.09	
FS-17-VS-T	5.04	12600	45.0	45	49.25	1.09	
NEHC-0052	5.54	11200	40.0	40	42.38	1.06	
FS-18-VS-T	4.42	9320	33.3	33.29	34.93	1.05	
FS-03-VS-T	4.03	8030	26.8	26.77	28.68	1.07	
FS-16-VS-T	5.52	9080	32.4	32.43	34.47	1.06	
NEHC-0008	5.76	14400	56.0	55.96	62.41	1.12	
FS-07-VS-T	14.9	10300	24.0	23.95	25.76	1.08	
FS-11-VS-T	4.53	43600	150.3	150.34	160.34	1.07	
FS-01-VS-T	5.67	11100	39.6	39.64	43.58	1.1	
FS-02-VS-T	6.18	8960	30.9	30.9	32.57	1.05	
NEHC-0037	6.04	10500	36.2	36.21	40.12	1.11	
FS-13-VS-T	5.17	9830	33.9	33.9	37.1	1.09	
NEHC-0029	5.75	12400	40.2	40.21	43.11	1.07	
FS-12-VS-T	3.35	2910	7.7	7.66	11.23	1.47	
FS-04-VS-T	7.99	13200	48.9	48.89	54.88	1.12	
FS-06-VS-T	4.92	8080	28.9	28.86	30.62	1.06	
FS-09-VS-T	14.4	22700	81.1	81.07	86.49	1.07	
NEHC-0038	34.2	49700	171.4	171.38	182.21	1.06	
FS-15-VS-T	12.5	19500	65.0	65.33	69.53	1.06	
FS-20-VS-T	6.09	9260	34.3	34.3	36.96	1.08	
FS-20-WG-R	9.47	1100	5.0	5	5.83	1.17	
FS-18-WG-R	5.16	565	2.6	2.57	3.24	1.26	
NEHC-0051	12.7	2000	8.3	8.33	9.69	1.16	
FS-17-WG-R	6	650	2.8	2.83	3.94	1.4	
FS-16-WG-R	12.8	1620	7.7	7.71	9.6	1.24	
FS-08-WG-R	8.56	1250	5.7	5.73	7.25	1.26	
NEHC-0028	31.8	1910	8.2	7.96	9.7	1.22	
FS-09-WG-R	5.56	732	3.4	3.36	4.54	1.35	

A4E.2 Result

ID_to_use	PCB209	tPCBw	tPCBd	X_PCB	x_PCBWB	ConvFac	
FS-10-WG-R	9.45	1170	5.5	5.49	6.79	1.24	
NEHC-0039	14.1	2360	10.3	10.26	12.41	1.21	
FS-06-WG-R	9.51	834	3.9	3.9	5.5	1.41	
NEHC-0025	14.1	2570	11.0	11.03	13.09	1.19	
FS-14-WG-R	5.45	838	4.5	4.53	6.76	1.49	
NEHC-0001	16.3	35700	143.2	143.21	166.29	1.16	
FS-19-WG-R	23.1	2040	9.7	9.71	12.36	1.27	
FS-03-WG-R	16.1	3280	14.4	14.39	17.79	1.24	
FS-12-WG-R	9.1	1850	8.8	8.81	11.41	1.29	
FS-02-WG-R	22.6	2950	13.1	13.11	15.24	1.16	
FS-13-WG-R	11	3650	16.2	16.47	21.08	1.28	
FS-01-WG-R	56.7	12800	47.6	49.37	55.87	1.13	
NEHC-0045	11.6	48400	193.7	193.66	241.48	1.25	
FS-14-WG-T	36	55100	234.5	234.47	273.17	1.17	
FS-09-WG-T	37.5	317000	1372.3	1372.29	1510.88	1.1	
FS-16-WG-T	63.2	402000	1440.9	1440.86	1612.23	1.12	
FS-05-WG-T	6.62	21300	85.9	85.89	98.98	1.15	
NEHC-0014	24.1	39400	152.3	152.33	173.64	1.14	
FS-08-WG-T	12.3	44600	180.6	180.57	206.17	1.14	
FS-04-WG-T	48.1	80200	287.5	281.2	327.09	1.16	
NEHC-0012	17.3	38700	152.8	152.79	182.56	1.19	
FS-03-WG-T	45	103000	350.3	350.34	396.15	1.13	
FS-11-WG-T	15.9	38200	151.0	150.99	170.26	1.13	
FS-07-WG-T	21.3	38900	137.0	136.97	149.63	1.09	
NEHC-0020	54.9	473000	1683.2	1683.17	1896.67	1.13	
FS-01-WG-T	57.8	69700	269.1	269.11	300.88	1.12	
NEHC-0032	44.5	96900	408.6	408.6	458.02	1.12	
FS-10-WG-T	343	619000	2446.6	2446.64	2855.8	1.17	
FS-02-WG-T	424	1470000	5122.0	5121.95	5639.22	1.1	
FS-15-WG-T	86.6	563000	2261.0	2261.04	2536.2	1.12	
FS-18-WG-T	146	1380000	4808.4	4808.36	5348.79	1.11	
FS-17-WG-T	114	167000	657.5	645.79	735.57	1.14	
NR = Not Rep							

The sample specific detection limits (pg/g wet weight) for each sample and analyte.

ID_to_use	Lab ID	Homo_CL1	Homo_CL2	Homo_CL3	Homo_CL4	Homo_CL5	Homo_CL6	Homo_CL7	Homo_CL8	Homo_CL9	PCB008	PCB018	PCB028	PCB044	PCB049
NEHC-000	L3606-5	0.142	0.317	0.120	0.532	1.720	1.550	0.121	0.167	0.201	0.225	0.087	0.099	0.064	0.060
NEHC-002	L3606-24	0.090	0.305	0.134	0.861	2.340	0.797	0.099	0.169	0.129	0.381	0.084	0.122	0.094	0.088
NEHC-004	L3606-48R	0.120	0.362	0.593	1.120	1.490	2.230	1.010	0.970	0.814	0.536	0.439	0.398	0.506	0.473
NEHC-000	L3606-7	0.112	0.327	0.110	0.300	0.828	1.140	0.107	0.118	0.130	0.205	0.080	0.055	0.080	0.075
NEHC-002	L3606-23	0.112	0.267	0.181	0.853	1.450	0.680	0.128	0.092	0.102	0.420	0.123	0.137	0.162	0.152
NEHC-002	L3606-23R	0.067	0.140	0.072	0.440	3.120	1.700	0.152	0.176	0.082	0.130	0.052	0.053	0.031	0.029
NEHC-000	L3606-2 i	0.111	0.225	0.202	0.432	0.910	0.780	0.157	0.204	0.256	0.235	0.143	0.135	0.136	0.128
NEHC-003	L3606-34			0.136	0.246	0.778	0.623	0.055	0.053	0.066	0.221	0.097	0.057	0.039	0.036
NEHC-000	L3606-4	0.091	0.154	0.128	0.152	0.500	0.741	0.151	0.169	0.186	0.253	0.093	0.087	0.113	0.106
NEHC-004	L3606-42R			0.827	1.180	3.270	1.650	0.588	0.562	0.434	0.409	0.609	0.199	0.312	0.289
NEHC-001	L3606-16	0.133	0.185								0.115	0.062	0.055	0.069	0.064
NEHC-001	L3606-16	0.126	0.551	0.082	0.320	1.090	1.050	0.113	0.107	0.129					
NEHC-001	L3606-17	0.073	0.202								0.135	0.081	0.073	0.059	0.056
NEHC-001	L3606-17	0.165	0.552	0.108	0.318	1.330	1.330	0.161	0.218	0.222					
NEHC-001	L3606-11 i	0.227	0.759	0.125	0.572	1.230	1.060	0.133	0.108	0.098	0.158	0.089	0.064	0.065	0.061
NEHC-003	L3606-33 i	0.130	0.278	0.125	0.332	1.510	0.904	0.095	0.116	0.067	0.189	0.094	0.070	0.035	0.033
NEHC-003	L3606-33R	0.114	0.325	0.099	1.480	2.820	1.170	0.212	0.252	0.226	0.205	0.072	0.070	0.050	0.046
NEHC-004	L3606-44R	0.151	0.311	0.486	1.150	2.560	1.600	0.371	0.411	0.324	0.247	0.358	0.241	0.360	0.333
NEHC-000	L3606-3	0.090	0.269	0.112	0.361	0.994	0.548	0.110	0.098	0.145	0.213	0.082	0.068	0.067	0.063
NEHC-004	L3606-46R	0.180	0.628	0.493	0.498	1.330	1.260	0.434	0.309	0.340	0.749	0.363	0.307	0.380	0.352
NEHC-002	L3606-26	0.209	0.349	0.195	0.294	1.510	1.150	0.121	0.133	0.130	0.490	0.133	0.160	0.116	0.108
NEHC-004	L3606-49R	0.231	1.060	0.416	0.855	1.600	2.190	0.328	0.384	0.261	0.266	0.260	0.338	0.319	0.291
NEHC-004	L3606-41R	0.290	0.822	0.139	0.810	6.380	2.160	0.430	0.381	0.217	0.162	0.097	0.100	0.064	0.059
NEHC-001	L3606-10 i	0.205	0.405	0.089	0.914	0.705	0.533	0.437	0.578	0.172	0.105	0.063	0.047	0.058	0.054
NEHC-004	L3606-43R	0.086	0.337	0.577	2.610	29.100	5.990	1.220	0.901	0.644	0.242	0.157	0.447	0.497	0.460
NEHC-002	L3606-27	0.117	0.192	0.138	3.600	14.700	3.050	0.323	0.322	0.239	0.361	0.090	0.125	0.080	0.075
NEHC-003	L3606-36R	0.225	0.442	0.193	2.020	1.690	2.120	0.367	0.459	0.341	0.180	0.111	0.162	0.078	0.074
NEHC-005	L3606-53R	0.207	0.798	0.144	1.200	6.540	2.140	0.162	0.102	0.055	0.094	0.041	0.110	0.033	0.031
NEHC-002	L3606-21			0.315	2.150	2.550	3.220	0.382	0.217	0.135	0.300	0.228	0.239	0.238	0.223
NEHC-000	L3606-6	0.137	0.488	0.161	2.500	1.700	1.210	0.183	0.211	0.150	0.238	0.117	0.087	0.098	0.091
NEHC-004	L3606-47R	0.134	0.326	0.272	1.260	5.490	4.060	0.327	0.266	0.260	0.205	0.136	0.233	0.118	0.107
NEHC-005	L3606-50R	0.105	0.257	0.273	4.330	4.500	14.100	0.576	0.816	0.735	0.453	0.218	0.187	0.130	0.118
NEHC-003	L3606-31	0.211	0.375	0.281	3.900	10.400	2.030	0.222	0.235	0.106	0.226	0.151	0.233	0.078	0.072
NEHC-001	L3606-13	0.090	0.313	0.152	8.010	1.340	1.310	0.274	0.215	0.156	0.142	0.108	0.092	0.073	0.068
NEHC-002	L3606-22	0.106	0.689	0.340	3.840	31.200	6.860	0.360	0.366	0.130	0.545	0.108	0.310	0.134	0.126
NEHC-002	L3606-22 \	0.052	0.145												
FS-17-VS-	L2767-12	0.203	0.690	0.165	0.486	1.370	0.556	0.078	0.039	0.093	0.309	0.129	0.089	0.041	0.034
FS-13-VS-	L2767-8	0.291	0.738	0.165	1.460	1.750	0.759	0.217	0.104	0.132	0.452	0.104	0.108	0.073	0.057
NEHC-000	L3606-9 i	0.195	0.399	0.110	1.250	1.090	0.708	0.120	0.093	0.102	0.141	0.078	0.094	0.050	0.047
FS-21-VS-	L2767-14			0.182	0.820	1.510	0.914	0.120	0.087	0.107	0.306	0.142	0.084	0.029	0.023
NEHC-001	L3606-15	0.283	0.750	0.096	0.891	1.730	1.070	0.180	0.115	0.173	0.094	0.068	0.066	0.082	0.077
FS-05-VS-	L2767-3	0.392	0.686	0.160	0.491	2.180	0.691	0.148	0.142	0.141					

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ID_to_use	Lab ID	Homo_CL1	Homo_CL2	Homo_CL3	Homo_CL4	Homo_CL5	Homo_CL6	Homo_CL7	Homo_CL8	Homo_CL9	PCB008	PCB018	PCB028	PCB044	PCB049
FS-05-VS-	L2767-3R	0.137	0.494								0.248	0.123	0.102	0.103	0.083
NEHC-003	L3606-35	0.135	0.462	0.123	1.740	2.460	1.030	0.159	0.104	0.097	0.155	0.087	0.086	0.047	0.044
FS-14-VS-	L2767-9	0.165	0.698	0.192	0.708	1.560	0.710	0.133	0.033	0.172	0.497	0.141	0.125	0.039	0.032
FS-07-VS-	L2767-4	0.283	0.842	0.294	0.986	2.510	1.370	0.267	0.260	0.210	0.497	0.234	0.178	0.206	0.161
FS-18-VS-	L2767-13	0.209	0.631	0.155	0.618	1.180	0.597	0.124	0.037	0.164	0.324	0.121	0.085	0.040	0.032
NEHC-004	L3606-40R	0.178	0.495	0.190	2.310	5.130	2.500	1.930	1.900	0.581	0.146	0.140	0.128	0.139	0.129
FS-22-VS-	L2767-15	0.258	0.515	0.172	0.711	2.170	0.397	0.099	0.029	0.096	0.329	0.134	0.086	0.036	0.029
FS-15-VS-	L2767-10	0.244	0.539	0.177	0.922	1.960	0.771	0.173	0.111	0.096	0.366	0.138	0.092	0.033	0.027
FS-02-VS-	L2767-2	0.239	0.514	0.315	2.340	3.520	2.410	0.508	0.361	0.251	0.497	0.250	0.156	0.270	0.211
FS-11-VS-	L2767-7	0.231	0.534	0.116	0.919	2.570	1.080	0.233	0.222	0.096	0.323	0.078	0.077	0.079	0.062
NEHC-001	L3606-18	0.109	0.191	0.127	2.380	4.060	1.530	0.230	0.137	0.145	0.128	0.092	0.096	0.034	0.032
FS-16-VS-	L2767-11	0.084	0.126	0.130	0.957	1.890	1.250	0.098	0.050	0.094	0.297	0.102	0.067	0.027	0.022
FS-10-VS-	L2767-6	0.083	0.182	0.152	1.590	1.710	0.997	0.268	0.179	0.117	0.337	0.112	0.100	0.087	0.068
NEHC-003	L3606-30	0.153	0.166	0.145	1.810	4.880	1.770	0.238	0.233	0.164	0.194	0.103	0.107	0.086	0.079
FS-01-VS-	L2767-1	0.109	0.285	0.237	1.010	2.680	1.510	0.351	0.281	0.246	0.473	0.187	0.156	0.206	0.161
NEHC-001	L3606-19	0.100	0.230	0.109	0.968	2.140	1.160	0.144	0.079	0.099	0.112	0.079	0.090	0.034	0.032
FS-09-VS-	L2767-5	0.128	0.212	0.248	0.552	1.170	1.180	0.064	0.049	0.178	0.461	0.166	0.151	0.030	0.025
NEHC-005	L3606-52R	0.130	0.302	0.163	5.680	8.230	2.270	0.211	0.080	0.067	0.075	0.057	0.128	0.032	0.029
FS-17-VS-	L2767-28	0.095	0.262	0.139	1.940	3.780	0.912	0.107	0.048	0.082	0.143	0.080	0.088	0.028	0.023
FS-18-VS-	L2767-29	0.096	0.263	0.104	0.972	2.950	0.497	0.126	0.055	0.095	0.117	0.064	0.072	0.027	0.022
FS-03-VS-	L2767-18	0.169	0.364	0.152	0.424	3.070	0.861	0.120	0.041	0.078	0.159	0.080	0.100	0.039	0.032
FS-16-VS-	L2767-27	0.183	0.300	0.142	0.817	2.840	0.742	0.088	0.036	0.130	0.154	0.065	0.091	0.034	0.027
NEHC-000	L3606-8	0.129	0.243	0.161	1.930	1.400	1.180	0.179	0.088	0.100	0.135	0.058	0.141	0.050	0.047
FS-07-VS-	L2767-21	0.108	0.264	0.175	0.973	3.120	0.816	0.132	0.072	0.108	0.154	0.115	0.108	0.042	0.034
FS-11-VS-	L2767-23	0.210	0.393	0.204	1.520	14.100	2.190	0.190	0.098	0.101	0.239	0.092	0.133	0.029	0.023
FS-01-VS-	L2767-16	0.115	0.178	0.160	1.170	3.100	0.808	0.107	0.073	0.068	0.194	0.088	0.105	0.037	0.030
FS-02-VS-	L2767-17	0.140	0.261	0.123	0.772	2.480	0.892	0.111	0.073	0.082	0.159	0.086	0.080	0.017	0.014
NEHC-003	L3606-37R	0.112	0.232	0.236	1.740	5.370	2.120	0.300	0.351	0.204	0.163	0.156	0.213	0.180	0.166
NEHC-002	L3606-29	0.155	0.256	0.210	3.790	5.590	1.520	0.165	0.146	0.111	0.217	0.105	0.190	0.105	0.097
FS-13-VS-	L2767-25	0.187	0.223	0.125	0.453	2.430	0.830	0.087	0.075	0.070	0.149	0.097	0.078	0.025	0.021
FS-12-VS-	L2767-24 i	0.165	0.199	0.082	0.330	0.922	0.359	0.056	0.027	0.074	0.106	0.056	0.054	0.038	0.030
FS-04-VS-	L2767-19	0.110	0.253	0.175	1.550	3.950	0.664	0.130	0.077	0.094	0.235	0.108	0.112	0.049	0.040
FS-06-VS-	L2767-20	0.073	0.182	0.158	1.180	2.340	0.618	0.100	0.056	0.139	0.186	0.096	0.098	0.053	0.043
FS-09-VS-	L2767-22	0.136	0.335	0.111	0.884	6.170	1.110	0.187	0.164	0.080	0.157	0.087	0.073	0.022	0.018
NEHC-003	L3606-38R	0.168	0.246	0.404	6.530	24.300	6.320	1.430	0.659	0.297	0.277	0.298	0.202	0.122	0.113
FS-15-VS-	L2767-26 (	0.254	0.386	0.174	0.672	5.000	1.050	0.108	0.107	0.086	0.141	0.069	0.114	0.022	0.018
FS-20-VS-	L2767-30	0.057	0.115	0.138	1.010	2.590	0.962	0.088	0.063	0.093	0.151	0.066	0.090	0.049	0.040
FS-20-WG	L2767-45	0.137	0.361	0.220	0.167	0.419	0.064	0.073	0.056	0.055	0.368	0.166	0.119	0.068	0.055
FS-18-WG	L2767-43	0.123	0.266	0.294	0.125	0.331	0.282	0.120	0.076	0.072	0.440	0.222	0.176	0.099	0.081
NEHC-005	L3606-51R	0.089	0.304	0.193	0.589	2.800	0.566	0.300	0.152	0.179	0.166	0.111	0.129	0.084	0.077
FS-17-WG	L2767-42	0.145	0.242	0.361	0.181	0.252	0.435	0.133	0.125	0.131	0.378	0.273	0.152	0.080	0.065
FS-16-WG	L2767-41	0.186	0.359	0.397	0.199	0.416	0.420	0.106	0.096	0.099	0.702	0.300	0.213	0.095	0.078
FS-08-WG	L2767-35	0.048	0.441	0.051	0.258	0.377	0.231	0.036	0.032	0.160	0.219	0.038	0.010	0.030	0.024

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ID_to_use	Lab ID	Homo_CL1	Homo_CL2	Homo_CL3	Homo_CL4	Homo_CL5	Homo_CL6	Homo_CL7	Homo_CL8	Homo_CL9	PCB008	PCB018	PCB028	PCB044	PCB049
NEHC-002	L3606-28	0.038	0.328	0.189	0.363	0.734	0.271	0.088	0.085	0.123	0.352	0.128	0.116	0.092	0.086
NEHC-002	L3606-28R	0.036	0.307	0.108	0.565	0.730	0.571	0.101	0.130	0.061	0.138	0.078	0.062	0.034	0.032
FS-09-WG	L2767-36	0.192	0.753	0.064	0.195	0.298	0.113	0.038	0.019	0.050	0.277	0.032	0.042	0.024	0.019
FS-10-WG	L2767-37	0.083	0.422	0.069	0.204	0.363	0.193	0.027	0.021	0.043	0.224	0.027	0.045	0.018	0.015
NEHC-003	L3606-39R	0.334	1.160	0.223	0.821	3.070	0.372	0.234	0.195	0.245	0.145	0.178	0.159	0.201	0.183
FS-06-WG	L2767-34	0.242	0.561	0.050	0.123	0.170	0.111	0.036	0.038	0.169	0.140	0.037	0.019	0.032	0.026
NEHC-002	L3606-25R	0.263	0.729	0.083	0.675	1.850	0.751	0.090	0.096	0.045	0.106	0.060	0.051	0.028	0.026
FS-14-WG	L2767-40	0.156	0.604	0.056	0.113	0.359	0.115	0.029	0.028	0.056	0.282	0.043	0.022	0.029	0.023
NEHC-000	L3606-1	0.220	0.545	0.131	0.887	0.800	1.100	0.167	0.120	0.138	0.299	0.095	0.101	0.091	0.085
FS-19-WG	L2767-44	0.079	0.427	0.175	0.314	0.578	0.186	0.062	0.052	0.055	0.376	0.132	0.110	0.056	0.046
FS-03-WG	L2767-33	0.060	0.164	0.049	0.241	0.892	0.167	0.043	0.050	0.064	0.208	0.037	0.016	0.032	0.026
FS-12-WG	L2767-38	0.192	0.459	0.023	0.242	0.499	0.132	0.045	0.019	0.037	0.211	0.017	0.015	0.020	0.016
FS-02-WG	L2767-32	0.102	0.205	0.037	0.306	0.997	0.194	0.045	0.038	0.145	0.166	0.027	0.014	0.029	0.023
FS-13-WG	L2767-39 (	0.142	0.224	0.076	0.167	1.430	0.175	0.049	0.031	0.044	0.466	0.058	0.026	0.017	0.014
FS-01-WG	L2767-31	0.106	0.305	0.066	1.240	2.900	0.374	0.252	0.155	0.249	0.212	0.049	0.023	0.042	0.034
NEHC-004	L3606-45R	0.198	0.696	0.338	10.100	32.800	6.450	0.552	0.470	0.359	0.242	0.249	0.189	0.298	0.276
FS-14-WG	L2767-56			0.345	1.320	9.920	6.300	0.704	0.706	0.271	0.263	0.174	0.223	0.187	0.150
FS-09-WG	L2767-53	0.308	1.200	1.030	4.710	51.900	16.300	1.410	1.180	0.246	0.306	0.163	0.681	0.115	0.092
FS-09-WG	L2767-53 Wi														
FS-16-WG	L2767-58	0.408	0.843	1.860	9.270	75.100	19.500	1.080	1.130	0.262	0.369	0.335	1.180	0.258	0.207
FS-16-WG	L2767-58 W														
FS-05-WG	L2767-50	0.221	0.450	0.223	0.821	7.250	1.070	0.186	0.172	0.113	0.226	0.122	0.150	0.147	0.118
NEHC-001	L3606-14			0.257	0.810	1.050	1.950	0.425	0.741	0.200	0.131	0.107	0.215	0.069	0.065
FS-08-WG	L2767-52	0.162	0.347	0.400	0.874	4.810	2.160	0.398	0.380	0.173	0.321	0.156	0.267	0.155	0.124
NEHC-001	L3606-12	0.432	0.461	0.105	1.090	1.480	1.310	0.245	0.368	0.094	0.115	0.075	0.083	0.053	0.050
FS-04-WG	L2767-49			1.600	2.060	16.000	3.090	0.443	0.691	0.214	0.256	0.167	1.150	0.198	0.159
FS-04-WG	L2767-49 \	0.200	0.484												
FS-03-WG	L2767-48	0.201	0.452	0.535	3.020	12.000	2.510	0.980	1.020	0.598					
FS-03-WG	L2767-48 i2										0.498	0.412	0.261	0.282	0.225
FS-11-WG	L2767-55	0.286	0.591	0.351	3.290	7.150	7.020	0.480	0.451	0.399					
FS-11-WG	L2767-55 i2										0.255	0.264	0.221	0.334	0.267
FS-07-WG	L2767-51	0.307	0.449	0.446	1.240	5.880	2.410	0.458	0.627	0.507					
FS-07-WG	L2767-51 i										0.284	0.344	0.168	0.263	0.210
NEHC-002	L3606-20	0.154	0.390	0.502	7.000	5.000	7.820	1.040	0.637	0.180	0.364	0.088	0.445	0.068	0.064
NEHC-002	L3606-20 N	0.214	0.664												
NEHC-002	L3606-20 W														
NEHC-003	L3606-32	0.428	0.555	0.257	3.960	1.500	2.800	0.491	0.773	0.177	0.146	0.084	0.226	0.053	0.049
NEHC-003	L3606-32 W														
FS-01-WG	L2767-46	0.196	0.442	0.434	1.280	16.600	3.790	0.430	0.833	0.216	0.417	0.125	0.313	0.116	0.093
FS-01-WG	L2767-46 Wi														
FS-10-WG	L2767-54	0.261	0.590	2.680	8.680	104.000	23.100	2.360	5.930	0.980	0.396	0.218	1.790	0.265	0.213
FS-10-WG	L2767-54 W														
FS-02-WG	L2767-47			4.140	16.000	134.000	43.300	2.810	10.400	0.631	0.754	0.185	2.820	0.427	

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ID_to_use	Lab ID	Homo_CL1	Homo_CL2	Homo_CL3	Homo_CL4	Homo_CL5	Homo_CL6	Homo_CL7	Homo_CL8	Homo_CL9	PCB008	PCB018	PCB028	PCB044	PCB049
FS-02-WG	L2767-47 N	0.087	0.155												5.100
FS-15-WG	L2767-57	0.122	0.177	1.750	7.230	99.200	35.500	1.310	1.960	0.281	0.440	0.163	1.180	0.296	0.238
FS-15-WG	L2767-57 \	0.155	0.533												
FS-18-WG	L2767-60			3.560	7.570	128.000	91.500	1.730	2.520	0.420	0.367	0.203	2.430	0.333	
FS-18-WG	L2767-60 N2														
FS-18-WG	L2767-60 N	0.094	0.214												5.380
FS-17-WG	L2767-59			0.385	4.840	49.000	9.130	1.100	1.480	0.243	0.289	0.137	0.244	0.108	0.086
FS-17-WG	L2767-59 \	0.213	0.351												
MIN Dection Limit		0.036	0.115	0.023	0.113	0.170	0.064	0.027	0.019	0.037	0.075	0.017	0.010	0.017	0.014
MAX Dection Limit		0.432	1.200	4.140	16.000	134.000	91.500	2.810	10.400	0.980	0.754	0.609	2.820	0.506	5.380
Avg Homolog		0.166	0.414	0.336	1.835	9.367	3.607	0.349	0.440	0.191					
Avg Congener											0.273	0.138	0.241	0.112	0.223
Overall		Min	Avg												
	Homolog	0.019	1.856												
	Congener	0.010	3.614												

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ID_to_use	PCB052	PCB066	PCB077	PCB087	PCB101	PCB105	PCB114	PCB118	PCB123	PCB126	PCB128	PCB138	PCB153	PCB167	PCB169	PCB170	PCB180
NEHC-000	0.065	0.446	0.532	0.273	0.275	1.460	1.440	1.370	1.460	1.720	1.240	1.230	1.090	0.957	1.130	0.117	0.091
NEHC-002	0.100	0.761	0.861	0.131	0.131	1.960	1.830	1.770	1.920	2.340	0.650	0.619	0.553	0.500	0.602	0.093	0.072
NEHC-004	0.540	0.960	1.120	0.578	0.590	1.260	1.200	1.130	1.210	1.490	1.820	1.810	1.620	1.420	1.680	1.010	0.792
NEHC-000	0.082	0.246	0.300	0.214	0.215	0.704	0.672	0.664	0.694	0.828	0.916	0.909	0.803	0.710	0.820	0.107	0.083
NEHC-002	0.172	0.745	0.853	0.158	0.158	1.190	1.200	1.160	1.200	1.450	0.554	0.529	0.472	0.434	0.504	0.085	0.066
NEHC-002	0.033	0.360	0.440	0.101	0.103	2.470	2.380	2.310	2.570	3.120	1.330	1.330	1.140	1.070	1.300	0.051	0.040
NEHC-000	0.140	0.354	0.432	0.121	0.121	0.700	0.651	0.645	0.635	0.910	0.628	0.606	0.522	0.489	0.636	0.157	0.120
NEHC-003	0.041	0.215	0.246	0.060	0.060	0.662	0.639	0.587	0.683	0.778	0.501	0.484	0.424	0.393	0.451	0.055	0.042
NEHC-000	0.116	0.124	0.152	0.220	0.222	0.425	0.422	0.393	0.428	0.489	0.594	0.590	0.521	0.457	0.531	0.151	0.117
NEHC-004	0.337	1.080	1.180	0.287	0.291	2.440	2.250	2.380	2.400	3.270	1.250	1.250	1.170	0.914	1.150	0.574	0.464
NEHC-001	0.071	0.299	0.221	0.069	0.070	0.930	0.892	0.849	0.908	1.090	0.852	0.844	0.736	0.664	0.794	0.113	0.088
NEHC-001																	
NEHC-001	0.061	0.269	0.318	0.096	0.097	1.150	1.120	1.060	1.120	1.330	1.080	1.070	0.933	0.844	0.973	0.161	0.124
NEHC-001																	
NEHC-001	0.067	0.498	0.572	0.113	0.113	1.080	1.050	0.999	1.100	1.230	0.854	0.824	0.710	0.654	0.756	0.121	0.092
NEHC-003	0.038	0.299	0.332	0.161	0.163	1.290	1.270	1.240	1.300	1.510	0.750	0.726	0.640	0.588	0.693	0.064	0.050
NEHC-003	0.053	1.240	1.480	0.123	0.124	2.200	2.230	2.090	2.170	2.820	0.915	0.915	0.781	0.718	0.890	0.211	0.166
NEHC-004	0.388	1.030	1.150	0.231	0.235	2.130	1.990	1.930	2.080	2.560	1.210	1.200	1.130	0.901	1.170	0.253	0.205
NEHC-000	0.069	0.297	0.361	0.154	0.155	0.848	0.828	0.821	0.870	0.994	0.439	0.436	0.385	0.338	0.392	0.110	0.086
NEHC-004	0.411	0.429	0.481	0.358	0.363	1.100	1.050	0.981	1.100	1.330	0.956	0.950	0.892	0.734	0.904	0.424	0.342
NEHC-002	0.123	0.264	0.294	0.136	0.135	1.260	1.220	1.180	1.240	1.510	0.941	0.897	0.801	0.733	0.847	0.121	0.094
NEHC-004	0.347	0.740	0.855	0.406	0.411	1.210	1.140	1.080	1.160	1.540	1.730	1.740	1.520	1.360	1.780	0.328	0.255
NEHC-004	0.068	0.655	0.810	0.226	0.228	4.890	4.790	4.830	4.840	6.380	1.690	1.690	1.450	1.320	1.640	0.429	0.337
NEHC-001	0.059	0.769	0.914	0.075	0.075	0.600	0.600	0.561	0.636	0.705	0.530	0.530	0.530	0.416	0.507	0.114	0.087
NEHC-004	0.537	2.350	2.610	1.520	1.540	23.200	22.500	21.000	24.500	29.100	4.540	4.510	4.230	3.440	4.130	1.190	0.964
NEHC-002	0.085	3.260	3.600	1.070	1.060	11.400	11.800	10.500	12.300	14.700	2.490	2.370	2.120	1.940	2.300	0.130	0.101
NEHC-003	0.084	1.660	2.020	0.733	0.735	1.410	1.350	1.240	1.410	1.690	1.680	1.600	1.420	1.170	1.430	0.312	0.243
NEHC-005	0.035	1.040	1.200	0.909	0.918	5.110	5.110	4.630	5.210	6.540	1.670	1.670	1.430	1.320	1.630	0.040	0.031
NEHC-002	0.247	1.790	2.150	0.450	0.452	2.000	2.000	2.000	2.000	2.550	2.690	2.610	2.290	2.100	2.420	0.121	0.096
NEHC-000	0.099	2.070	2.500	0.401	0.404	1.700	1.700	1.700	1.700	1.700	0.973	0.966	0.854	0.756	0.881	0.162	0.126
NEHC-004	0.128	1.260	1.260	0.535	0.542	4.180	4.340	3.570	4.350	5.490	3.210	3.230	2.830	2.510	3.200	0.231	0.179
NEHC-005	0.141	3.750	4.330	0.467	0.473	2.080	2.190	1.850	2.180	4.500	11.100	11.200	9.790	9.270	11.200	0.200	0.155
NEHC-003	0.084	3.250	3.900	0.518	0.521	8.420	8.390	7.940	9.110	10.400	1.630	1.580	1.380	1.290	1.520	0.068	0.052
NEHC-001	0.075	1.500	1.500	0.341	0.340	1.110	1.070	0.905	1.130	1.340	1.310	1.310	1.310	1.010	1.240	0.171	0.131
NEHC-002	0.142	3.540	3.740	0.794	0.791	24.900	26.100		25.900	31.200	5.590	5.330	4.760	4.190	4.990	0.258	0.201
NEHC-002								34.500									
FS-17-VS-	0.037	0.373	0.486	0.079	0.068	1.290	1.300	1.240	1.370	1.300	0.435	0.421	0.372	0.340	0.483	0.021	0.018
FS-13-VS-	0.062	1.200	1.440	0.284	0.238	1.560	1.510	1.480	1.610	1.600	0.595	0.583	0.512	0.410	0.454	0.102	0.093
NEHC-000	0.052	1.060	1.250	0.122	0.122	0.908	0.862	0.841	0.901	1.090	0.570	0.550	0.474	0.423	0.526	0.120	0.092
FS-21-VS-	0.026	0.647	0.820	0.102	0.088	1.420	1.380	1.360	1.510	1.400	0.597	0.578	0.511	0.469	0.914	0.047	0.042
NEHC-001	0.084	0.756	0.891	0.173	0.173	1.500	1.510	1.460	1.560	1.730	0.859	0.830	0.715	0.647	0.751	0.140	0.107
FS-05-VS-																	

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ID_to_use	PCB052	PCB066	PCB077	PCB087	PCB101	PCB105	PCB114	PCB118	PCB123	PCB126	PCB128	PCB138	PCB153	PCB167	PCB169	PCB170	PCB180
FS-05-VS-	0.092	0.404	0.491	0.439	0.369	2.170	1.930	1.710	1.990	2.180	0.551	0.528	0.456	0.399	0.519	0.096	0.084
NEHC-003	0.051	1.570	1.720	0.233	0.234	2.130	2.120	2.030	2.180	2.460	0.833	0.804	0.705	0.653	0.770	0.071	0.054
FS-14-VS-	0.035	0.560	0.708	0.221	0.190	1.560	1.470	1.410	1.540	1.500	0.529	0.512	0.452	0.411	0.710	0.042	0.037
FS-07-VS-	0.177	0.797	0.986	0.397	0.333	2.290	2.150	2.180	2.330	2.380	1.070	1.050	0.923	0.753	0.814	0.199	0.180
FS-18-VS-	0.036	0.485	0.618	0.095	0.082	1.140	1.120	1.080	1.180	1.160	0.467	0.452	0.400	0.367	0.407	0.032	0.028
NEHC-004	0.151	2.190	2.310	0.375	0.380	4.130	3.870	4.030	4.070	5.130	1.900	1.880	1.770	1.360	1.660	1.890	1.520
FS-22-VS-	0.032	0.547	0.711	0.118	0.101	2.020	1.990	1.940	2.170	2.020	0.293	0.283	0.250	0.229	0.397	0.033	0.029
FS-15-VS-	0.030	0.715	0.922	0.095	0.081	1.870	1.840	1.700	1.890	1.960	0.604	0.584	0.516	0.447	0.668	0.025	0.023
FS-02-VS-	0.233	1.920	2.330	0.500	0.419	3.260	3.150	2.870	3.230	3.260	1.890	1.850	1.620	1.260	1.490	0.328	0.297
FS-11-VS-	0.068	0.752	0.899	0.240	0.202	2.180	2.240	2.180	2.480	2.170	0.849	0.831	0.729	0.621	0.628	0.072	0.065
NEHC-001	0.036	1.910	2.380	0.131	0.132	3.410	3.320	3.140	3.370	4.060	1.280	1.240	1.090	0.977	1.170	0.055	0.044
FS-16-VS-	0.024	0.742	0.957	0.100	0.086	1.820	1.870	1.720	1.890	1.850	0.491	0.476	0.420	0.382	1.250	0.028	0.025
FS-10-VS-	0.075	1.300	1.540	0.297	0.249	1.510	1.490	1.420	1.620	1.460	0.782	0.766	0.672	0.570	0.600	0.119	0.107
NEHC-003	0.092	1.580	1.810	0.175	0.176	4.100	4.170	3.940	4.260	4.880	1.430	1.380	1.210	1.110	1.290	0.111	0.085
FS-01-VS-	0.177	0.826	0.990	0.411	0.345	2.400	2.280	2.310	2.530	2.370	1.190	1.160	1.020	0.887	0.880	0.261	0.237
NEHC-001	0.035	0.813	0.968	0.182	0.183	1.850	1.820	1.730	1.870	2.140	0.967	0.938	0.824	0.758	0.838	0.061	0.048
FS-09-VS-	0.027	0.415	0.552	0.130	0.112	1.140	1.090	1.050	1.140	1.170	0.926	0.896	0.792	0.722	0.825	0.033	0.029
NEHC-005	0.034	4.970	5.680	0.440	0.445	6.350	6.550	5.850	6.490	8.230	1.780	1.770	1.520	1.350	1.600	0.087	0.068
FS-17-VS-	0.025	1.540	1.940	0.335	0.287	3.620	3.420	3.180	3.500	3.780	0.728	0.696	0.604	0.542	0.641	0.036	0.031
FS-18-VS-	0.024	0.793	0.970	0.447	0.383	2.630	2.660	2.530	2.860	2.740	0.397	0.380	0.329	0.308	0.334	0.038	0.033
FS-03-VS-	0.035	0.333	0.424	0.224	0.192	2.830	2.840	2.730	3.020	3.000	0.688	0.658	0.571	0.525	0.592	0.038	0.032
FS-16-VS-	0.030	0.654	0.817	0.411	0.352	2.540	2.590	2.490	2.740	2.530	0.593	0.567	0.492	0.457	0.480	0.030	0.026
NEHC-000	0.051	1.610	1.930	0.195	0.196	1.400	1.400	1.400	1.400	1.400	0.943	0.936	0.827	0.748	0.846	0.123	0.095
FS-07-VS-	0.037	0.746	0.973	0.170	0.146	2.910	2.900	2.750	2.990	3.060	0.652	0.623	0.541	0.489	0.546	0.036	0.031
FS-11-VS-	0.026	1.200	1.520	0.171	0.147	12.800	13.000	10.300	12.800	14.100	1.750	1.680	1.450	1.300	1.630	0.031	0.027
FS-01-VS-	0.032	0.909	1.170	0.356	0.305	2.900	2.840	2.700	2.940	3.080	0.645	0.617	0.535	0.498	0.547	0.033	0.028
FS-02-VS-	0.015	0.601	0.772	0.489	0.419	2.250	2.360	2.180	2.390	2.390	0.713	0.681	0.591	0.548	0.694	0.048	0.041
NEHC-003	0.194	1.740	1.710	0.196	0.199	4.440	4.320	4.110	4.540	5.370	1.610	1.600	1.500	1.190	1.470	0.293	0.237
NEHC-002	0.112	3.430	3.760	0.155	0.156	4.640	4.560	4.390	4.820	5.590	1.220	1.180	1.040	0.984	1.050	0.117	0.089
FS-13-VS-	0.022	0.359	0.453	0.424	0.363	2.200	2.240	2.130	2.370	2.220	0.663	0.634	0.550	0.510	0.554	0.026	0.022
FS-12-VS-	0.033	0.258	0.330	0.171	0.147	0.869	0.808	0.801	0.922	0.861	0.287	0.274	0.238	0.223	0.249	0.044	0.038
FS-04-VS-	0.043	1.220	1.550	0.264	0.226	3.690	3.740	3.380	3.810	3.760	0.530	0.507	0.440	0.404	0.568	0.037	0.031
FS-06-VS-	0.047	0.884	1.180	0.280	0.240	2.220	2.100	1.990	2.250	2.340	0.494	0.472	0.410	0.367	0.425	0.050	0.043
FS-09-VS-	0.020	0.684	0.884	0.331	0.284	5.750	5.870	5.170	5.990	6.050	0.886	0.847	0.735	0.646	0.710	0.050	0.042
NEHC-003	0.131	6.200	6.530	1.590	1.610	18.200	19.700	16.600	19.800	24.300	4.790	4.760	4.460	3.540	4.300	1.400	1.130
FS-15-VS-	0.019	0.535	0.672	0.169	0.145	4.500	4.590	4.280	4.940	4.650	0.840	0.803	0.697	0.644	0.704	0.032	0.028
FS-20-VS-	0.044	0.796	1.010	0.331	0.284	2.390	2.340	2.270	2.480	2.490	0.768	0.735	0.637	0.588	0.641	0.049	0.042
FS-20-WG	0.061	0.131	0.167	0.058	0.050	0.399	0.401	0.357	0.377	0.365	0.049	0.047	0.041	0.037	0.031	0.049	0.044
FS-18-WG	0.090	0.103	0.121	0.119	0.102	0.286	0.280	0.283	0.331	0.271	0.214	0.208	0.182	0.159	0.139	0.080	0.073
NEHC-005	0.089	0.451	0.589	0.142	0.143	2.290	2.160	2.100	2.190	2.800	0.443	0.443	0.379	0.355	0.443	0.299	0.235
FS-17-WG	0.072	0.141	0.181	0.134	0.115	0.224	0.227	0.228	0.242	0.221	0.330	0.321	0.281	0.239	0.222	0.089	0.081
FS-16-WG	0.086	0.172	0.198	0.119	0.103	0.374	0.363	0.363	0.395	0.351	0.319	0.310	0.272	0.236	0.211	0.071	0.064
FS-08-WG	0.026	0.181	0.258	0.020	0.017	0.348	0.337	0.343	0.377	0.353	0.182	0.175	0.152	0.149	0.164	0.028	0.024

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ID_to_use	PCB052	PCB066	PCB077	PCB087	PCB101	PCB105	PCB114	PCB118	PCB123	PCB126	PCB128	PCB138	PCB153	PCB167	PCB169	PCB170	PCB180
NEHC-002	0.098	0.324	0.363	0.134	0.134	0.613	0.606	0.586	0.642	0.734	0.221	0.210	0.188	0.165	0.192	0.076	0.059
NEHC-002	0.036	0.489	0.565	0.067	0.068	0.583	0.568	0.550	0.583	0.730	0.447	0.447	0.382	0.333	0.462	0.091	0.072
FS-09-WG	0.021	0.152	0.195	0.036	0.030	0.260	0.256	0.248	0.269	0.258	0.091	0.085	0.076	0.066	0.092	0.030	0.026
FS-10-WG	0.016	0.160	0.203	0.017	0.015	0.321	0.317	0.308	0.326	0.327	0.156	0.146	0.130	0.116	0.126	0.021	0.018
NEHC-003	0.219	0.670	0.821	0.158	0.160	2.580	2.400	2.430	2.530	3.070	0.293	0.295	0.259	0.237	0.291	0.233	0.181
FS-06-WG	0.028	0.086	0.123	0.034	0.029	0.158	0.155	0.156	0.170	0.168	0.087	0.084	0.073	0.073	0.075	0.028	0.024
NEHC-002	0.030	0.572	0.675	0.077	0.077	1.500	1.510	1.470	1.510	1.850	0.588	0.588	0.502	0.453	0.551	0.055	0.043
FS-14-WG	0.025	0.088	0.108	0.019	0.016	0.309	0.323	0.297	0.325	0.319	0.093	0.087	0.077	0.066	0.074	0.023	0.020
NEHC-000	0.092	0.764	0.887	0.178	0.180	0.800	0.800	0.800	0.800	0.800	0.879	0.872	0.771	0.668	0.782	0.129	0.100
FS-19-WG	0.051	0.250	0.314	0.049	0.042	0.544	0.530	0.498	0.567	0.497	0.141	0.138	0.121	0.106	0.095	0.041	0.037
FS-03-WG	0.028	0.187	0.241	0.027	0.023	0.773	0.786	0.760	0.843	0.784	0.135	0.126	0.112	0.102	0.109	0.034	0.029
FS-12-WG	0.018	0.189	0.236	0.015	0.013	0.433	0.439	0.421	0.461	0.445	0.107	0.100	0.089	0.080	0.088	0.016	0.013
FS-02-WG	0.025	0.213	0.293	0.035	0.030	0.875	0.928	0.846	0.997	0.967	0.153	0.147	0.128	0.117	0.135	0.035	0.030
FS-13-WG	0.015	0.131	0.153	0.017	0.014	1.200	1.210	1.140	1.310	1.200	0.142	0.133	0.118	0.104	0.113	0.021	0.018
FS-01-WG	0.037	0.884	1.240	0.087	0.074	2.710	2.680	2.560	2.900	2.900	0.294	0.284	0.246	0.245	0.260	0.052	0.045
NEHC-004	0.322	9.620	10.100	1.100	1.120	23.900	24.400	21.000	25.900	32.800	4.890	4.860	4.560	3.770	4.470	0.397	0.321
FS-14-WG	0.166	1.050	1.320	0.313	0.263	8.820	8.670	7.310	8.880	9.920	5.020	4.810	4.150	3.780	4.890	0.130	0.113
FS-09-WG	0.102	3.640	4.710	0.355		38.200	41.000		43.500	51.900	13.000			9.890	12.100	0.301	
FS-09-WG					4.110			48.700				18.300	16.000				2.580
FS-16-WG	0.229	6.810	9.270				66.700		70.600	75.100	15.600			12.000	14.600	0.378	
FS-16-WG				3.880	3.260	74.300		53.000				14.500	12.700				2.500
FS-05-WG	0.130	0.697	0.816	0.366	0.307	6.330	6.530	5.680	6.990	6.720	0.852	0.816	0.704	0.635	0.703	0.101	0.088
NEHC-001	0.071	0.810	0.809	0.285	0.284	0.876	0.877	0.777	0.920	1.050	1.570	1.520	1.310	1.140	1.370	0.159	0.122
FS-08-WG	0.137	0.716	0.874	0.261	0.220	4.150	4.250	3.430	4.810	4.660	1.720	1.650	1.420	1.260	1.480	0.130	0.114
NEHC-001	0.055	1.090	1.090	0.194	0.193	1.170	1.180	1.000	1.260	1.480	1.310	1.310	1.310	1.040	1.200	0.126	0.097
FS-04-WG	0.175	1.750	2.060	0.370	0.311	13.800	13.800		16.000	15.300	2.460	2.360	2.030	1.920	2.100	0.127	0.111
FS-04-WG								13.200									
FS-03-WG																	
FS-03-WG	0.248	2.380	3.020	0.427	0.361	10.500	9.430	7.140	10.200	12.000	2.000	1.890	1.640	1.430	1.750	0.417	0.363
FS-11-WG																	
FS-11-WG	0.294	2.440	3.290	0.325	0.275	7.150	6.310	5.160	6.880	6.850	5.590	5.300	4.580	3.910	5.060	0.273	0.238
FS-07-WG																	
FS-07-WG	0.232	0.924	1.240	0.348	0.295	5.380	5.520	4.470	5.690	5.880	1.920	1.820	1.570	1.470	1.590	0.358	0.312
NEHC-002			7.000				5.000		5.000	5.000	6.520	6.330		5.230	6.390	0.378	0.299
NEHC-002					14.800	276.000		259.000					39.800				
NEHC-002	0.150	43.400		0.669													
NEHC-003	0.057	3.490	3.960	0.364	0.366	1.500	1.500		1.500	1.500	2.250	2.170	1.900	1.800	2.070	0.233	0.178
NEHC-003								29.300									
FS-01-WG	0.103	1.090	1.270	0.166	0.139	13.600	14.500		16.600	15.600	3.020	2.890	2.500	2.260	2.500	0.160	0.140
FS-01-WG								15.000									
FS-10-WG	0.235	6.750	8.680				85.400		89.000	104.000	18.400			13.900	18.800	0.399	
FS-10-WG				7.810	6.560	103.000		64.200				18.300	16.000				2.250
FS-02-WG			16.000				8.900		9.500	11.100				25.400	36.100		

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ID_to_use	PCB052	PCB066	PCB077	PCB087	PCB101	PCB105	PCB114	PCB118	PCB123	PCB126	PCB128	PCB138	PCB153	PCB167	PCB169	PCB170	PCB180
FS-02-WG	5.770	122.000		10.400	8.900	706.000					374.0	361.0	321.0			5.740	4.970
FS-15-WG	0.263	5.640	7.230				87.500		91.700	99.200	28.300			21.600	28.300	0.537	
FS-15-WG				4.240	3.560	114.000		76.700				35.400	31.000				3.080
FS-18-WG			7.150				97.800		102.000	128.000				54.500	89.000	0.821	
FS-18-WG								105.000									
FS-18-WG	6.090	96.700		6.840	5.860	586.000					79.700	76.800	68.300				5.920
FS-17-WG	0.095	3.710	4.840	0.458	0.385	35.800	40.700		43.000	49.000	7.280			5.530	7.200	0.133	0.117
FS-17-WG								55.500				8.280	7.250				
MIN De	0.015	0.086	0.108	0.015	0.013	0.158	0.155	0.156	0.170	0.168	0.049	0.047	0.041	0.037	0.031	0.016	0.013
MAX De	6.090	122.000	16.000	10.400	14.800	706.000	97.800	259.000	102.000	128.000	374.000	361.000	321.000	54.500	89.000	5.740	5.920
Avg H																	
Avg	0.253	4.506	1.877	0.637	0.770	25.479	7.610	11.072	7.979	9.190	8.926	8.756	8.061	2.600	3.619	0.278	0.360
Overall																	

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The sampl								
ID_to_use	PCB183	PCB184	PCB187	PCB189	PCB195	PCB206	PCB209	tPCB
NEHC-000	0.102	0.071	0.095	0.121	0.167	0.201	0.159	
NEHC-002	0.079	0.053	0.075	0.099	0.169	0.129	0.054	
NEHC-004	0.845	0.605	0.799	0.486	0.796	0.814	0.919	
NEHC-000	0.093	0.065	0.087	0.069	0.112	0.130	0.120	
NEHC-002	0.073	0.049	0.069	0.128	0.092	0.102	0.050	
NEHC-002	0.045	0.030	0.041	0.152	0.176	0.082	0.043	
NEHC-000	0.130	0.089	0.123	0.134	0.204	0.256	0.123	
NEHC-003	0.046	0.031	0.043	0.036	0.053	0.066	0.039	
NEHC-000	0.131	0.092	0.122	0.108	0.096	0.186	0.241	
NEHC-004	0.523	0.375	0.473	0.341	0.418	0.434	0.335	
NEHC-001	0.093	0.063	0.087	0.098	0.090	0.129	0.072	
NEHC-001							0.072	
NEHC-001	0.132	0.090	0.124	0.116	0.218	0.222	0.123	
NEHC-001							0.123	
NEHC-001	0.100	0.068	0.094	0.133	0.065	0.098	0.070	
NEHC-003	0.052	0.035	0.049	0.095	0.116	0.067	0.049	
NEHC-003	0.186	0.123	0.170	0.199	0.252	0.226	0.226	
NEHC-004	0.231	0.165	0.209	0.371	0.411	0.324	0.260	
NEHC-000	0.095	0.067	0.089	0.090	0.073	0.145	0.125	
NEHC-004	0.386	0.276	0.349	0.274	0.237	0.340	0.218	
NEHC-002	0.103	0.070	0.098	0.095	0.133	0.130	0.068	
NEHC-004	0.280	0.190	0.257	0.230	0.384	0.261	0.197	
NEHC-004	0.377	0.250	0.345	0.379	0.381	0.217	0.154	
NEHC-001	0.095	0.065	0.089	0.437	0.578	0.172	0.075	
NEHC-004	1.090	0.779	0.984	0.686	0.901	0.644	0.765	
NEHC-002	0.111	0.075	0.105	0.323	0.322	0.239	0.048	
NEHC-003	0.268	0.185	0.255	0.367	0.459	0.341	0.401	
NEHC-005	0.035	0.023	0.032	0.162	0.102	0.055	0.035	
NEHC-002	0.103	0.070	0.095	0.382	0.217	0.135	0.052	
NEHC-000	0.140	0.099	0.131	0.183	0.211	0.150	0.193	
NEHC-004	0.197	0.134	0.181	0.327	0.266	0.260	0.164	
NEHC-005	0.170	0.116	0.156	0.576	0.816	0.735	0.322	
NEHC-003	0.057	0.038	0.053	0.222	0.235	0.106	0.068	
NEHC-001	0.142	0.097	0.134	0.274	0.215	0.156	0.102	
NEHC-002	0.221	0.149	0.209	0.360	0.366	0.130	0.052	
NEHC-002								
FS-17-VS-	0.023	0.017	0.017	0.078	0.039	0.093	0.021	
FS-13-VS-	0.125	0.091	0.087	0.217	0.052	0.122	0.057	
NEHC-000	0.100	0.068	0.094	0.103	0.093	0.102	0.071	
FS-21-VS-	0.053	0.038	0.038	0.120	0.087	0.107	0.021	
NEHC-001	0.116	0.079	0.110	0.180	0.115	0.173	0.103	
FS-05-VS-								

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ID_to_use	PCB183	PCB184	PCB187	PCB189	PCB195	PCB206	PCB209	tPCB
FS-05-VS-	0.103	0.074	0.073	0.148	0.142	0.141	0.062	
NEHC-003	0.060	0.040	0.055	0.159	0.104	0.097	0.045	
FS-14-VS-	0.047	0.034	0.034	0.133	0.033	0.172	0.030	
FS-07-VS-	0.242	0.176	0.169	0.243	0.158	0.193	0.160	
FS-18-VS-	0.035	0.026	0.026	0.124	0.037	0.164	0.028	
NEHC-004	1.720	1.230	1.550	0.524	0.337	0.581	0.675	
FS-22-VS-	0.036	0.027	0.026	0.099	0.028	0.096	0.022	
FS-15-VS-	0.028	0.021	0.020	0.173	0.111	0.096	0.026	
FS-02-VS-	0.400	0.290	0.278	0.508	0.350	0.251	0.146	
FS-11-VS-	0.088	0.064	0.061	0.233	0.222	0.092	0.070	
NEHC-001	0.047	0.032	0.043	0.230	0.137	0.145	0.053	
FS-16-VS-	0.031	0.023	0.022	0.098	0.050	0.094	0.016	
FS-10-VS-	0.145	0.105	0.101	0.268	0.179	0.115	0.056	
NEHC-003	0.094	0.062	0.086	0.238	0.233	0.164	0.056	
FS-01-VS-	0.319	0.231	0.222	0.301	0.256	0.246	0.195	
NEHC-001	0.052	0.035	0.048	0.144	0.079	0.099	0.049	
FS-09-VS-	0.037	0.027	0.026	0.064	0.049	0.178	0.024	
NEHC-005	0.076	0.051	0.070	0.211	0.068	0.067	0.032	
FS-17-VS-	0.038	0.026	0.027	0.107	0.048	0.082	0.023	
FS-18-VS-	0.041	0.028	0.029	0.126	0.054	0.095	0.024	
FS-03-VS-	0.040	0.028	0.029	0.120	0.040	0.078	0.026	
FS-16-VS-	0.033	0.022	0.023	0.088	0.036	0.130	0.020	
NEHC-000	0.106	0.075	0.099	0.179	0.070	0.100	0.090	
FS-07-VS-	0.039	0.027	0.028	0.132	0.071	0.108	0.028	
FS-11-VS-	0.033	0.023	0.024	0.190	0.097	0.101	0.021	
FS-01-VS-	0.036	0.025	0.025	0.107	0.072	0.068	0.018	
FS-02-VS-	0.052	0.036	0.037	0.111	0.072	0.082	0.024	
NEHC-003	0.267	0.191	0.242	0.241	0.216	0.204	0.224	
NEHC-002	0.098	0.065	0.091	0.165	0.146	0.111	0.045	
FS-13-VS-	0.028	0.019	0.020	0.087	0.074	0.070	0.014	
FS-12-VS-	0.047	0.033	0.034	0.055	0.026	0.074	0.024	
FS-04-VS-	0.039	0.027	0.028	0.130	0.076	0.094	0.028	
FS-06-VS-	0.053	0.037	0.038	0.100	0.055	0.139	0.025	
FS-09-VS-	0.053	0.037	0.038	0.187	0.161	0.080	0.026	
NEHC-003	1.280	0.914	1.150	0.597	0.659	0.297	0.261	
FS-15-VS-	0.034	0.024	0.025	0.108	0.106	0.086	0.017	
FS-20-VS-	0.053	0.036	0.038	0.088	0.062	0.093	0.025	
FS-20-WG	0.064	0.046	0.045	0.025	0.040	0.052	0.033	
FS-18-WG	0.105	0.075	0.075	0.048	0.058	0.066	0.040	
NEHC-005	0.263	0.174	0.240	0.169	0.152	0.179	0.114	
FS-17-WG	0.117	0.084	0.083	0.066	0.086	0.127	0.063	
FS-16-WG	0.093	0.066	0.066	0.065	0.056	0.089	0.045	
FS-08-WG	0.030	0.022	0.021	0.022	0.032	0.160	0.039	

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ID_to_use	PCB183	PCB184	PCB187	PCB189	PCB195	PCB206	PCB209	tPCB
NEHC-002	0.065	0.044	0.062	0.088	0.085	0.123	0.061	
NEHC-002	0.080	0.053	0.073	0.101	0.100	0.061	0.055	
FS-09-WG	0.032	0.022	0.022	0.018	0.019	0.050	0.018	
FS-10-WG	0.022	0.015	0.016	0.014	0.021	0.043	0.016	
NEHC-003	0.199	0.135	0.183	0.217	0.189	0.245	0.238	
FS-06-WG	0.030	0.022	0.021	0.019	0.031	0.169	0.026	
NEHC-002	0.049	0.032	0.044	0.090	0.096	0.045	0.038	
FS-14-WG	0.024	0.017	0.017	0.024	0.027	0.056	0.026	
NEHC-000	0.111	0.078	0.104	0.167	0.120	0.138	0.116	
FS-19-WG	0.054	0.039	0.039	0.046	0.052	0.050	0.030	
FS-03-WG	0.036	0.024	0.026	0.042	0.050	0.064	0.027	
FS-12-WG	0.017	0.011	0.012	0.045	0.019	0.037	0.014	
FS-02-WG	0.038	0.027	0.027	0.041	0.027	0.145	0.027	
FS-13-WG	0.022	0.015	0.016	0.049	0.031	0.044	0.018	
FS-01-WG	0.056	0.041	0.040	0.252	0.155	0.249	0.042	
NEHC-004	0.362	0.259	0.327	0.552	0.470	0.359	0.322	
FS-14-WG	0.140	0.100	0.099	0.704	0.706	0.271	0.081	
FS-09-WG	0.324	0.231		1.410	1.180	0.246	0.120	
FS-09-WG			2.240					
FS-16-WG	0.407	0.291	0.288	1.080	1.130	0.262	0.122	
FS-16-WG								
FS-05-WG	0.109	0.078	0.077	0.186	0.172	0.113	0.066	
NEHC-001	0.132	0.090	0.125	0.425	0.741	0.200	0.107	
FS-08-WG	0.141	0.100	0.099	0.398	0.380	0.173	0.089	
NEHC-001	0.105	0.072	0.099	0.245	0.368	0.094	0.059	
FS-04-WG	0.137	0.098	0.097	0.443	0.691	0.214	0.069	
FS-04-WG								
FS-03-WG								
FS-03-WG	0.460	0.313	0.318	0.980	1.020	0.598	0.351	
FS-11-WG								
FS-11-WG	0.302	0.205	0.208	0.480	0.451	0.399	0.363	
FS-07-WG								
FS-07-WG	0.396	0.269	0.274	0.393	0.627	0.507	0.333	
NEHC-002	0.321	0.218	0.297	1.040	0.637	0.180	0.055	
NEHC-002								
NEHC-002								
NEHC-003	0.196	0.130	0.181	0.491	0.773	0.177	0.039	
NEHC-003								
FS-01-WG	0.172	0.123	0.121	0.430	0.833	0.216	0.091	
FS-01-WG								
FS-10-WG	0.430	0.307		2.360	5.930	0.950	0.122	
FS-10-WG			1.950					
FS-02-WG		0.785		2.810	10.400	0.627	0.150	

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ID_to_use	PCB183	PCB184	PCB187	PCB189	PCB195	PCB206	PCB209	tPCB
FS-02-WG	6.350		4.520					
FS-15-WG	0.579	0.413	0.409	1.310	1.960	0.281	0.143	
FS-15-WG								
FS-18-WG	0.884	0.631		1.730	2.520	0.420	0.116	
FS-18-WG								
FS-18-WG			5.380					
FS-17-WG	0.144	0.103	0.102	1.100	1.480	0.243	0.104	
FS-17-WG								
MIN De	0.017	0.011	0.012	0.014	0.019	0.037	0.014	
MAX De	6.350	1.230	5.380	2.810	10.400	0.950	0.919	
Avg H								
Avg	0.280	0.138	0.299	0.327	0.498	0.196	0.117	
Overall								

A4E.4 Qualifiers

The analytical qualifier codes reported for the chemical analysis of homologs and congeners.										
ID_to_use	Lab ID	Species	Site	Homo_CL1	Homo_CL2	Homo_CL3	Homo_CL4	Homo_CL5	Homo_CL6	Homo_CL7
NEHC-0005	L3606-5	Black Seabass	Reference							
NEHC-0024	L3606-24	Black Seabass	Reference							
NEHC-0048	L3606-48R i	Black Seabass	Reference							
NEHC-0007	L3606-7	Black Seabass	Reference							
NEHC-0023	L3606-23	Black Seabass	Reference							
NEHC-0002	L3606-2 i	Black Seabass	Reference							
NEHC-0034	L3606-34	Black Seabass	Reference							
NEHC-0004	L3606-4	Black Seabass	Reference	U						
NEHC-0042	L3606-42R	Black Seabass	Reference							
NEHC-0016	L3606-16	Black Seabass	Reference							
NEHC-0017	L3606-17	Black Seabass	Reference							
NEHC-0011	L3606-11 i	Black Seabass	Reference							
NEHC-0033	L3606-33 i	Black Seabass	Reference							
NEHC-0044	L3606-44R	Black Seabass	Reference							
NEHC-0003	L3606-3	Black Seabass	Reference							
NEHC-0046	L3606-46R	Black Seabass	Reference							
NEHC-0026	L3606-26	Black Seabass	Reference							
NEHC-0049	L3606-49R	Black Seabass	Reference							
NEHC-0041	L3606-41R	Black Seabass	Reference							
NEHC-0010	L3606-10 i	Black Seabass	Reference							
NEHC-0043	L3606-43R	Black Seabass	Target							
NEHC-0027	L3606-27	Black Seabass	Target							
NEHC-0036	L3606-36R	Black Seabass	Target							
NEHC-0053	L3606-53R	Black Seabass	Target							
NEHC-0021	L3606-21	Black Seabass	Target							
NEHC-0006	L3606-6	Black Seabass	Target							
NEHC-0047	L3606-47R	Black Seabass	Target							
NEHC-0050	L3606-50R	Black Seabass	Target							
NEHC-0031	L3606-31	Black Seabass	Target							
NEHC-0013	L3606-13	Black Seabass	Target							
NEHC-0022	L3606-22	Black Seabass	Target							
FS-13-VS-R	L2767-8	Vermilion Snapper	Reference							
FS-17-VS-R	L2767-12	Vermilion Snapper	Reference							
NEHC-0009	L3606-9 i	Vermilion Snapper	Reference							
FS-21-VS-R	L2767-14	Vermilion Snapper	Reference							
NEHC-0015	L3606-15	Vermilion Snapper	Reference							
FS-05-VS-R	L2767-3	Vermilion Snapper	Reference							
FS-14-VS-R	L2767-9	Vermilion Snapper	Reference							
NEHC-0035	L3606-35	Vermilion Snapper	Reference							
FS-07-VS-R	L2767-4	Vermilion Snapper	Reference	U						
FS-18-VS-R	L2767-13	Vermilion Snapper	Reference							
NEHC-0040	L3606-40R	Vermilion Snapper	Reference							
FS-22-VS-R	L2767-15	Vermilion Snapper	Reference							
FS-02-VS-R	L2767-2	Vermilion Snapper	Reference							
FS-15-VS-R	L2767-10	Vermilion Snapper	Reference							
FS-11-VS-R	L2767-7	Vermilion Snapper	Reference							
NEHC-0018	L3606-18	Vermilion Snapper	Reference							
FS-10-VS-R	L2767-6	Vermilion Snapper	Reference							
FS-16-VS-R	L2767-11	Vermilion Snapper	Reference							
NEHC-0030	L3606-30	Vermilion Snapper	Reference							
FS-01-VS-R	L2767-1	Vermilion Snapper	Reference							
NEHC-0019	L3606-19	Vermilion Snapper	Reference							

A4E.4 Qualifiers

ID_to_use	Lab ID	Species	Site	Homo_C L1	Homo_C L2	Homo_C L3	Homo_C L4	Homo_C L5	Homo_C L6	Homo_C L7
FS-09-VS-R	L2767-5	Vermilion Snapper	Reference	U						
FS-17-VS-T	L2767-28	Vermilion Snapper	Target							
NEHC-0052	L3606-52R	Vermilion Snapper	Target							
FS-18-VS-T	L2767-29	Vermilion Snapper	Target							
FS-03-VS-T	L2767-18	Vermilion Snapper	Target							
FS-16-VS-T	L2767-27	Vermilion Snapper	Target							
NEHC-0008	L3606-8	Vermilion Snapper	Target							
FS-07-VS-T	L2767-21	Vermilion Snapper	Target							
FS-11-VS-T	L2767-23	Vermilion Snapper	Target							
FS-01-VS-T	L2767-16	Vermilion Snapper	Target							
FS-02-VS-T	L2767-17	Vermilion Snapper	Target							
NEHC-0037	L3606-37R	Vermilion Snapper	Target							
FS-13-VS-T	L2767-25	Vermilion Snapper	Target							
NEHC-0029	L3606-29	Vermilion Snapper	Target							
FS-12-VS-T	L2767-24 i	Vermilion Snapper	Target							
FS-04-VS-T	L2767-19	Vermilion Snapper	Target							
FS-06-VS-T	L2767-20	Vermilion Snapper	Target							
FS-09-VS-T	L2767-22	Vermilion Snapper	Target							
NEHC-0038	L3606-38R	Vermilion Snapper	Target							
FS-15-VS-T	L2767-26 (A)	Vermilion Snapper	Target							
FS-20-VS-T	L2767-30	Vermilion Snapper	Target							
FS-20-WG-R	L2767-45	White Grunt	Reference	U						
FS-18-WG-R	L2767-43	White Grunt	Reference	U						
NEHC-0051	L3606-51R	White Grunt	Reference							
FS-17-WG-R	L2767-42	White Grunt	Reference							
FS-16-WG-R	L2767-41	White Grunt	Reference	U						
FS-08-WG-R	L2767-35	White Grunt	Reference							
NEHC-0028	L3606-28	White Grunt	Reference							
FS-09-WG-R	L2767-36	White Grunt	Reference							
FS-10-WG-R	L2767-37	White Grunt	Reference							
NEHC-0039	L3606-39R	White Grunt	Reference							
FS-06-WG-R	L2767-34	White Grunt	Reference							
NEHC-0025	L3606-25R	White Grunt	Reference							
FS-14-WG-R	L2767-40	White Grunt	Reference							
NEHC-0001	L3606-1	White Grunt	Reference							
FS-19-WG-R	L2767-44	White Grunt	Reference	U						
FS-03-WG-R	L2767-33	White Grunt	Reference							
FS-12-WG-R	L2767-38	White Grunt	Reference							
FS-02-WG-R	L2767-32	White Grunt	Reference							
FS-13-WG-R	L2767-39 (A)	White Grunt	Reference	U	U					
FS-01-WG-R	L2767-31	White Grunt	Reference							
NEHC-0045	L3606-45R	White Grunt	Target							
FS-14-WG-T	L2767-56	White Grunt	Target							
FS-09-WG-T	L2767-53	White Grunt	Target							
FS-16-WG-T	L2767-58	White Grunt	Target							
FS-05-WG-T	L2767-50	White Grunt	Target							
NEHC-0014	L3606-14	White Grunt	Target							
FS-08-WG-T	L2767-52	White Grunt	Target							
FS-04-WG-T	L2767-49	White Grunt	Target							
NEHC-0012	L3606-12	White Grunt	Target							
FS-03-WG-T	L2767-48	White Grunt	Target							
FS-11-WG-T	L2767-55	White Grunt	Target							
FS-07-WG-T	L2767-51	White Grunt	Target							
NEHC-0020	L3606-20	White Grunt	Target							

A4E.4 Qualifiers

ID_to_use	Lab ID	Species	Site	Homo_C L1	Homo_C L2	Homo_C L3	Homo_C L4	Homo_C L5	Homo_C L6	Homo_C L7
FS-01-WG-T	L2767-46	White Grunt	Target							
NEHC-0032	L3606-32	White Grunt	Target							
FS-10-WG-T	L2767-54	White Grunt	Target							
FS-02-WG-T	L2767-47	White Grunt	Target							
FS-15-WG-T	L2767-57	White Grunt	Target							
FS-18-WG-T	L2767-60	White Grunt	Target							
FS-17-WG-T	L2767-59	White Grunt	Target							
number detected				105	112	113	113	113	113	113
	nondetected			8	1	0	0	0	0	0
	%detected			93%	99%	100%	100%	100%	100%	100%
Qualifier	Definition									
	Data unqualified, meets all data quality objectives									
D	dilution data ;									
J	result is less than the minimum reporting limit;									
R	peak detected, but did not meet quantification criteria;									
RJ	peak detected, but did not meet quantification criteria; result is less than the minimum reporting limit;									
U	not detected;									
UY	not detected; results confirmed separately									
C	co-eluting congener;									
C D	co-eluting congener; dilution data ;									
C J	co-eluting congener; result is less than the minimum reporting limit;									
C RJ	co-eluting congener; peak detected, but did not meet quantification criteria; result is less than th									
C U	co-eluting congener; not detected;									
D	dilution data ;									
DZ	dilution data ; spiked amount is negligible when compared to sample									
J	result is less than the minimum reporting limit;									
JY	result is less than the minimum reporting limit; results confirmed separately									
R	peak detected, but did not meet quantification criteria;									
RJ	peak detected, but did not meet quantification criteria; result is less than the minimum reporting limit;									
RJD	peak detected, but did not meet quantification criteria; result is less than the minimum report									
RJY	peak detected, but did not meet quantification criteria; result is less than the minimum reporting limit;									
U	not detected;									
UD	not detected; dilution data ;									
UDY	not detected; dilution data ;									
UY	not detected; results confirmed separately									
Z	spiked amount is negligible when compared to sample									

A4E.4 Qualifiers

The analytica											
ID_to_use	Homo_CL8	Homo_CL9	PCB008	PCB018	PCB028	PCB044	PCB049	PCB052	PCB066	PCB077	PCB087
NEHC-0005			J	C J	C	C	C				C
NEHC-0024			J	C J	C	C	C			J	C
NEHC-0048			J	C J	C	C J	C J			U	C J
NEHC-0007			J	C J	C	C	C J			J	C
NEHC-0023			J	C J	C	C	C			J	C
NEHC-0002			J	C J	C J	C J	C J			U	C J
NEHC-0034			J	C RJ	C	C J	C J			J	C J
NEHC-0004			J	C RJ	C J	C J	C J			J	C J
NEHC-0042			J	C J	C	C J	C J			U	C J
NEHC-0016			J	C RJ	C	C	C			RJ	C
NEHC-0017			J	C RJ	C J	C J	C J			J	C J
NEHC-0011			J	C RJ	C	C	C J			J	C
NEHC-0033			J	C J	C	C	C			RJ	C
NEHC-0044			J	C J	C	C	C			J	C
NEHC-0003			J	C J	C	C J	C J			J	C J
NEHC-0046			RJ	C J	C RJ	C J	C J			U	C J
NEHC-0026			J	C J	C J	C J	C J			RJ	C J
NEHC-0049			J	C J	C	C	C J			U	C
NEHC-0041				C J	C	C	C			J	C
NEHC-0010				C J	C	C	C				C
NEHC-0043				C	C	C	C				C
NEHC-0027				C	C	C	C				C
NEHC-0036				C	C	C	C				C
NEHC-0053				C	C	C	C			J	C
NEHC-0021				C	C	C	C				C
NEHC-0006				C	C	C	C				C
NEHC-0047				C	C	C	C				C
NEHC-0050				C	C	C	C				C
NEHC-0031				C	C	C	C				C
NEHC-0013				C	C	C	C				C
NEHC-0022				C	C	C	C				C
FS-13-VS-R				C	C	C	C				C
FS-17-VS-R				C	C	C	C				C
NEHC-0009				C	C	C	C				C
FS-21-VS-R				C	C	C	C				C
NEHC-0015				C	C	C	C				C
FS-05-VS-R											
FS-14-VS-R				C	C	C	C				C
NEHC-0035				C	C	C	C				C
FS-07-VS-R				C	C	C	C				C
FS-18-VS-R				C	C	C	C				C
NEHC-0040				C J	C	C	C				C
FS-22-VS-R			J	C J	C	C	C				C
FS-02-VS-R				C	C	C	C				C
FS-15-VS-R				C	C	C	C				C
FS-11-VS-R				C	C	C	C				C
NEHC-0018				C	C	C	C				C
FS-10-VS-R				C	C	C	C				C
FS-16-VS-R				C	C	C	C				C
NEHC-0030				C	C	C	C				C
FS-01-VS-R				C	C	C	C				C
NEHC-0019				C	C	C	C				C

A4E.4 Qualifiers

ID_to_use	Homo_CL8	Homo_CL9	PCB008	PCB018	PCB028	PCB044	PCB049	PCB052	PCB066	PCB077	PCB087
FS-09-VS-R				C	C	C	C				C
FS-17-VS-T				C	C	C	C				C
NEHC-0052				C	C	C	C			U	C
FS-18-VS-T				C	C	C	C				C
FS-03-VS-T				C	C	C	C				C
FS-16-VS-T				C	C	C	C				C
NEHC-0008				C	C	C	C				C
FS-07-VS-T				C	C	C	C				C
FS-11-VS-T				C	C	C	C				C
FS-01-VS-T				C	C	C	C				C
FS-02-VS-T				C	C	C	C				C
NEHC-0037				C	C	C	C				C
FS-13-VS-T				C	C	C	C				C
NEHC-0029				C	C	C	C			R	C
FS-12-VS-T				C	C	C	C			J	C
FS-04-VS-T				C	C	C	C				C
FS-06-VS-T				C	C	C	C				C
FS-09-VS-T				C	C	C	C				C
NEHC-0038				C	C	C	C				C
FS-15-VS-T				C	C	C	C				C
FS-20-VS-T				C	C	C	C				C
FS-20-WG-R			J	C RJ	C	C J	C J			RJ	C J
FS-18-WG-R			RJ	C J	C J	C J	C J			RJ	C J
NEHC-0051				C	C	C	C			J	C
FS-17-WG-R			J	C J	C	C J	C J			J	C J
FS-16-WG-R			U	C J	C	C J	C J			J	C
FS-08-WG-R			J	C J	C	C J	C J			RJ	C J
NEHC-0028				C J	C	C J	C J			J	C J
FS-09-WG-R			J	C J	C J	C J	C J			U	C J
FS-10-WG-R			J	C J	C	C J	C J			J	C J
NEHC-0039				C J	C	C J	C J			U	C
FS-06-WG-R			J	C RJ	C	C J	C J			U	C J
NEHC-0025				C J	C	C	C			U	C
FS-14-WG-R			J	C J	C J	C J	C J	J		J	C J
NEHC-0001				C J	C	C	C				C
FS-19-WG-R			J	C J	C	C J	C RJ			J	C J
FS-03-WG-R				C J	C	C	C			J	C
FS-12-WG-R											
FS-02-WG-R				C J	C	C	C J			J	C
FS-13-WG-R			RJ	C J	C	C J	C J			RJ	C J
FS-01-WG-R				C J	C	C	C				C
NEHC-0045				C	C	C	C			U	C
FS-14-WG-T				C	C	C	C				C
FS-09-WG-T				C	C	C	C				C
FS-16-WG-T				C	C	C	C				
FS-05-WG-T				C	C	C	C				C
NEHC-0014				C	C	C	C				C
FS-08-WG-T				C	C	C	C				C
FS-04-WG-T				C	C	C	C				C
NEHC-0012				C	C	C	C				C
FS-03-WG-T											
FS-11-WG-T											
FS-07-WG-T											
NEHC-0020				C	C	C	C			R	

A4E.4 Qualifiers

ID_to_use	Homo_CL8	Homo_CL9	PCB008	PCB018	PCB028	PCB044	PCB049	PCB052	PCB066	PCB077	PCB087
FS-01-WG-T				C	C	C	C				C
NEHC-0032				C	C	C	C				C
FS-10-WG-T				C	C	C	C				
FS-02-WG-T				C	C	C					
FS-15-WG-T				C	C	C	C				
FS-18-WG-T				C	C	C					
FS-17-WG-T				C	C	C	C				C
nur	113	113	113	113	113	113	113	113	113	103	113
	0	0	0	0	0	0	0	0	0	10	0
	100%	100%	100%	100%	100%	100%	100%	100%	100%	91%	100%
Qualifier											
D											
J											
R											
RJ											
U											
UY											
C											
C D											
C J											
C RJ	e minimum reporting limit;										
C U											
D											
DZ											
J											
JY											
R											
RJ											
RJD	ing limit; dilution data ;										
RJY	results confirmed separately										
U											
UD											
UDY											
UY											
Z											

A4E.4 Qualifiers

The analytica											
ID_to_use	PCB101	PCB105	PCB114	PCB118	PCB123	PCB126	PCB128	PCB138	PCB153	PCB167	PCB169
NEHC-0005	C						C	C	C		UY
NEHC-0024	C				J	U	C	C	C		UY
NEHC-0048	C				RJ	U	C	C	C		UY
NEHC-0007	C				J	U	C	C	C		UY
NEHC-0023	C				J	U	C	C	C		UY
NEHC-0002	C		J		U	J	C	C	C		UY
NEHC-0034	C				J	J	C	C	C		UY
NEHC-0004	C				J	J	C	C	C		UY
NEHC-0042	C					U	C	C	C		UY
NEHC-0016	C				J	J	C	C	C		UY
NEHC-0017	C				J	U	C	C	C		UY
NEHC-0011	C					U	C	C	C		UY
NEHC-0033	C				J	U	C	C	C		UY
NEHC-0044	C					U	C	C	C		UY
NEHC-0003	C				J	U	C	C	C		UY
NEHC-0046	C				RJ	J	C	C	C		UY
NEHC-0026	C				U	U	C	C	C		UY
NEHC-0049	C				J	U	C	C	C		UY
NEHC-0041	C					U	C	C	C		UY
NEHC-0010	C						C	C	C		UY
NEHC-0043	C					U	C	C	C		UY
NEHC-0027	C					U	C	C	C		UY
NEHC-0036	C						C	C	C		UY
NEHC-0053	C					U	C	C	C		UY
NEHC-0021	C					U	C	C	C		UY
NEHC-0006	C					J	C	C	C		UY
NEHC-0047	C					U	C	C	C		UY
NEHC-0050	C					U	C	C	C		UY
NEHC-0031	C					U	C	C	C		UY
NEHC-0013	C						C	C	C		UY
NEHC-0022	C					U	C	C	C		UY
FS-13-VS-R	C					J	C	C	C		UY
FS-17-VS-R	C					J	C	C	C		UY
NEHC-0009	C					J	C	C	C		UY
FS-21-VS-R	C					J	C	C	C		UY
NEHC-0015	C						C	C	C		UY
FS-05-VS-R											
FS-14-VS-R	C						C	C	C		UY
NEHC-0035	C						C	C	C		UY
FS-07-VS-R	C		R			J	C	C	C		UY
FS-18-VS-R	C					J	C	C	C		UY
NEHC-0040	C					U	C	C	C		UY
FS-22-VS-R	C					U	C	C	C		UY
FS-02-VS-R	C						C	C	C		UY
FS-15-VS-R	C						C	C	C		UY
FS-11-VS-R	C						C	C	C		UY
NEHC-0018	C					U	C	C	C		UY
FS-10-VS-R	C						C	C	C		JY
FS-16-VS-R	C						C	C	C		UY
NEHC-0030	C					U	C	C	C		UY
FS-01-VS-R	C					U	C	C	C		UY
NEHC-0019	C						C	C	C		UY

A4E.4 Qualifiers

ID_to_use	PCB101	PCB105	PCB114	PCB118	PCB123	PCB126	PCB128	PCB138	PCB153	PCB167	PCB169
FS-09-VS-R	C					J	C	C	C		UY
FS-17-VS-T	C					U	C	C	C		UY
NEHC-0052	C					U	C	C	C		UY
FS-18-VS-T	C					U	C	C	C		UY
FS-03-VS-T	C					U	C	C	C		UY
FS-16-VS-T	C					U	C	C	C		UY
NEHC-0008	C					J	C	C	C		UY
FS-07-VS-T	C					U	C	C	C		UY
FS-11-VS-T	C					U	C	C	C		UY
FS-01-VS-T	C					U	C	C	C		UY
FS-02-VS-T	C					U	C	C	C		UY
NEHC-0037	C					U	C	C	C		UY
FS-13-VS-T	C					U	C	C	C		UY
NEHC-0029	C					U	C	C	C		UY
FS-12-VS-T	C					U	C	C	C		UY
FS-04-VS-T	C					U	C	C	C		UY
FS-06-VS-T	C					U	C	C	C		UY
FS-09-VS-T	C					U	C	C	C		UY
NEHC-0038	C					U	C	C	C		UY
FS-15-VS-T	C					U	C	C	C		UY
FS-20-VS-T	C					U	C	C	C		UY
FS-20-WG-R	C		RJ		J	J	C	C	C		JY
FS-18-WG-R	C		J		J	U	C	C	C		UY
NEHC-0051	C				J	U	C	C	C		UY
FS-17-WG-R	C		J		RJ	RJ	C	C	C		UY
FS-16-WG-R	C		J		J	J	C	C	C		UY
FS-08-WG-R	C		J		J	U	C	C	C		UY
NEHC-0028	C		J		U	U	C	C	C		UY
FS-09-WG-R	C		J		RJ	U	C	C	C		UY
FS-10-WG-R	C		J		J	RJ	C	C	C		UY
NEHC-0039	C				U	U	C	C	C		UY
FS-06-WG-R	C		J		J	J	C	C	C		UY
NEHC-0025	C				J	U	C	C	C		UY
FS-14-WG-R	C		J		RJ	RJ	C	C	C		UY
NEHC-0001	C					J	C	C	C		UY
FS-19-WG-R	C		J		J	J	C	C	C		UY
FS-03-WG-R	C				J	J	C	C	C		RJY
FS-12-WG-R											
FS-02-WG-R	C				J	RJ	C	C	C		JY
FS-13-WG-R	C				J	U	C	C	C		UY
FS-01-WG-R	C						C	C	C		RJY
NEHC-0045	C					U	C	C	C		UY
FS-14-WG-T	C					U	C	C	C		UY
FS-09-WG-T						U	C				UY
FS-16-WG-T						U	C				UY
FS-05-WG-T	C					U	C	C	C		UY
NEHC-0014	C					J	C	C	C		UY
FS-08-WG-T	C					U	C	C	C		UY
FS-04-WG-T	C					U	C	C	C		UY
NEHC-0012	C					J	C	C	C		UY
FS-03-WG-T											
FS-11-WG-T											
FS-07-WG-T											
NEHC-0020						U	C	C			UY

A4E.4 Qualifiers

ID_to_use	PCB101	PCB105	PCB114	PCB118	PCB123	PCB126	PCB128	PCB138	PCB153	PCB167	PCB169
FS-01-WG-T	C					U	C	C	C		UY
NEHC-0032	C						C	C	C		UY
FS-10-WG-T						U	C				UY
FS-02-WG-T											UY
FS-15-WG-T						U	C				UY
FS-18-WG-T						U					UY
FS-17-WG-T	C					U	C				UY
nur	113	113	113	113	110	48	113	113	113	113	8
	0	0	0	0	3	65	0	0	0	0	105
	100%	100%	100%	100%	97%	42%	100%	100%	100%	100%	7%
Qualifier											
D											
J											
R											
RJ											
U											
UY											
C											
C D											
C J											
C RJ											
C U											
D											
DZ											
J											
JY											
R											
RJ											
RJD											
RJY											
U											
UD											
UDY											
UY											
Z											

A4E.4 Qualifiers

The analytica									
ID_to_use	PCB170	PCB180	PCB183	PCB184	PCB187	PCB189	PCB195	PCB206	PCB209
NEHC-0005		C	C	J					
NEHC-0024		C	C	RJ					
NEHC-0048		C	C	U					
NEHC-0007		C	C	J		J			
NEHC-0023		C	C	RJ					
NEHC-0002		C	C	U					
NEHC-0034		C	C	U					
NEHC-0004		C	C	U					
NEHC-0042		C	C	U					
NEHC-0016		C	C	J					
NEHC-0017		C	C	RJ					
NEHC-0011		C	C	J					
NEHC-0033		C	C	J					
NEHC-0044		C	C	J					
NEHC-0003		C	C	RJ					
NEHC-0046		C	C	U					
NEHC-0026		C	C	RJ					
NEHC-0049		C	C	J					
NEHC-0041		C	C	J					
NEHC-0010		C	C						
NEHC-0043		C	C	J					
NEHC-0027		C	C						
NEHC-0036		C	C	J					
NEHC-0053		C	C	RJ					
NEHC-0021		C	C	J					
NEHC-0006		C	C	J					
NEHC-0047		C	C	J					
NEHC-0050		C	C						
NEHC-0031		C	C	J					
NEHC-0013		C	C						
NEHC-0022		C	C						
FS-13-VS-R		C	C	J					
FS-17-VS-R		C	C	J					
NEHC-0009		C	C	J					
FS-21-VS-R		C	C	J					
NEHC-0015		C	C						
FS-05-VS-R									
FS-14-VS-R		C	C	J					
NEHC-0035		C	C						
FS-07-VS-R		C	C	RJ					
FS-18-VS-R		C	C	J					
NEHC-0040		C	C						
FS-22-VS-R		C	C	J					
FS-02-VS-R		C	C						
FS-15-VS-R		C	C						
FS-11-VS-R		C	C						
NEHC-0018		C	C						
FS-10-VS-R		C	C						
FS-16-VS-R		C	C	J					
NEHC-0030		C	C						
FS-01-VS-R		C	C						
NEHC-0019		C	C	J					

A4E.4 Qualifiers

ID_to_use	PCB170	PCB180	PCB183	PCB184	PCB187	PCB189	PCB195	PCB206	PCB209
FS-09-VS-R		C	C	J					
FS-17-VS-T		C	C	J					
NEHC-0052		C	C	J					
FS-18-VS-T		C	C	J					
FS-03-VS-T		C	C	J					
FS-16-VS-T		C	C	J					
NEHC-0008		C	C	J					
FS-07-VS-T		C	C	J					
FS-11-VS-T		C	C	J					
FS-01-VS-T		C	C	J					
FS-02-VS-T		C	C	J					
NEHC-0037		C	C	J					
FS-13-VS-T		C	C	J					
NEHC-0029		C	C	J					
FS-12-VS-T		C	C	J		J	J		
FS-04-VS-T		C	C	J					
FS-06-VS-T		C	C	J					
FS-09-VS-T		C	C						
NEHC-0038		C	C						
FS-15-VS-T		C	C						
FS-20-VS-T		C	C	J					
FS-20-WG-R		C	C	RJ		J	J		
FS-18-WG-R		C	C	RJ		J	J		
NEHC-0051		C	C	J		J			
FS-17-WG-R		C	C	RJ		RJ	J		
FS-16-WG-R		C	C	J		J	J		
FS-08-WG-R		C	C	J		J	J		
NEHC-0028		C	C	RJ		J			
FS-09-WG-R		C	C	RJ		J	J		
FS-10-WG-R		C	C	J		J	J		
NEHC-0039		C	C	J		J			
FS-06-WG-R		C	C	J		J	J		
NEHC-0025		C	C	J		J			
FS-14-WG-R		C	C	J		J	J		
NEHC-0001		C	C	RJ					
FS-19-WG-R		C	C	J		J			
FS-03-WG-R		C	C	J					
FS-12-WG-R									
FS-02-WG-R		C	C	J					
FS-13-WG-R		C	C	RJ					
FS-01-WG-R		C	C						
NEHC-0045		C	C	RJ					
FS-14-WG-T		C	C	RJ					
FS-09-WG-T			C	J					
FS-16-WG-T			C						
FS-05-WG-T		C	C	J					
NEHC-0014		C	C	J					
FS-08-WG-T		C	C	J					
FS-04-WG-T		C	C	J					
NEHC-0012		C	C	J					
FS-03-WG-T									
FS-11-WG-T									
FS-07-WG-T									
NEHC-0020		C	C						

A4E.4 Qualifiers

ID_to_use	PCB170	PCB180	PCB183	PCB184	PCB187	PCB189	PCB195	PCB206	PCB209
FS-01-WG-T		C	C						
NEHC-0032		C	C						
FS-10-WG-T			C						
FS-02-WG-T									
FS-15-WG-T			C						
FS-18-WG-T			C						
FS-17-WG-T		C	C						
nur	113	113	113	107	113	113	113	113	113
	0	0	0	6	0	0	0	0	0
	100%	100%	100%	95%	100%	100%	100%	100%	100%
Qualifier									
D									
J									
R									
RJ									
U									
UY									
C									
C D									
C J									
C RJ									
C U									
D									
DZ									
J									
JY									
R									
RJ									
RJD									
RJY									
U									
UD									
UDY									
UY									
Z									

A4E.5 Normality

Test for normality Null Hypothesis: Data are normally distributed, reject null when p<=0.05
LIN-MUDHOLKAR TEST FOR NORMALITY

All fish all sites

VARIABLE	N	R	P
HOMO_CL1	113	0.8936	0
HOMO_CL2	113	0.9352	0
HOMO_CL3	113	0.9102	0
HOMO_CL4	113	0.9457	0
HOMO_CL5	113	0.9329	0
HOMO_CL6	113	0.936	0
HOMO_CL7	113	0.8825	0
HOMO_CL8	113	0.9463	0
HOMO_CL9	113	0.9575	0
PCB008	113	0.9195	0
PCB018	113	0.9479	0
PCB028	113	0.903	0
PCB044	113	0.947	0
PCB049	113	0.9403	0
PCB052	113	0.9451	0
PCB066	113	0.9492	0
PCB077	113	0.8924	0
PCB081E	113	0.8924	0
PCB087	113	0.9292	0
PCB101	113	0.9355	0
PCB105	113	0.9309	0
PCB114	113	0.9298	0
PCB118	113	0.9367	0
PCB123	113	0.9195	0
PCB126	113	0.9323	0
PCB128	113	0.9328	0
PCB138	113	0.9353	0
PCB153	113	0.9405	0
PCB156E	113	0.9274	0
PCB157E	113	0.9240	0
PCB167	113	0.9384	0
PCB169	113	0.9042	0
PCB170	113	0.9121	0
PCB180	113	0.8949	0
PCB183	113	0.9119	0
PCB184	113	0.8261	0
PCB187	113	0.8719	0
PCB189	113	0.9306	0
PCB195	113	0.9075	0
PCB206	113	0.9579	0

A4E.5 Normality

All fish all sites

VARIABLE	N	R	P	
PCB209	113	0.8722	0	
TPCBW	113	0.9329	0	
ZHOMO_CL1	113	-0.2999	0.0544	Normal
ZHOMO_CL2	113	0.2072	0.1949	Normal
ZHOMO_CL3	113	0.3404	0.0267	
ZHOMO_CL4	113	0.3977	0.008	
ZHOMO_CL5	113	0.4709	0.001	
ZHOMO_CL6	113	0.5445	0	
ZHOMO_CL7	113	0.4908	0.0005	
ZHOMO_CL8	113	0.5776	0	
ZHOMO_CL9	113	0.5704	0	
ZPCB008	113	0.4706	0.0011	
ZPCB018	113	0.2586	0.1013	Normal
ZPCB028	113	0.3798	0.012	
ZPCB044	113	0.4149	0.0052	
ZPCB049	113	0.362	0.0175	
ZPCB052	113	0.2971	0.0569	Normal
ZPCB066	113	0.5286	0.0001	
ZPCB077	113	0.0201	0.9019	Normal
ZPCB081E	113	0.0201	0.9019	Normal
ZPCB087	113	0.2956	0.0583	Normal
ZPCB101	113	0.3845	0.0108	
ZPCB105	113	0.5824	0	
ZPCB114	113	0.5996	0	
ZPCB118	113	0.5924	0	
ZPCB123	113	0.3834	0.0111	
ZPCB126	113	0.3187	0.0396	
ZPCB128	113	0.5949	0	
ZPCB138	113	0.5695	0	
ZPCB153	113	0.6074	0	
ZPCB156E	113	0.6042	0	
ZPCB157E	113	0.6062	0	
ZPCB167	113	0.6027	0	
ZPCB169	113	0.4133	0.0055	
ZPCB170	113	0.5848	0	
ZPCB180	112	0.583	0	
ZPCB183	113	0.561	0	
ZPCB184	113	-0.4779	0.0008	
ZPCB187	113	0.3741	0.0136	
ZPCB189	113	0.654	0	
ZPCB195	113	0.6914	0	
ZPCB206	113	0.5764	0	
ZPCB209	113	0.3766	0.0128	
ZTPCBW	113	0.5133	0.0002	

	All Fish Reference				Vermilion Snapper Reference				White Grunt Reference				Black Sea Bass Reference			
VARIABLE	N	R	P		N	R	P		N	R	P		N	R	P	
HOMO_CL1	62	0.6632	0		22	0.7501	0.0021		20	0.751	0.004		20	0.6207	0.0474	
HOMO_CL2	62	0.7079	0		22	0.0073	0.9845	Normal	20	0.7224	0.009		20	0.8132	0	
HOMO_CL3	62	0.6493	0		22	0.6439	0.0265		20	0.8908	0		20	0.8571	0	
HOMO_CL4	62	0.8677	0		22	0.9404	0		20	0.9888	0		20	0.7919	0.0003	
HOMO_CL5	62	0.9086	0		22	0.7351	0.0037		20	0.9813	0		20	0.9014	0	
HOMO_CL6	62	0.863	0		22	0.7435	0.0028		20	0.9401	0		20	0.9757	0	
HOMO_CL7	62	0.9194	0		22	0.7482	0.0023		20	0.9254	0		20	0.9877	0	
HOMO_CL8	62	0.8696	0		22	0.543	0.0871	Normal	20	0.8677	0		20	0.9513	0	
HOMO_CL9	62	0.7939	0		22	0.5244	0.103	Normal	20	0.8576	0		20	0.8801	0	
PCB008	62	0.6649	0		22	-0.3682	0.292	Normal	20	0.7345	0.006		20	0.8069	0	
PCB018	62	0.7966	0		22	0.0067	0.9857	Normal	20	0.7215	0.009		20	0.6965	0.0151	
PCB028	62	0.6333	0.0001		22	0.7259	0.0049		20	0.9239	0		20	0.8325	0	
PCB044	62	0.8206	0		22	0.9593	0		20	0.9618	0		20	0.7854	0.0006	
PCB049	62	0.8561	0		22	0.9512	0		20	0.9936	0		20	0.8009	0	
PCB052	62	0.8603	0		22	0.9102	0		20	0.9969	0		20	0.8077	0	
PCB066	62	0.8895	0		22	0.9171	0		20	0.9801	0		20	0.7347	0.0064	
PCB077	62	0.6348	0.0001		22	0.8042	0		20	0.9231	0		20	0.8938	0	
PCB081E	62	0.6348	0.0001		22	0.8042	0		20	0.9231	0		20	0.8938	0	
PCB087	62	0.8883	0		22	0.7908	0		20	0.995	0		20	0.8303	0	
PCB101	62	0.9059	0		22	0.7565	0.0016		20	0.9953	0		20	0.8684	0	
PCB105	62	0.9337	0		22	0.6669	0.0183		20	0.9712	0		20	0.9288	0	
PCB114	62	0.9437	0		22	0.5705	0.0665	Normal	20	0.973	0		20	0.8975	0	
PCB118	62	0.9185	0		22	0.7163	0.0064		20	0.9632	0		20	0.9455	0	
PCB123	62	0.8794	0		22	0.7614	0.0012		20	0.9787	0		20	0.7835	0.0008	
PCB126	62	0.5036	0.0084		22	-0.0062	0.9868	Normal	20	0.8398	0		20	0.789	0.0004	
PCB128	62	0.851	0		22	0.6998	0.0096		20	0.9496	0		20	0.9299	0	
PCB138	62	0.8326	0		22	0.7207	0.0057		20	0.9459	0		20	0.9466	0	
PCB153	62	0.8633	0		22	0.7405	0.0031		20	0.9245	0		20	0.988	0	
PCB156E	62	0.8899	0		22	0.6845	0.0132		20	0.9685	0		20	0.9831	0	
PCB157E	62	0.8657	0		22	0.6835	0.0135		20	0.9509	0		20	0.9733	0	
PCB167	62	0.8511	0		22	0.6963	0.0103		20	0.9511	0		20	0.9608	0	
PCB169	62	0.6306	0.0001		22	0.5059	0.1202	Normal	20	0.9369	0		20	0.6784	0.0209	
PCB170	62	0.9052	0		22	0.6742	0.016		20	0.9238	0		20	0.9905	0	
PCB180	62	0.9367	0		22	0.7283	0.0046		20	0.929	0		20	0.9934	0	
PCB183	62	0.9118	0		22	0.7494	0.0022		20	0.9468	0		20	0.9892	0	
PCB184	62	0.7053	0		22	0.5974	0.0493		20	0.8805	0		20	0.8938	0	
PCB187	62	0.9336	0		22	0.7164	0.0064		20	0.8917	0		20	0.9844	0	
PCB189	62	0.8725	0		22	0.6031	0.046		20	0.9177	0		20	0.9874	0	
PCB195	62	0.9266	0		22	0.7035	0.0088		20	0.9518	0		20	0.9883	0	
PCB206	62	0.7994	0		22	0.5475	0.0836	Normal	20	0.8403	0		20	0.8896	0	
PCB209	62	0.7863	0		22	0.7805	0.0002		20	0.8472	0		20	0.8561	0	
TPCBW	62	0.8754	0		22	0.7540	0.0018		20	0.7260	0		20	0.9736	0	
ZHOMO_CL1	62	-0.4178	0.0377		22	-0.4812	0.1455	Normal	20	-0.2071	0.591	Normal	20	-0.4643	0.1859	Normal
ZHOMO_CL2	62	-0.0809	0.7135	Normal	22	-0.73	0.0044		20	-0.1635	0.674	Normal	20	0.2774	0.4642	Normal
ZHOMO_CL3	62	0.0071	0.9745	Normal	22	-0.2318	0.5253	Normal	20	0.5043	0.141	Normal	20	0.4513	0.2016	Normal

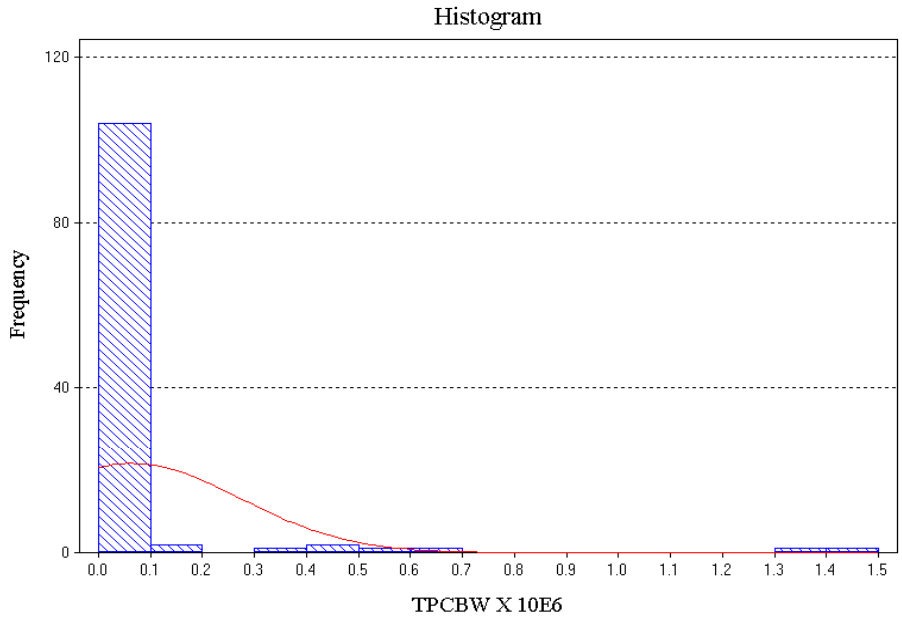
	All Fish Reference				Vermilion Snapper Reference				White Grunt Reference				Black Sea Bass Reference			
VARIABLE	N	R	P		N	R	P		N	R	P		N	R	P	
ZHOMO_CL4	62	0.2286	0.2881	Normal	22	0.7768	0.0003		20	0.8178	0		20	0.3568	0.3336	Normal
ZHOMO_CL5	62	0.2493	0.2441	Normal	22	0.5057	0.1205	Normal	20	0.7957	1E-04		20	0.6236	0.0457	
ZHOMO_CL6	62	-0.0651	0.7677	Normal	22	0.4171	0.2226	Normal	20	0.6918	0.017		20	0.7882	0.0005	
ZHOMO_CL7	62	-0.2367	0.2702	Normal	22	0.3959	0.2516	Normal	20	0.4679	0.182	Normal	20	0.8488	0	
ZHOMO_CL8	62	-0.2751	0.1955	Normal	22	0.1471	0.6916	Normal	20	0.2598	0.495	Normal	20	0.7505	0.004	
ZHOMO_CL9	62	-0.1094	0.6184	Normal	22	0.0212	0.955	Normal	20	0.3506	0.343	Normal	20	0.6564	0.0295	
ZPCB008	62	0.0587	0.79	Normal	22	-0.7716	0.0006		20	0.044	0.911	Normal	20	0.4707	0.1783	Normal
ZPCB018	62	0.3946	0.0523	Normal	22	-0.7043	0.0087		20	-0.0189	0.962	Normal	20	0.3495	0.3448	Normal
ZPCB028	62	0.0132	0.9522	Normal	22	0.0584	0.8759	Normal	20	0.5765	0.077	Normal	20	0.4994	0.1464	Normal
ZPCB044	62	0.1622	0.4568	Normal	22	0.8104	0		20	0.7827	8E-04		20	0.2982	0.4285	Normal
ZPCB049	62	0.1983	0.36	Normal	22	0.7946	0		20	0.7985	0		20	0.3505	0.3434	Normal
ZPCB052	62	0.02	0.928	Normal	22	0.7356	0.0037		20	0.7902	4E-04		20	0.4669	0.1828	Normal
ZPCB066	62	0.1874	0.3878	Normal	22	0.7143	0.0068		20	0.7747	0.001		20	0.1309	0.7375	Normal
ZPCB077	62	-0.1532	0.4829	Normal	22	0.54	0.0896	Normal	20	0.2316	0.546	Normal	20	0.4416	0.2139	Normal
ZPCB081E	62	-0.1532	0.4829	Normal	22	0.54	0.0896	Normal	20	0.2316	0.546	Normal	20	0.4416	0.2139	Normal
ZPCB087	62	0.2396	0.2642	Normal	22	0.5615	0.0729	Normal	20	0.8334	0		20	0.3772	0.3028	Normal
ZPCB101	62	0.1497	0.4932	Normal	22	0.5395	0.0901	Normal	20	0.8313	0		20	0.5542	0.0943	Normal
ZPCB105	62	0.3248	0.1204	Normal	22	0.3749	0.282	Normal	20	0.785	7E-04		20	0.7017	0.0137	
ZPCB114	62	0.3822	0.0615	Normal	22	0.2127	0.5616	Normal	20	0.7876	5E-04		20	0.586	0.0696	Normal
ZPCB118	62	0.3442	0.0974	Normal	22	0.4528	0.1777	Normal	20	0.7753	0.001		20	0.7277	0.0076	
ZPCB123	62	-0.0299	0.8923	Normal	22	0.5112	0.1152	Normal	20	0.7478	0.004		20	-0.2907	0.4412	Normal
ZPCB126	62	-0.4542	0.0212		22	-0.6067	0.044		20	0.1733	0.655	Normal	20	0.4984	0.1474	Normal
ZPCB128	62	0.0683	0.7567	Normal	22	0.3281	0.355	Normal	20	0.7336	0.007		20	0.681	0.02	
ZPCB138	62	0.0151	0.9454	Normal	22	0.3822	0.2712	Normal	20	0.7024	0.014		20	0.6628	0.0268	
ZPCB153	62	0.0677	0.7587	Normal	22	0.4083	0.2345	Normal	20	0.6443	0.035		20	0.8431	0	
ZPCB156E	62	0.1775	0.4144	Normal	22	0.3453	0.3273	Normal	20	0.7571	0.003		20	0.8385	0	
ZPCB157E	62	0.1332	0.5431	Normal	22	0.3454	0.3274	Normal	20	0.7260	0.008		20	0.8072	0	
ZPCB167	62	0.1193	0.5865	Normal	22	0.3753	0.2814	Normal	20	0.7266	0.008		20	0.7179	0.0097	
ZPCB169	62	-0.5183	0.0061		22	-0.066	0.8599	Normal	20	0.6037	0.058	Normal	20	0.2164	0.574	Normal
ZPCB170	62	0.0323	0.8836	Normal	22	0.2732	0.4492	Normal	20	0.57	0.082	Normal	20	0.8561	0	
ZPCB180	62	0.0057	0.9796	Normal	22	0.3463	0.3259	Normal	20	0.494	0.152	Normal	20	0.8712	0	
ZPCB183	62	-0.1469	0.5016	Normal	22	0.3924	0.2566	Normal	20	0.4847	0.162	Normal	20	0.8506	0	
ZPCB184	62	-0.4648	0.0177		22	0.2577	0.4772	Normal	20	-0.0373	0.925	Normal	20	-0.335	0.3679	Normal
ZPCB187	62	-0.2878	0.174	Normal	22	0.3429	0.3312	Normal	20	0.315	0.401	Normal	20	0.8278	0	
ZPCB189	62	0.0203	0.9266	Normal	22	0.2003	0.5857	Normal	20	0.5817	0.073	Normal	20	0.8599	0	
ZPCB195	62	0.0766	0.728	Normal	22	0.3098	0.3854	Normal	20	0.4575	0.194	Normal	20	0.8508	0	
ZPCB206	62	-0.1334	0.5423	Normal	22	-0.0085	0.9818	Normal	20	0.3397	0.36	Normal	20	0.6635	0.0266	
ZPCB209	62	0.3202	0.1264	Normal	22	0.4421	0.1906	Normal	20	0.4693	0.18	Normal	20	0.3902	0.2837	Normal
ZTPCBW	62	-0.082	0.7097	Normal	22	0.4593	0.1699	Normal	20	0.7075	0.012		20	0.8033	0	

	All fish Target				Vermilion Snapper Target				White Grunt Target				Black Sea Bass Target			
VARIABLE	N	R	P		N	R	P		N	R	P		N	R	P	
HOMO_CL1	51	0.9468	0		20	0.2616	0.492	Normal	20	0.9617	0		11	0.2601	0.6212	Normal
HOMO_CL2	51	0.939	0		20	-0.3698	0.3138	Normal	20	0.9373	0		11	0.6026	0.1763	Normal
HOMO_CL3	51	0.9017	0		20	-0.4299	0.2289	Normal	20	0.8671	0		11	0.4792	0.322	Normal
HOMO_CL4	51	0.9413	0		20	0.7509	0.0039		20	0.9187	0		11	0.7295	0.0618	Normal
HOMO_CL5	51	0.9256	0		20	0.8823	0		20	0.89	0		11	0.6041	0.1747	Normal
HOMO_CL6	51	0.9284	0		20	0.9118	0		20	0.8954	0		11	0.3212	0.5348	Normal
HOMO_CL7	51	0.8667	0		20	0.9543	0		20	0.8145	0		11	0.4631	0.3426	Normal
HOMO_CL8	51	0.9429	0		20	0.9526	0		20	0.9348	0		11	0.782	0.0299	
HOMO_CL9	51	0.9572	0		20	0.9198	0		20	0.9563	0		11	0.8213	0.0132	
PCB008	51	0.9161	0		20	0.0493	0.9003	Normal	20	0.8983	0		11	0.3381	0.5111	Normal
PCB018	51	0.9514	0		20	-0.0305	0.9383	Normal	20	0.9492	0		11	0.707	0.0786	Normal
PCB028	51	0.8948	0		20	-0.0751	0.8484	Normal	20	0.8581	0		11	0.6939	0.0892	Normal
PCB044	51	0.9442	0		20	0.1683	0.6649	Normal	20	0.9245	0		11	0.7782	0.0318	
PCB049	51	0.933	0		20	0.6909	0.0168		20	0.9003	0		11	0.6143	0.1641	Normal
PCB052	51	0.9398	0		20	0.6695	0.0242		20	0.9115	0		11	0.7593	0.0424	
PCB066	51	0.9452	0		20	0.8535	0		20	0.9273	0		11	0.4633	0.3424	Normal
PCB077	51	0.887	0		20	0.7023	0.0135		20	0.8606	0		11	0.6239	0.1541	Normal
PCB081E	51	0.887	0		20	0.7023	0.0135		20	0.8606	0		11	0.6239	0.1541	Normal
PCB087	51	0.921	0		20	0.835	0		20	0.8815	0		11	0.6512	0.1272	Normal
PCB101	51	0.9259	0		20	0.8908	0		20	0.8769	0		11	0.5753	0.2063	Normal
PCB105	51	0.922	0		20	0.9001	0		20	0.8827	0		11	-0.0737	0.8919	Normal
PCB114	51	0.9241	0		20	0.908	0		20	0.9014	0		11	0.6599	0.119	Normal
PCB118	51	0.9314	0		20	0.9092	0		20	0.9083	0		11	0.579	0.2022	Normal
PCB123	51	0.9103	0		20	0.9188	0		20	0.8709	0		11	0.4225	0.3958	Normal
PCB126	51	0.9145	0		20	0.8927	0		20	0.827	0		11	0.8673	0.0019	
PCB128	51	0.921	0		20	0.9323	0		20	0.866	0		11	0.1682	0.7538	Normal
PCB138	51	0.9269	0		20	0.9353	0		20	0.8905	0		11	0.1202	0.8238	Normal
PCB153	51	0.9351	0		20	0.9033	0		20	0.9131	0		11	0.1166	0.8291	Normal
PCB156E	51	0.9167	0		20	0.9391	0		20	0.8721	0		11	0.6092	0.1693	Normal
PCB157E	51	0.9129	0		20	0.942	0		20	0.866	0		11	0.4678	0.3365	Normal
PCB167	51	0.9309	0		20	0.94	0		20	0.899	0		11	0.4874	0.3116	Normal
PCB169	51	0.9028	0		20	0.9011	0		20	0.9	0		11	0.8899	0	
PCB170	51	0.8961	0		20	0.9355	0		20	0.8294	0		11	-0.1796	0.7372	Normal
PCB180	51	0.8864	0		20	0.9627	0		20	0.8604	0		11	0.2742	0.6012	Normal
PCB183	51	0.8993	0		20	0.9322	0		20	0.8522	0		11	0.43	0.3859	Normal
PCB184	51	0.8766	0		20	0.9054	0		20	0.8719	0		11	0.7739	0.0341	
PCB187	51	0.859	0		20	0.9739	0		20	0.819	0		11	0.7363	0.0571	Normal
PCB189	51	0.9204	0		20	0.8994	0		20	0.8797	0		11	0.2902	0.5784	Normal
PCB195	51	0.898	0		20	0.9593	0		20	0.8743	0		11	0.6624	0.1167	Normal
PCB206	51	0.9573	0		20	0.9224	0		20	0.9551	0		11	0.824	0.0123	
PCB209	51	0.8914	0		20	0.8984	0		20	0.9209	0		11	0.6908	0.0918	Normal
TPCBW	51	0.9248	0		20	0.9096	0		20	0.8892	0		11	0.4793	0.3219	
ZHOMO_CL1	51	0.2955	0.205	Normal	20	-0.5549	0.0936	Normal	20	0.4233	0.238	Normal	11	-0.544	0.2423	Normal
ZHOMO_CL2	51	0.7052	0		20	-0.7429	0.005		20	0.499	0.147	Normal	11	-0.3379	0.5114	Normal

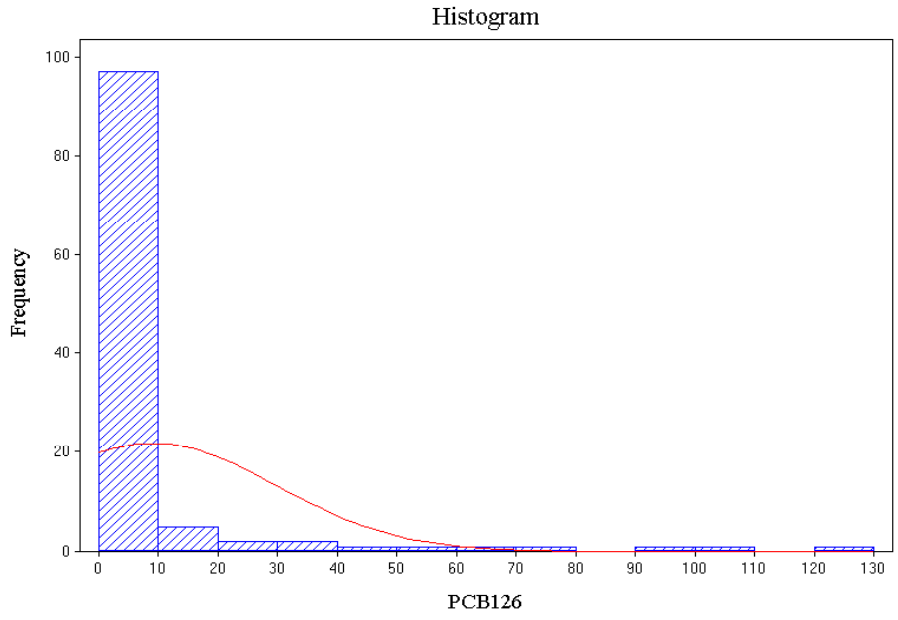
	All fish Target				Vermilion Snapper Target				White Grunt Target				Black Sea Bass Target			
VARIABLE	N	R	P		N	R	P		N	R	P		N	R	P	
ZHOMO_CL3	51	0.7636	0		20	-0.8166	0		20	0.3739	0.308	Normal	11	-0.3785	0.4553	Normal
ZHOMO_CL4	51	0.6686	0		20	-0.3949	0.2769	Normal	20	0.4978	0.148	Normal	11	-0.2162	0.6842	Normal
ZHOMO_CL5	51	0.6115	0.0013		20	0.1959	0.6122	Normal	20	0.5805	0.074	Normal	11	-0.3633	0.4761	Normal
ZHOMO_CL6	51	0.5805	0.0034		20	0.4016	0.2675	Normal	20	0.5395	0.107	Normal	11	-0.546	0.24	Normal
ZHOMO_CL7	51	0.5118	0.0147		20	0.57	0.0815	Normal	20	0.0741	0.85	Normal	11	-0.3183	0.5388	Normal
ZHOMO_CL8	51	0.5557	0.0061		20	0.7057	0.0126		20	0.0575	0.884	Normal	11	0.2654	0.6138	Normal
ZHOMO_CL9	51	0.541	0.0084		20	0.7482	0.0043		20	0.1887	0.626	Normal	11	0.288	0.5816	Normal
ZPCB008	51	0.7824	0		20	-0.6221	0.0466		20	0.6188	0.048		11	-0.4553	0.3528	Normal
ZPCB018	51	0.5772	0.0037		20	-0.6797	0.0205		20	0.4408	0.215	Normal	11	-0.4769	0.3249	Normal
ZPCB028	51	0.7257	0		20	-0.7277	0.0076		20	0.5055	0.14	Normal	11	-0.0432	0.9366	Normal
ZPCB044	51	0.7053	0		20	-0.7336	0.0065		20	0.4729	0.176	Normal	11	-0.0921	0.8649	Normal
ZPCB049	51	0.7062	0		20	-0.4733	0.1753	Normal	20	0.3654	0.32	Normal	11	-0.3593	0.4817	Normal
ZPCB052	51	0.6618	0.0001		20	-0.5055	0.14	Normal	20	0.5163	0.129	Normal	11	-0.1509	0.7791	Normal
ZPCB066	51	0.6138	0.0012		20	-0.0472	0.9045	Normal	20	0.5414	0.105	Normal	11	-0.4436	0.368	Normal
ZPCB077	51	0.7246	0		20	-0.0551	0.8887	Normal	20	0.5022	0.143	Normal	11	-0.2962	0.57	Normal
ZPCB081E	51	0.7246	0		20	-0.0551	0.8887	Normal	20	0.5022	0.143	Normal	11	-0.2962	0.57	Normal
ZPCB087	51	0.6976	0		20	0.0067	0.9864	Normal	20	0.604	0.058	Normal	11	-0.32	0.5364	Normal
ZPCB101	51	0.6376	0.0005		20	0.3133	0.4032	Normal	20	0.6349	0.04		11	-0.3797	0.4537	Normal
ZPCB105	51	0.5581	0.0058		20	0.3998	0.2701	Normal	20	0.5818	0.073	Normal	11	-0.6601	0.1188	Normal
ZPCB114	51	0.5421	0.0082		20	0.4682	0.1812	Normal	20	0.5654	0.085	Normal	11	-0.3144	0.5443	Normal
ZPCB118	51	0.5222	0.0122		20	0.3701	0.3134	Normal	20	0.5663	0.084	Normal	11	-0.3842	0.4475	Normal
ZPCB123	51	0.5895	0.0026		20	0.5186	0.1268	Normal	20	0.5008	0.145	Normal	11	-0.4761	0.326	Normal
ZPCB126	51	0.5138	0.0142		20	0.3934	0.2792	Normal	20	0.0805	0.838	Normal	11	0.3019	0.5619	Normal
ZPCB128	51	0.5876	0.0028		20	0.4104	0.2552	Normal	20	0.5527	0.096	Normal	11	-0.5929	0.1869	Normal
ZPCB138	51	0.5827	0.0032		20	0.4071	0.2598	Normal	20	0.5537	0.095	Normal	11	-0.6069	0.1717	Normal
ZPCB153	51	0.5216	0.0123		20	0.4804	0.1671	Normal	20	0.4715	0.177	Normal	11	-0.6142	0.1641	Normal
ZPCB156E	51	0.5871	0.0028		20	0.5158	0.1295	Normal	20	0.5932	0.065	Normal	11	-0.3164	0.5415	Normal
ZPCB157E	51	0.5564	0.006		20	0.5000	0.1457	Normal	20	0.5821	0.072	Normal	11	-0.4092	0.4137	Normal
ZPCB167	51	0.5668	0.0047		20	0.5345	0.1116	Normal	20	0.5854	0.07	Normal	11	-0.4721	0.331	Normal
ZPCB169	51	0.5415	0.0083		20	0.5738	0.0786	Normal	20	0.3696	0.314	Normal	11	0.542	0.2448	Normal
ZPCB170	51	0.4671	0.0307		20	0.5506	0.0973	Normal	20	0.2232	0.561	Normal	11	-0.5938	0.1859	Normal
ZPCB180	50	0.4888	0.0232		20	0.6213	0.047		19	0.1324	0.741	Normal	11	-0.4462	0.3646	Normal
ZPCB183	51	0.5499	0.0069		20	0.5184	0.1269	Normal	20	0.1963	0.612	Normal	11	-0.33	0.5224	Normal
ZPCB184	51	0.4424	0.0435		20	0.5144	0.1309	Normal	20	0.3045	0.418	Normal	11	0.3962	0.4312	Normal
ZPCB187	51	0.4767	0.0265		20	0.6301	0.0422		20	-0.051	0.897	Normal	11	0.1093	0.8397	Normal
ZPCB189	51	0.5913	0.0025		20	0.6256	0.0446		20	0.415	0.249	Normal	11	-0.4283	0.3882	Normal
ZPCB195	51	0.4607	0.0337		20	0.6836	0.0191		20	-0.0358	0.928	Normal	11	-0.1278	0.8127	Normal
ZPCB206	51	0.5481	0.0072		20	0.7551	0.0034		20	0.1982	0.608	Normal	11	0.2831	0.5885	Normal
ZPCB209	51	0.3314	0.1502	Normal	20	0.774	0.0015		20	0.3217	0.39	Normal	11	0.1149	0.8315	Normal
ZTPCBW	51	0.5803	0.0034		20	0.2557	0.5024	Normal	20	0.5426	0.104	Normal	11	-0.4525	0.3564	Normal

All Fish From Both Reefs

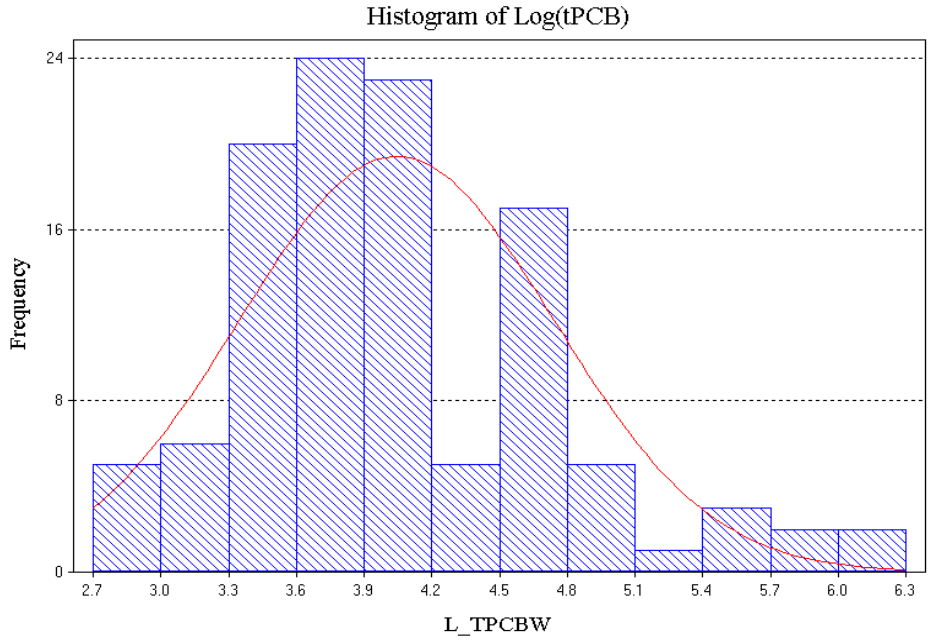
A. tPCB (pg/g wet weight)



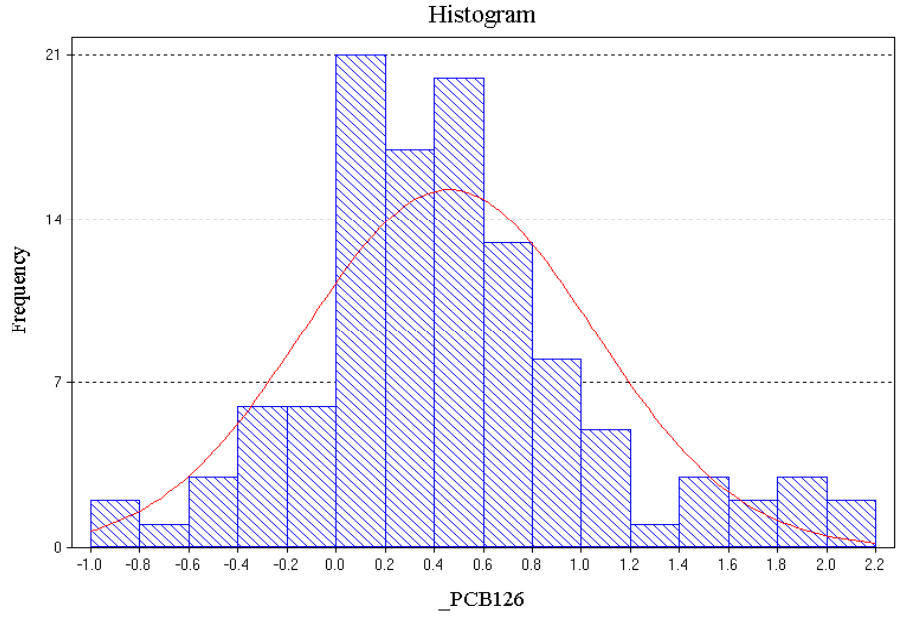
B. PCB126 (pg/g wet weight)



C. LOG(tPCB) (pg/g wet weight)

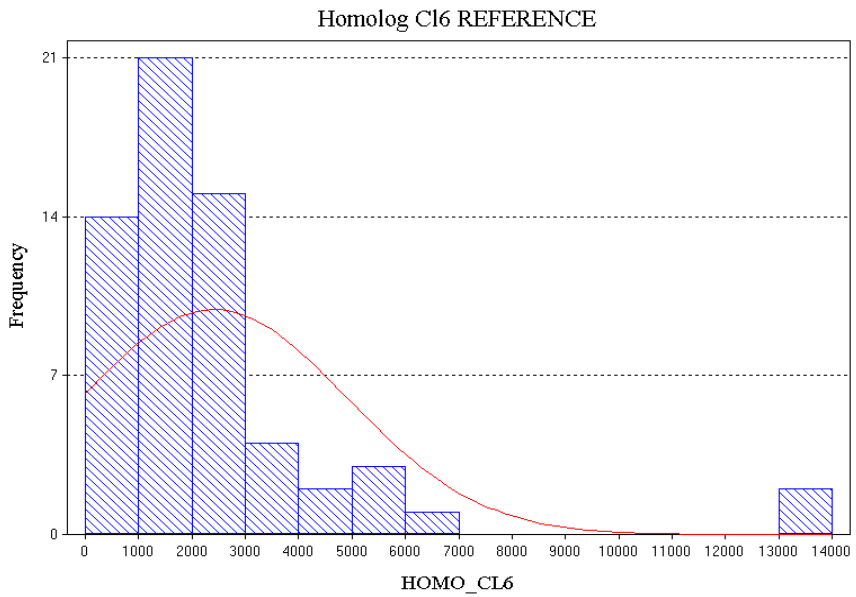


D. LOG(tPCB) (pg/g wet weight)

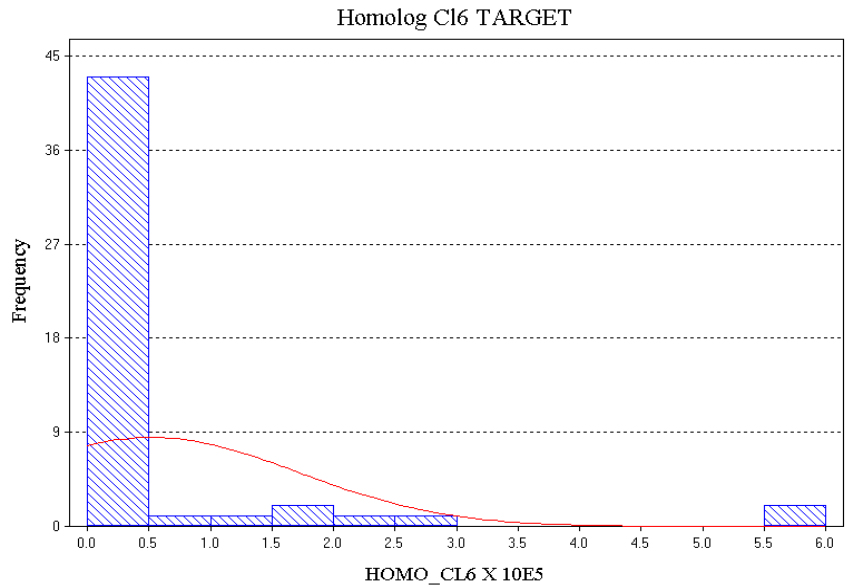


Histograms of tPCB and PCB126 measured in all fish from target and reference reefs combined.

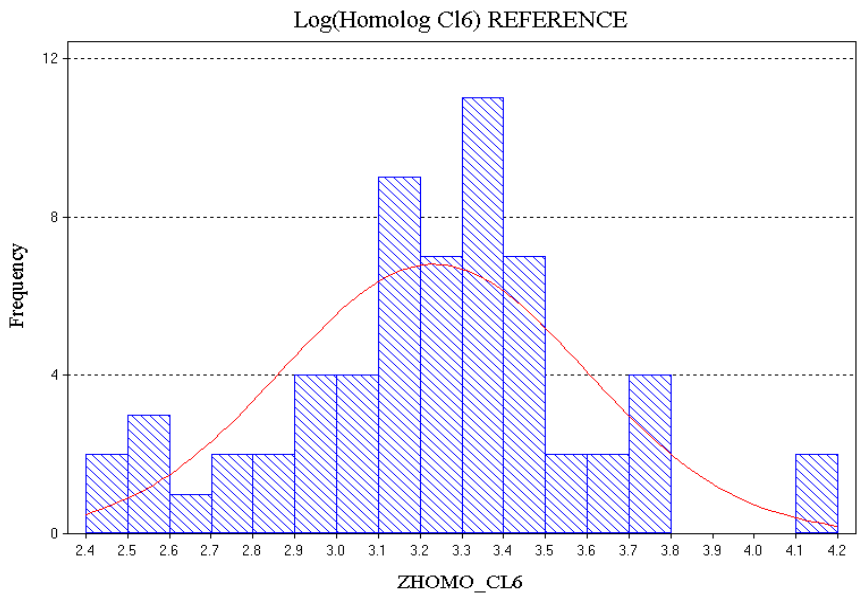
E. Reference HOMO_CL6 (pg/g wet weight)



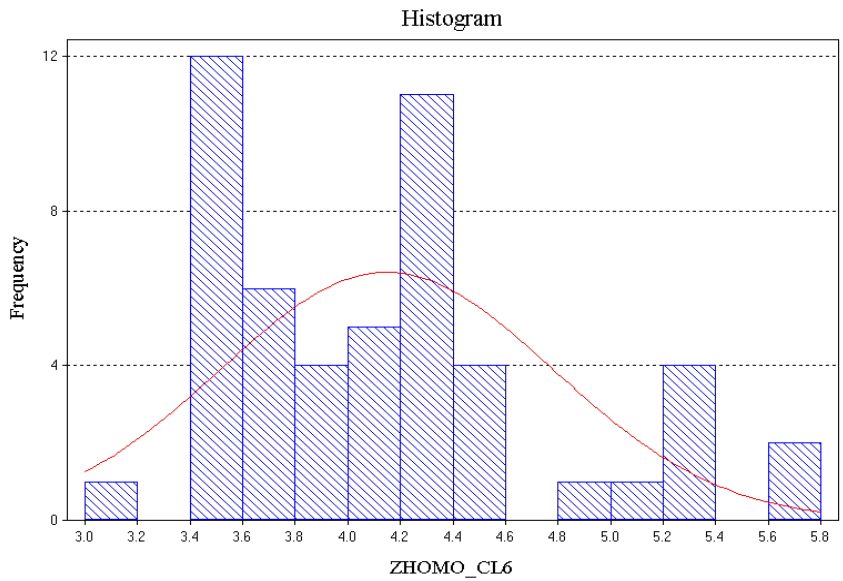
F. Target HOMO_CL6 (pg/g wet weight)



G. Reference LOG(HOMO_CL6) (pg/g wet weight)

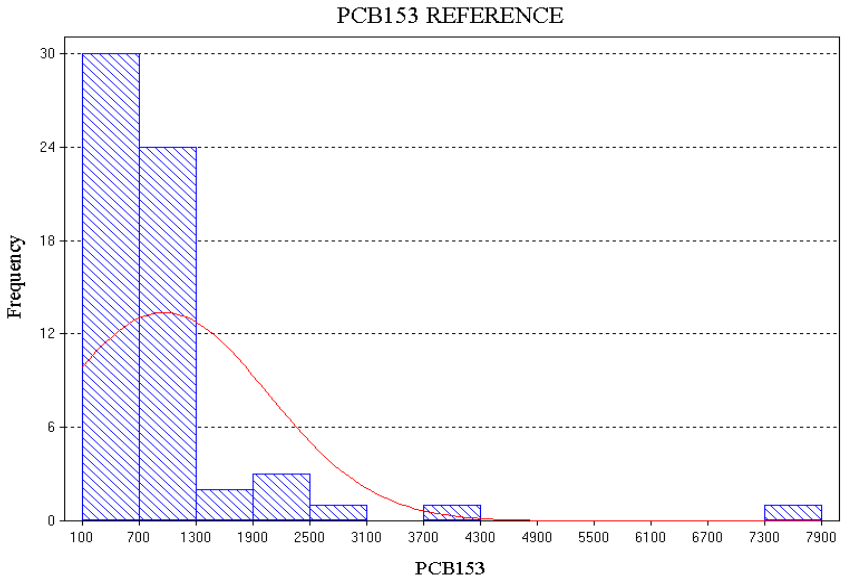


H. Target LOG(HOMO_CL6) (pg/g wet weight)

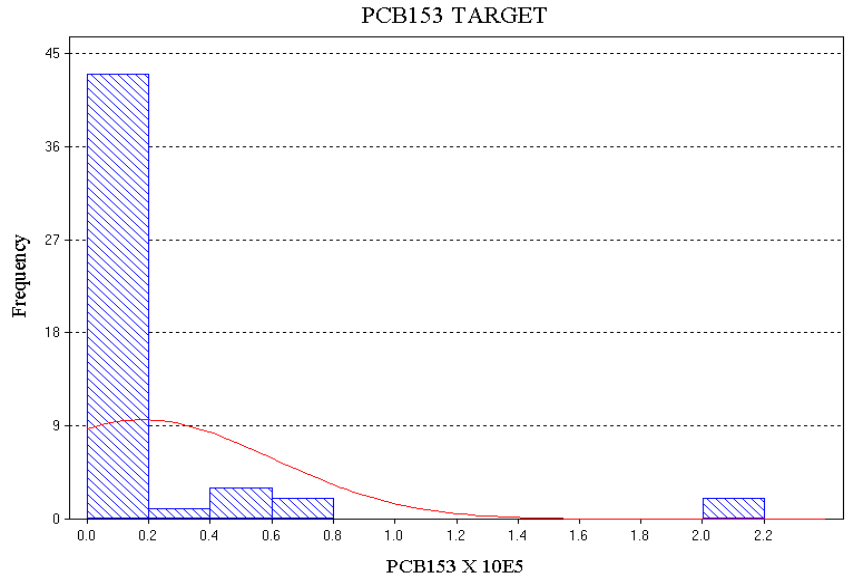


Histograms of hexachlorobiphenyl (HOMO_CL6) measured in all fish from target and reference reefs.

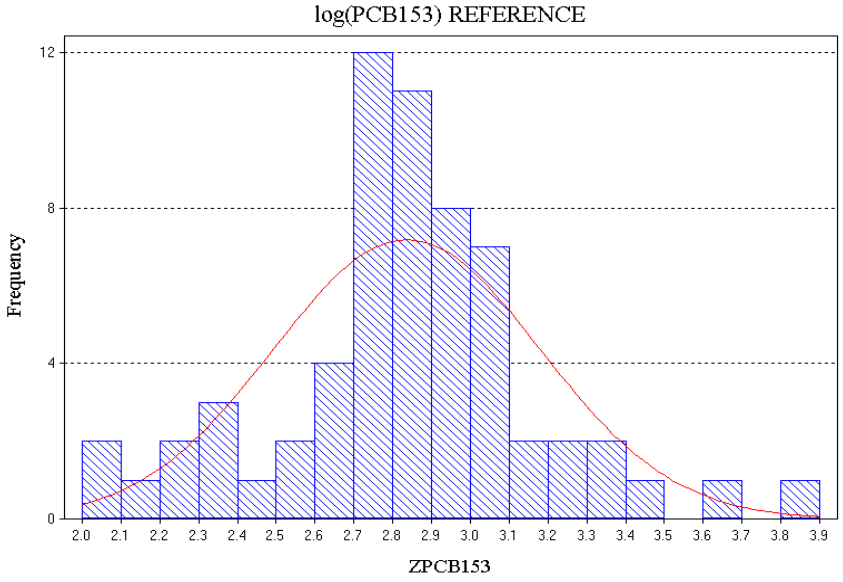
I. Reference PBC153 (pg/g wet weight)



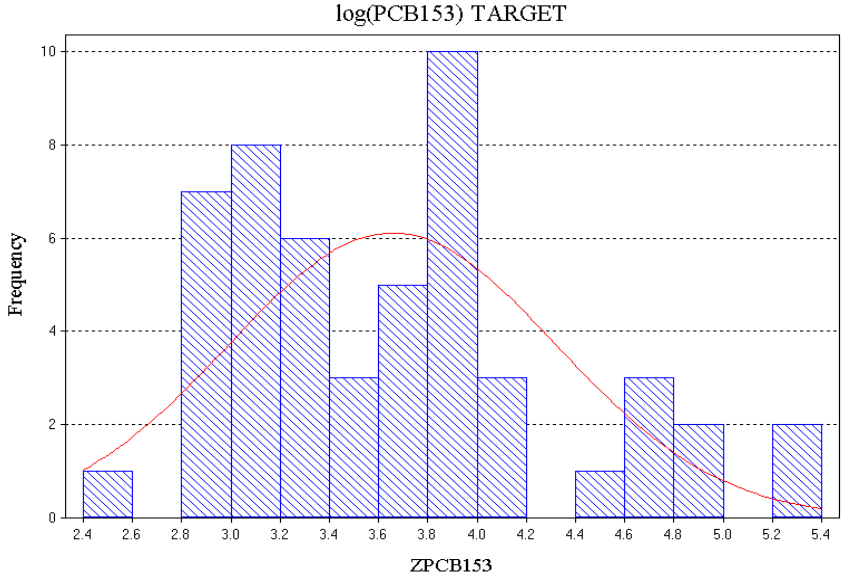
J. Target PBC153 (pg/g wet weight)



K. Reference LOG(PBC153) (pg/g wet weight)



L. Target LOG(PBC153) (pg/g wet weight)



Histograms of PCB153 measured in all fish from target and reference reefs.

Descriptive Statistics for congeners and homologs measured in supplemental fish samples (pg/g wet)

	ALL FISH Reference					Vermilion Snapper Reference					Black Sea Bass Reference					White Grunt Reference				
VARIABLE	N	MEAN	SD	MIN	MAX	N	MEAN	SD	MIN	MAX	N	MEAN	SD	MIN	MAX	N	MEAN	SD	MIN	MAX
PCB008	62	2.1	1.6	0.4	6.0	22	3.8	1.3	0.8	6.0	20	1.0	0.5	0.5	2.6	20	1.5	1.0	0.4	3.8
PCB018	62	3.2	3.3	0.4	12.5	22	6.9	2.8	1.3	12.5	20	0.8	0.4	0.4	2.0	20	1.4	0.8	0.4	3.5
PCB028	62	11.3	9.6	1.8	48.0	22	20.5	8.2	7.8	48.0	20	5.5	4.6	1.8	21.2	20	6.9	6.8	1.8	24.6
PCB044	62	26.4	28.1	3.9	161.0	22	45.2	26.8	27.9	161.0	20	14.6	11.4	4.0	52.1	20	17.4	31.2	3.9	144.0
PCB049	62	18.4	25.6	1.6	155.0	22	34.1	20.6	19.0	122.0	20	7.3	6.7	1.7	29.0	20	12.3	33.8	1.6	155.0
PCB052	62	43.4	62.8	2.9	446.0	22	72.0	32.2	44.6	204.0	20	24.2	20.7	6.7	92.2	20	31.2	97.9	2.9	446.0
PCB066	62	37.1	51.6	4.9	378.0	22	50.6	30.5	26.0	176.0	20	25.5	17.2	6.1	75.6	20	33.8	82.8	4.9	378.0
PCB077	62	3.1	3.3	0.1	15.6	22	6.8	2.4	4.2	15.6	20	1.1	1.1	0.2	4.0	20	1.1	1.8	0.1	7.9
PCB087	62	95.6	157.7	6.9	1170.0	22	161.4	57.0	92.8	365.0	20	37.2	33.5	9.5	153.0	20	81.6	257.4	6.9	1170.0
PCB101	62	229.5	376.0	15.0	2850.0	22	351.3	140.2	187.0	785.0	20	127.4	98.2	45.7	488.0	20	197.7	627.1	15.0	2850.0
PCB105	62	144.4	231.9	19.0	1810.0	22	164.7	53.8	94.5	271.0	20	102.3	79.5	45.7	417.0	20	164.1	400.5	19.0	1810.0
PCB114	62	8.3	14.4	1.1	113.0	22	9.0	3.2	4.9	17.0	20	5.7	4.3	1.9	22.1	20	10.0	25.0	1.1	113.0
PCB118	62	424.6	648.0	60.8	4970.0	22	471.8	185.3	257.0	862.0	20	318.4	268.3	138.0	1400.0	20	479.0	1104.7	60.8	4970.0
PCB123	62	5.3	7.6	0.3	56.4	22	8.0	2.8	4.7	14.4	20	2.9	2.2	0.3	8.6	20	4.7	12.5	0.3	56.4
PCB126	62	1.7	1.2	0.1	4.4	22	2.7	0.8	1.0	4.4	20	1.4	1.1	0.4	4.2	20	0.8	0.9	0.1	3.8
PCB128	62	100.3	109.8	13.0	795.0	22	123.8	48.4	62.0	243.0	20	85.0	60.4	36.3	325.0	20	89.7	177.4	13.0	795.0
PCB138	62	659.1	704.1	75.0	4710.0	22	830.4	341.0	417.0	1590.0	20	584.2	544.0	202.0	2780.0	20	545.6	1055.3	75.0	4710.0
PCB153	62	958.6	1108.1	118.0	7830.0	22	1055.3	512.4	502.0	2220.0	20	1148.8	1590.1	459.0	7830.0	20	661.9	990.8	118.0	4170.0
PCB167	62	29.5	33.8	3.8	231.0	22	36.4	15.6	18.3	78.1	20	25.9	25.7	9.8	131.0	20	25.7	51.5	3.8	231.0
PCB169	62	0.4	0.3	0.0	1.6	22	0.4	0.2	0.2	0.8	20	0.4	0.2	0.2	0.9	20	0.2	0.3	0.0	1.6
PCB170	62	105.1	145.2	9.9	1100.0	22	101.7	53.8	43.3	261.0	20	149.2	225.8	56.4	1100.0	20	64.7	98.8	9.9	437.0
PCB180	62	296.8	457.7	23.3	3610.0	22	293.8	154.7	134.0	688.0	20	443.5	749.9	150.0	3610.0	20	153.3	198.5	23.3	801.0
PCB183	62	100.2	133.4	7.5	1040.0	22	106.6	53.8	49.5	239.0	20	146.2	212.5	54.8	1040.0	20	47.3	59.7	7.5	228.0
PCB184	62	1.5	1.5	0.0	6.1	22	3.1	1.1	1.7	6.1	20	0.6	0.8	0.0	3.5	20	0.7	0.6	0.1	3.0
PCB187	62	268.0	412.0	15.0	3250.0	22	235.8	113.9	108.0	537.0	20	485.8	660.1	188.0	3250.0	20	85.5	93.1	15.0	353.0
PCB189	62	5.2	5.7	0.6	42.2	22	5.7	2.2	3.0	10.9	20	6.4	8.5	2.7	42.2	20	3.5	4.8	0.6	20.4
PCB195	62	12.7	17.5	1.1	138.0	22	11.0	5.7	5.1	23.8	20	20.2	28.0	8.1	138.0	20	6.9	7.9	1.1	29.4
PCB206	62	97.4	90.5	11.4	637.0	22	82.2	33.6	38.9	151.0	20	163.9	125.0	71.9	637.0	20	47.7	43.7	11.4	203.0
PCB209	62	25.0	24.4	5.2	152.0	22	14.1	8.8	5.7	41.3	20	47.0	30.6	14.5	152.0	20	15.0	11.9	5.2	56.7

	ALL FISH Target					Vermilion Snapper Target					Black Sea Bass Target					White Grunt Target				
VARIABLE	N	MEAN	SD	MIN	MAX	N	MEAN	SD	MIN	MAX	N	MEAN	SD	MIN	MAX	N	MEAN	SD	MIN	MAX
PCB008	51	17.6	44.9	1.5	280.0	20	4.2	1.2	1.5	7.1	11	5.2	2.4	1.8	9.9	20	37.7	67.9	2.6	280.0
PCB018	51	77.3	228.3	3.7	1580.0	20	24.5	8.4	6.2	40.9	11	24.6	17.4	3.7	66.7	20	159.0	354.0	6.1	1580.0
PCB028	51	119.6	253.2	6.9	1460.0	20	25.5	7.5	6.9	42.0	11	49.6	35.2	13.2	128.0	20	252.1	370.6	19.7	1460.0
PCB044	51	1001.6	2410.8	26.6	12000.0	20	142.7	51.3	26.6	255.0	11	336.1	209.7	97.6	872.0	20	2226.6	3557.5	109.0	12000.0
PCB049	51	1309.1	3389.8	20.0	17600.0	20	121.2	63.1	20.0	280.0	11	256.1	149.2	74.4	548.0	20	3076.3	4980.8	83.7	17600.0
PCB052	51	3228.8	7987.9	59.7	41000.0	20	395.4	209.4	59.7	942.0	11	1087.5	747.4	281.0	2840.0	20	7239.9	11812.0	281.0	41000.0
PCB066	51	1669.8	4373.6	23.6	22700.0	20	138.6	99.1	23.6	460.0	11	382.4	208.3	102.0	814.0	20	3908.9	6449.8	210.0	22700.0
PCB077	51	28.1	63.0	1.7	389.0	20	6.7	2.9	2.5	14.5	11	9.4	6.4	1.7	21.9	20	59.8	93.2	3.7	389.0
PCB087	51	3989.5	9391.2	112.0	49200.0	20	590.5	402.4	112.0	1860.0	11	1076.5	704.9	251.0	2640.0	20	8990.8	13721.0	615.0	49200.0
PCB101	51	8657.3	19480.0	205.0	92200.0	20	1105.8	955.6	205.0	4280.0	11	2819.4	1844.9	610.0	6780.0	20	19420.0	28182.0	1480.0	92200.0
PCB105	51	4513.2	10149.0	86.7	50200.0	20	464.3	434.0	86.7	1980.0	11	1213.5	606.1	339.0	2060.0	20	10377.0	14524.0	796.0	50200.0
PCB114	51	290.6	708.3	5.0	3880.0	20	26.4	25.5	5.0	110.0	11	75.5	48.3	19.0	188.0	20	673.0	1031.6	50.0	3880.0
PCB118	51	13239.0	30701.0	234.0	156000.0	20	1281.6	1165.1	234.0	5060.0	11	3946.4	2427.0	950.0	9390.0	20	30308.0	44370.0	2530.0	156000.0
PCB123	51	148.2	336.4	3.4	1800.0	20	17.9	18.5	3.4	81.9	11	46.0	26.7	10.7	98.6	20	334.8	486.4	23.1	1800.0
PCB126	51	10.1	15.9	0.4	65.4	20	2.6	2.7	0.4	12.2	11	5.8	4.9	1.3	15.6	20	20.0	21.7	1.6	65.4
PCB128	51	2499.3	5530.7	50.5	26200.0	20	239.5	201.0	50.5	824.0	11	701.2	383.6	177.0	1350.0	20	5748.0	7875.4	384.0	26200.0
PCB138	51	15800.0	36561.0	298.0	179000.0	20	1517.0	1336.4	298.0	5430.0	11	4312.7	2330.3	1090.0	8420.0	20	36401.0	52680.0	2530.0	179000.0
PCB153	51	17971.0	42468.0	305.0	212000.0	20	1548.0	1521.9	305.0	7150.0	11	5280.9	2799.0	1350.0	10400.0	20	41373.0	61532.0	2380.0	212000.0
PCB167	51	694.4	1640.6	12.6	7970.0	20	60.0	56.6	12.6	229.0	11	195.8	117.7	43.9	446.0	20	1603.0	2374.1	112.0	7970.0
PCB169	51	3.0	6.9	0.1	44.5	20	0.5	0.4	0.1	2.2	11	1.6	1.5	0.4	5.6	20	6.3	10.2	0.4	44.5
PCB170	51	1495.2	3023.4	26.9	15000.0	20	136.7	155.1	26.9	751.0	11	477.2	239.5	127.0	763.0	20	3413.6	4193.4	201.0	15000.0
PCB180	51	4151.3	9470.5	0.0	55800.0	20	382.2	507.5	71.6	2460.0	11	1156.8	634.5	311.0	2160.0	20	9567.5	13584.0	0.0	55800.0
PCB183	51	1619.4	3652.5	27.9	19600.0	20	127.7	127.8	27.9	633.0	11	405.4	233.4	110.0	759.0	20	3778.8	5192.1	155.0	19600.0
PCB184	51	3.4	3.6	0.6	17.1	20	2.5	1.5	0.9	8.2	11	2.8	2.2	0.8	7.9	20	4.7	5.1	0.6	17.1
PCB187	51	2754.8	5440.0	62.3	31500.0	20	314.1	414.1	62.3	2030.0	11	1136.4	736.1	331.0	2250.0	20	6085.6	7612.9	271.0	31500.0
PCB189	51	74.8	168.9	1.7	826.0	20	6.1	5.4	1.7	25.9	11	19.2	10.2	5.3	34.8	20	174.1	240.4	8.8	826.0
PCB195	51	284.8	664.7	2.9	3750.0	20	13.8	19.0	2.9	91.1	11	52.1	35.3	12.1	124.0	20	683.8	941.0	23.1	3750.0
PCB206	51	653.7	1685.6	21.0	9330.0	20	60.7	57.8	21.0	283.0	11	238.9	184.1	62.8	700.0	20	1474.9	2505.3	53.7	9330.0
PCB209	51	47.7	77.8	3.4	424.0	20	8.1	7.0	3.4	34.2	11	60.0	40.3	18.8	148.0	20	80.5	110.3	6.6	424.0

VARIABLE	ALL FISH Reference N	MEAN	SD	MIN	MAX	Vermilion Snapper Reference N	MEAN	SD	MIN	MAX	Black Sea Bass Reference N	MEAN	SD	MIN	MAX	White Grunt Reference N	MEAN	SD	MIN	MAX
HOMO_CL1	62	0.8	0.6	0.1	3.5	22	1.0	0.7	0.1	3.5	20	0.7	0.5	0.1	2.0	20	0.5	0.5	0.1	1.8
HOMO_CL2	62	6.8	6.1	0.4	24.5	22	13.3	5.0	2.4	24.5	20	2.6	1.4	0.9	7.4	20	3.7	3.2	0.4	12.8
HOMO_CL3	62	36.2	34.7	2.7	167.0	22	73.1	28.5	23.6	167.0	20	11.1	10.0	2.7	46.8	20	20.7	19.4	5.1	73.7
HOMO_CL4	62	238.0	341.1	26.0	2390.0	22	389.9	205.5	231.0	1260.0	20	115.6	93.5	29.0	422.0	20	193.3	523.0	26.0	2390.0
HOMO_CL5	62	1433.5	2181.5	163.0	16700.0	22	1993.6	731.2	1090.0	4040.0	20	846.3	683.9	318.0	3470.0	20	1404.5	3673.2	163.0	16700.0
HOMO_CL6	62	2412.1	2497.5	253.0	13900.0	22	3026.8	1272.3	1500.0	5870.0	20	2442.3	2758.5	926.0	13900.0	20	1705.7	3108.7	253.0	13800.0
HOMO_CL7	62	970.4	1324.7	62.4	10400.0	22	987.6	454.3	472.0	2130.0	20	1505.0	2117.5	592.0	10400.0	20	416.9	546.0	62.4	2240.0
HOMO_CL8	62	373.9	408.0	28.2	3110.0	22	342.9	120.8	194.0	665.0	20	624.2	613.4	281.0	3110.0	20	157.7	160.8	28.2	742.0
HOMO_CL9	62	150.0	137.8	19.1	957.0	22	122.0	46.2	62.8	220.0	20	256.1	187.3	116.0	957.0	20	74.9	70.0	19.1	330.0
PCB209	62	25.0	24.4	5.2	152.0	22	14.1	8.8	5.7	41.3	20	47.0	30.6	14.5	152.0	20	15.0	11.9	5.2	56.7

VARIABLE	ALL FISH Target N	MEAN	SD	MIN	MAX	Vermilion Snapper Target N	MEAN	SD	MIN	MAX	Black Sea Bass Target N	MEAN	SD	MIN	MAX	White Grunt Target N	MEAN	SD	MIN	MAX
HOMO_CL1	51	2.0	2.4	0.4	18.0	20	1.5	0.4	0.6	2.7	11	1.9	0.8	0.7	3.5	20	2.5	3.8	0.4	18.0
HOMO_CL2	51	59.1	152.9	5.4	1050.0	20	17.6	4.8	5.4	25.4	11	22.5	13.0	5.8	51.5	20	120.6	234.2	7.6	1050.0
HOMO_CL3	51	1020.4	2571.0	36.7	14900.0	20	148.5	40.8	36.7	218.0	11	234.7	140.2	61.7	511.0	20	2324.4	3799.3	77.6	14900.0
HOMO_CL4	51	12557.0	31618.0	239.0	163000.0	20	1415.4	780.5	239.0	3600.0	11	3287.3	2106.0	884.0	8400.0	20	28797.0	46581.0	1410.0	163000.0
HOMO_CL5	51	47966.0	107870.0	1150.0	538000.0	20	6165.0	4851.0	1150.0	21700.0	11	14940.0	9328.2	3590.0	36000.0	20	107931.0	155870.0	9080.0	538000.0
HOMO_CL6	51	52080.0	119520.0	1070.0	581000.0	20	5290.0	4581.0	1070.0	20000.0	11	15407.0	8567.3	3820.0	32600.0	20	119041.0	172423.0	8210.0	581000.0
HOMO_CL7	51	13456.0	27830.0	268.0	156000.0	20	1303.6	1494.6	268.0	7370.0	11	4172.7	2385.9	1140.0	7850.0	20	30715.0	38910.0	1430.0	156000.0
HOMO_CL8	51	5194.9	12432.0	103.0	62200.0	20	389.9	441.6	103.0	2170.0	11	1311.4	957.2	352.0	3240.0	20	12136.0	17953.0	416.0	62200.0
HOMO_CL9	51	919.1	2294.2	33.1	12600.0	20	93.3	85.0	33.1	419.0	11	378.9	291.9	101.0	1110.0	20	2041.9	3403.8	79.9	12600.0
PCB209	51	47.7	77.8	3.4	424.0	20	8.1	7.0	3.4	34.2	11	60.0	40.3	18.8	148.0	20	80.5	110.3	6.6	424.0

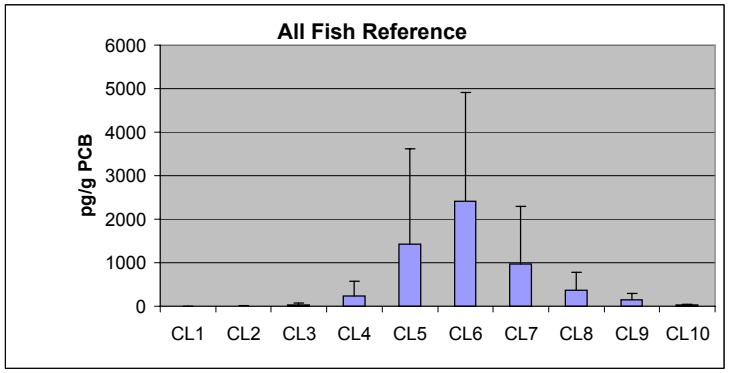
All fish

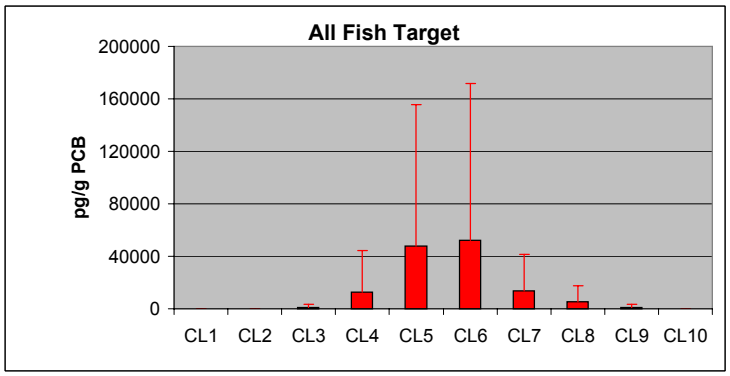
DESCRIPTIVI STATISTICS FOR SITE = Reference

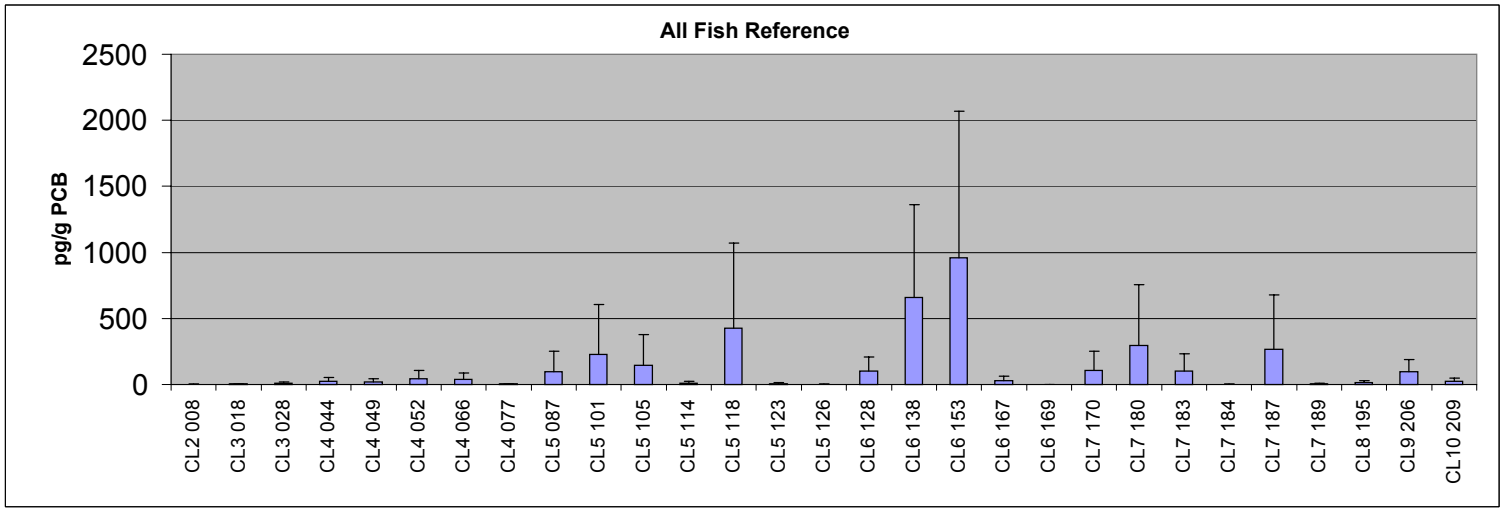
	tPCB w	log(tPCB) whole body
	TPCBW	ZTPCBW
N	62	62
LO 95% CI	4114	3.5073
MEAN	5646	3.6002
UP 95% CI	7179	3.6931
SD	6036	0.3658
MIN	565	2.752
MAX	35700	4.5527

DESCRIPTIVI STATISTICS FOR SITE = Target

	TPCBW	ZTPCBW
N	51	51
LO 95% CI	49453	4.4116
MEAN	1E+05	4.585
UP 95% CI	2E+05	4.7584
SD	3E+05	0.6165
MIN	2910	3.4639
MAX	1E+06	6.1673







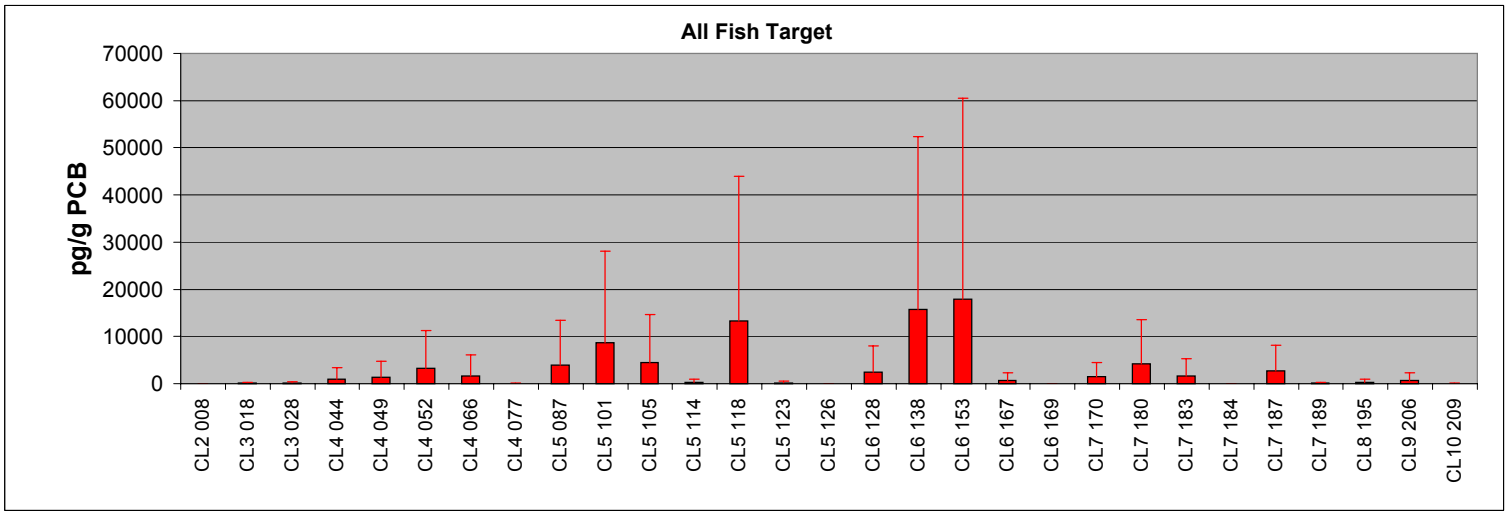
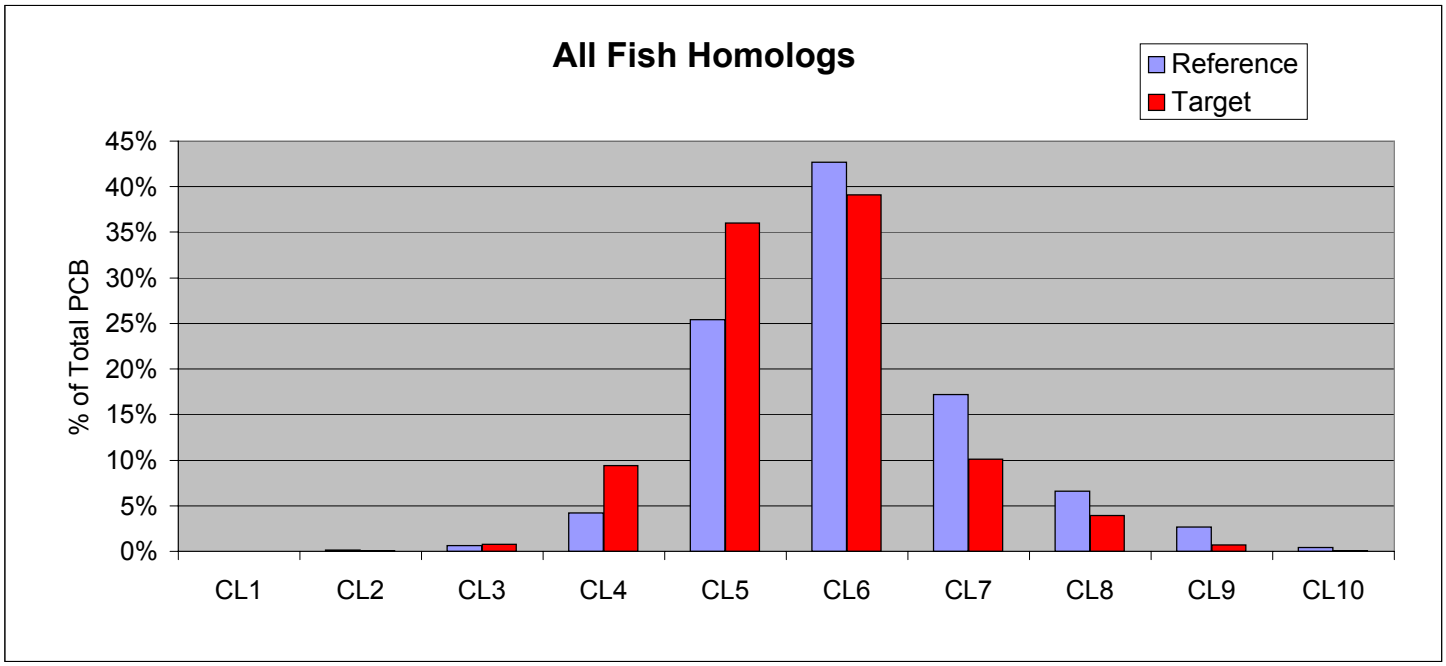


Fig. A4E-2. Distribution of homologs and congers from reference and target reefs for all fish.



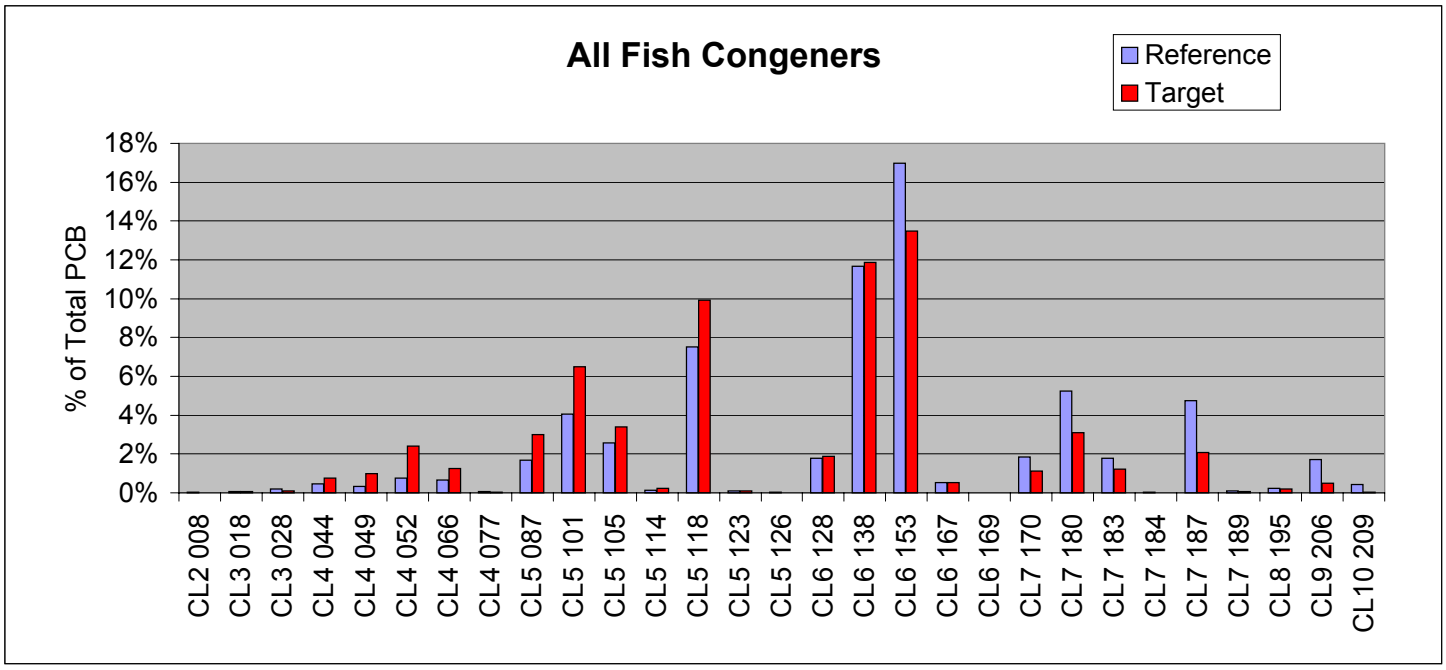
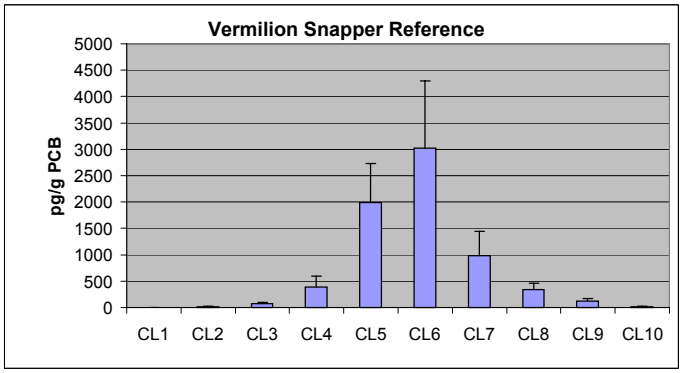
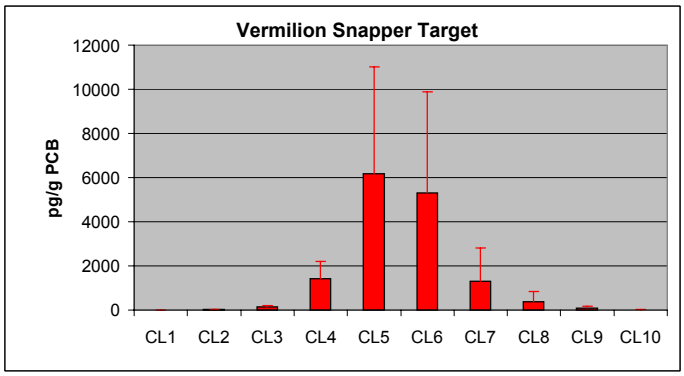
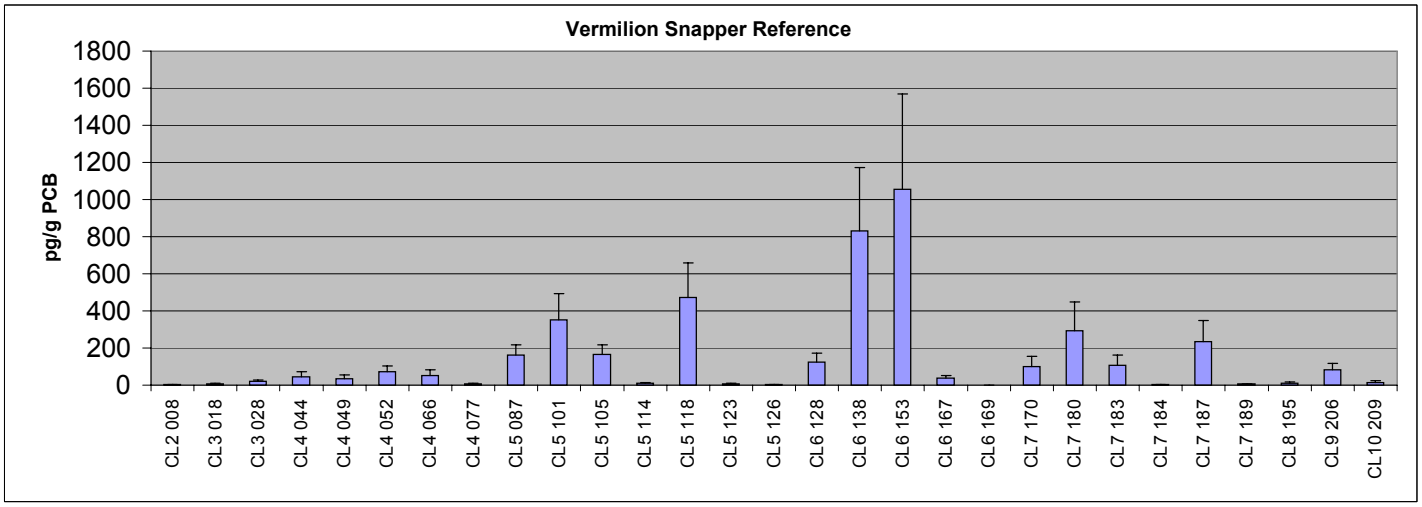


Figure A4E-3. Average homologs and congeners from reference and target reefs for all fish.







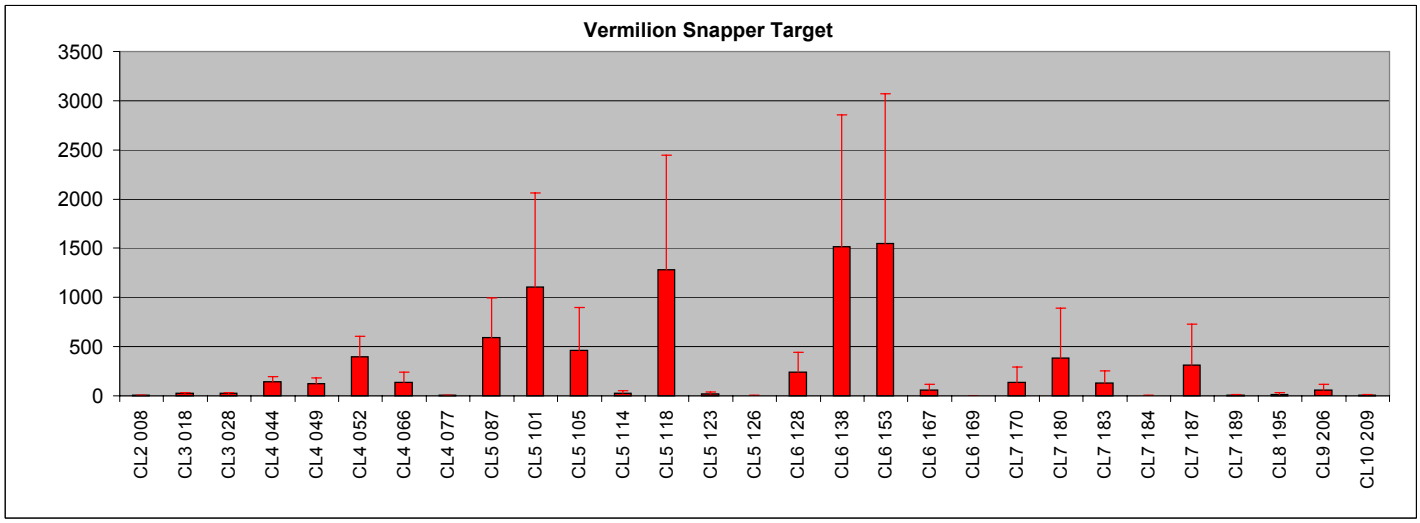
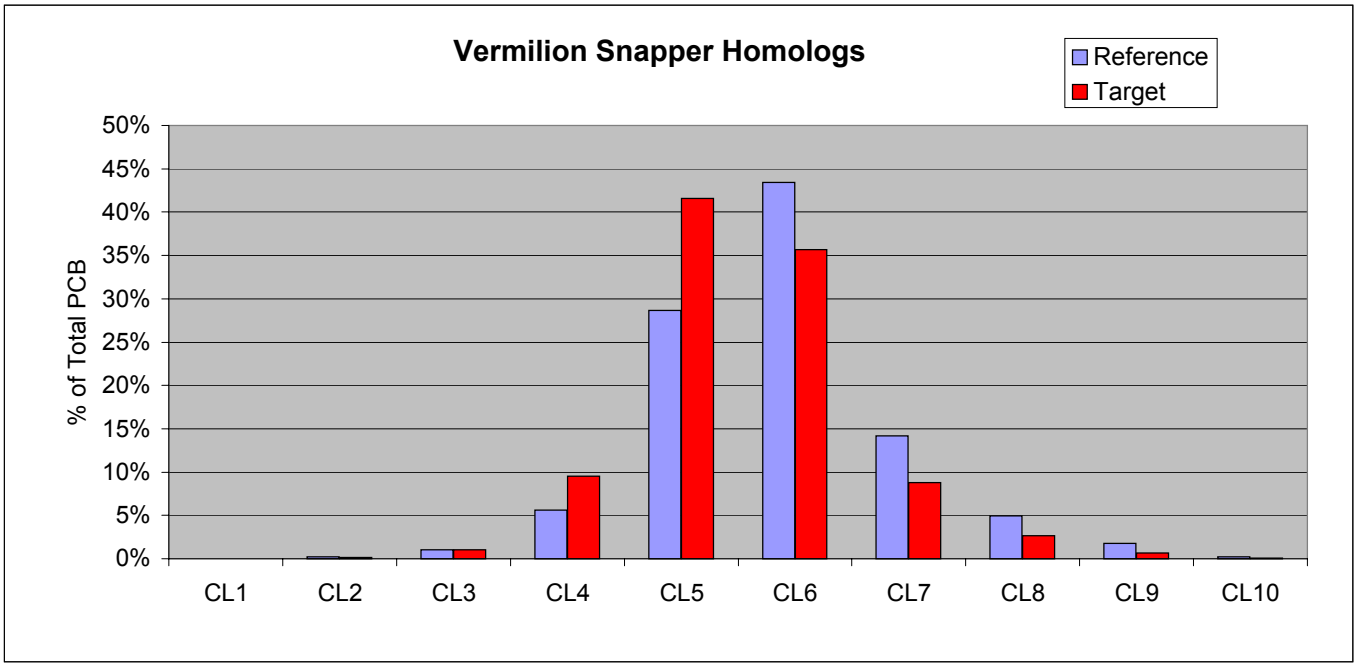


Fig. A4E-4. Distribution of homologs and congers from reference and target reefs for Vermilion Snapper.



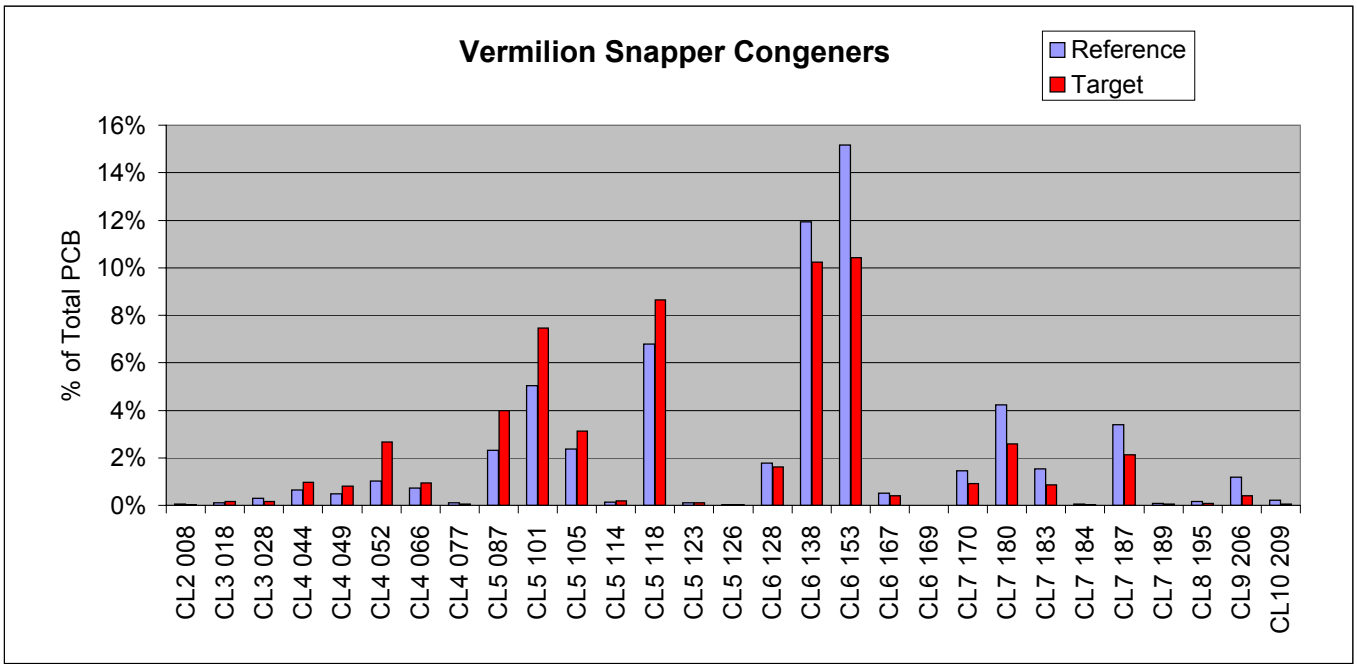
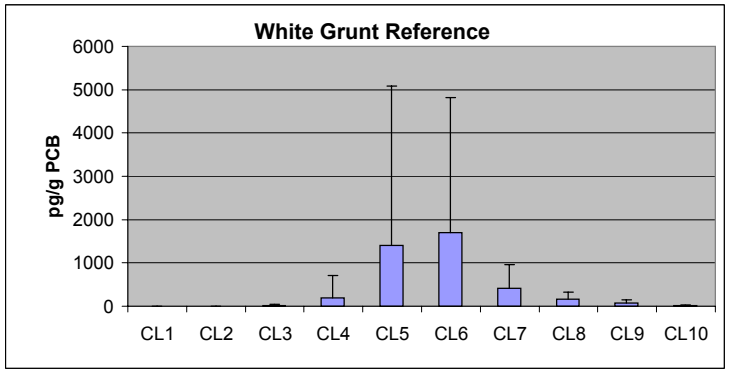
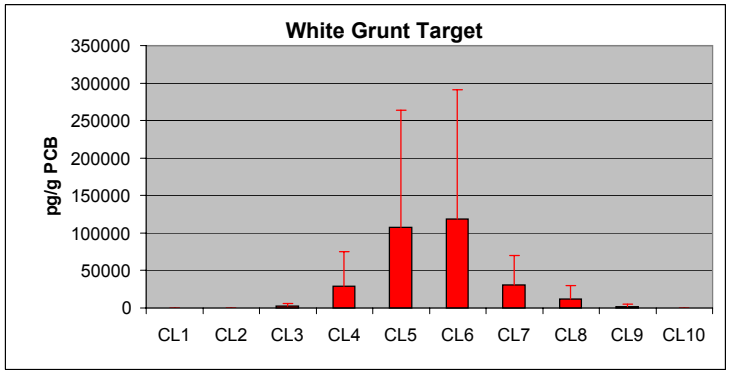
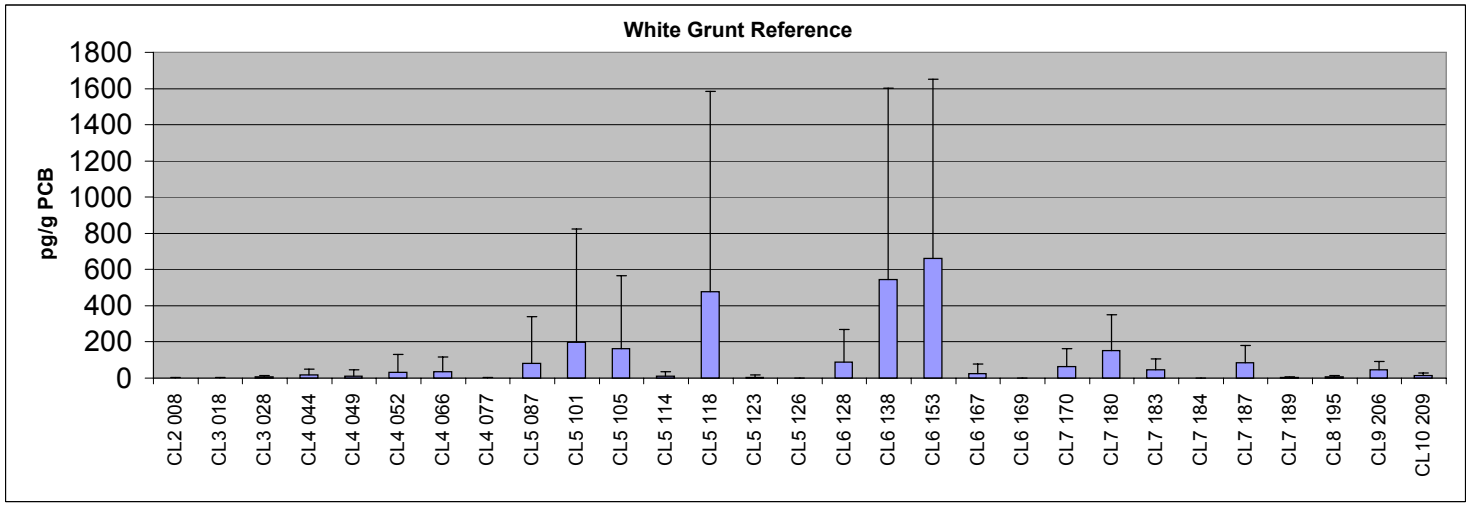


Figure A4E-5. Average homologs and congeners from reference and target reefs for vermilion snapper.







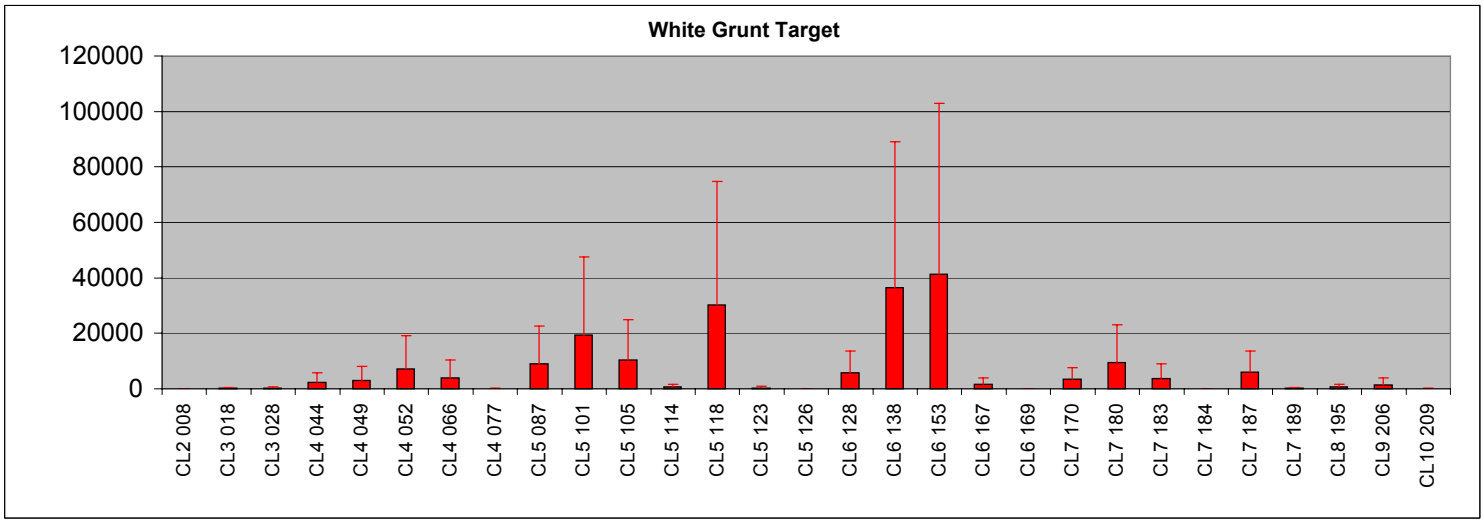
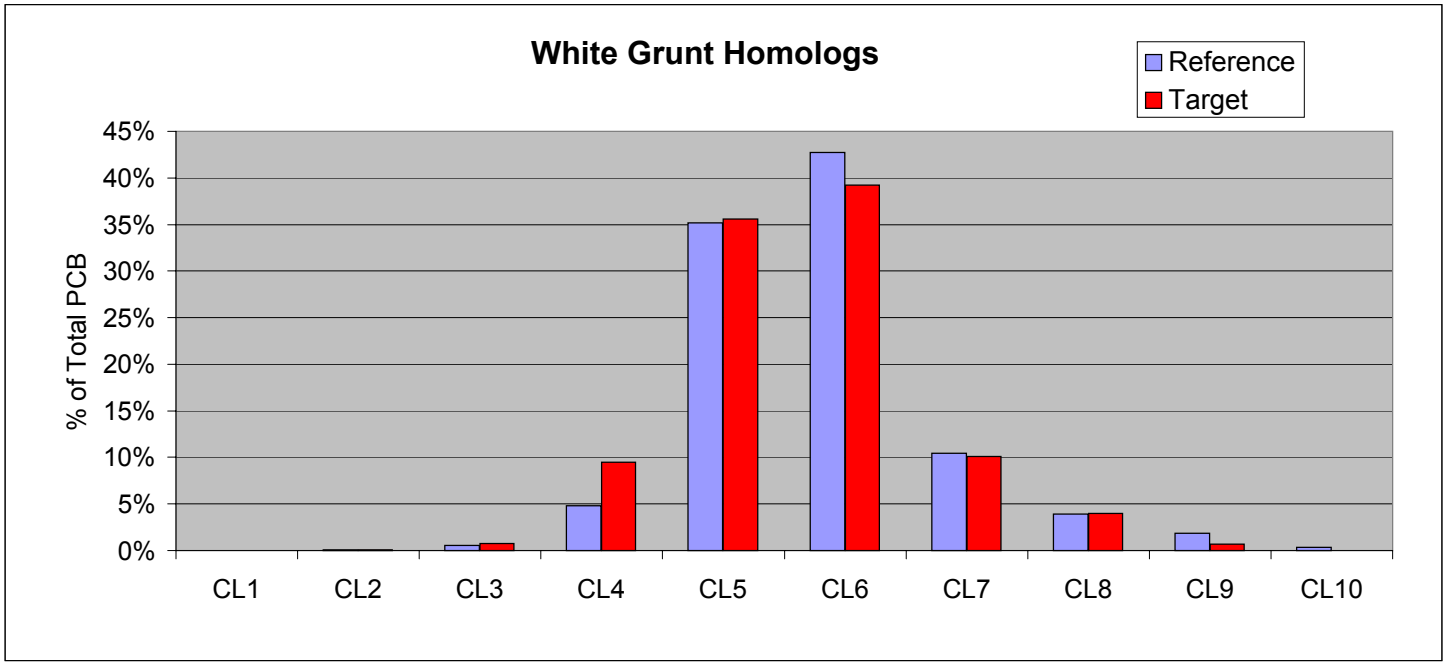


Fig. A4E-6. Distribution of homologs and congers from reference and target reefs for White Grunt.



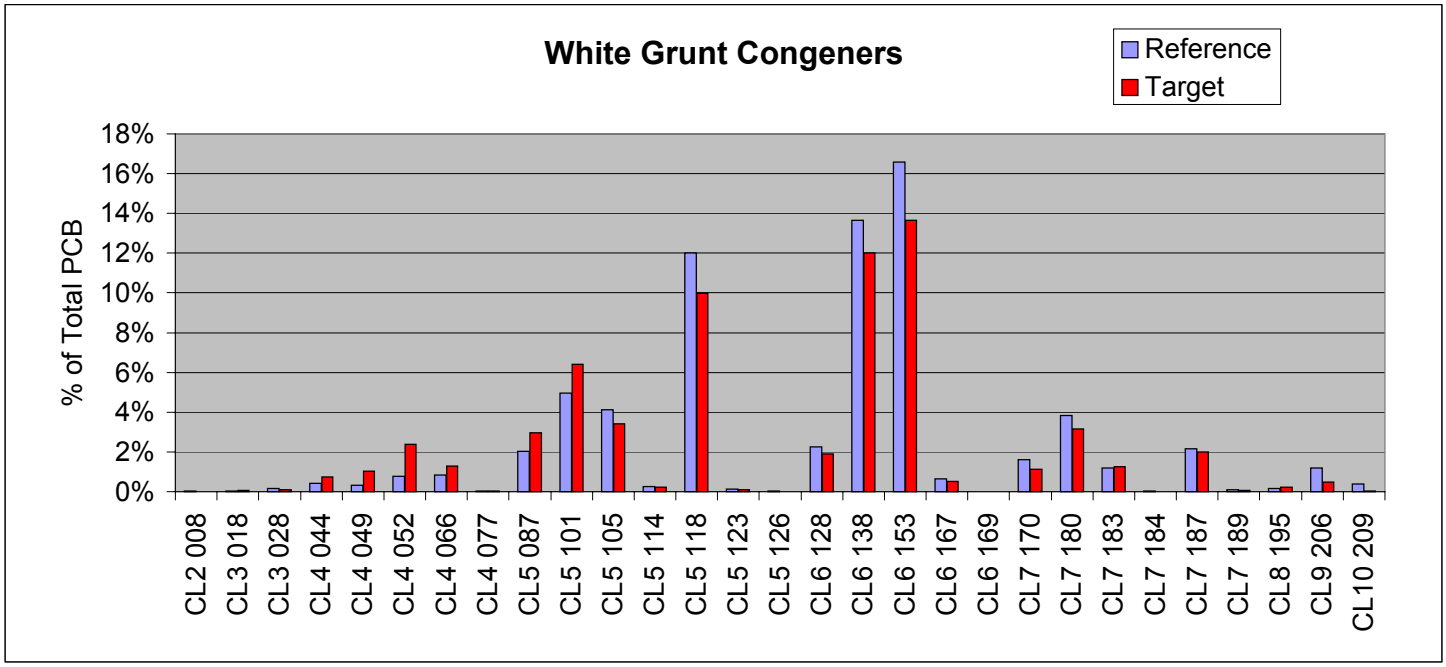
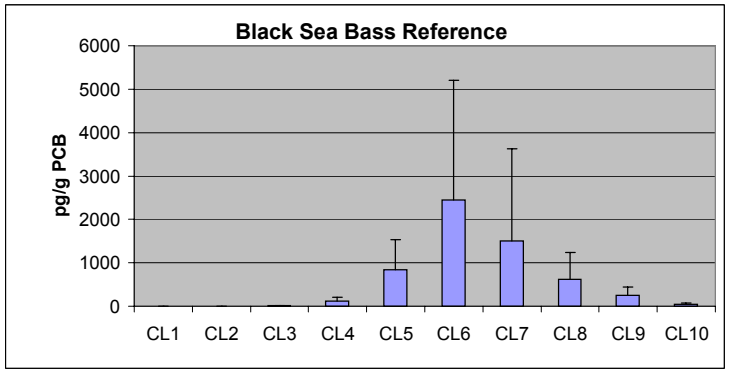
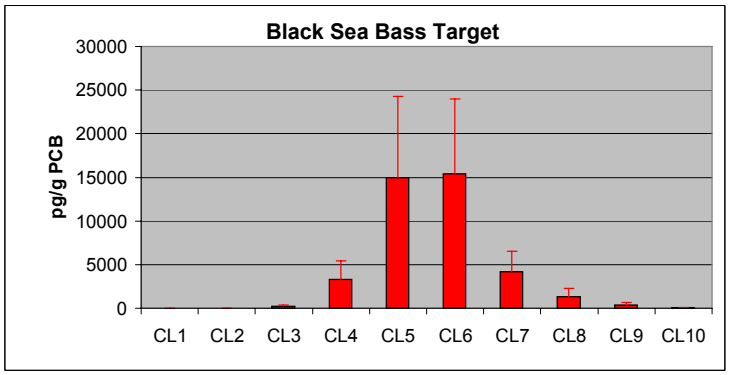
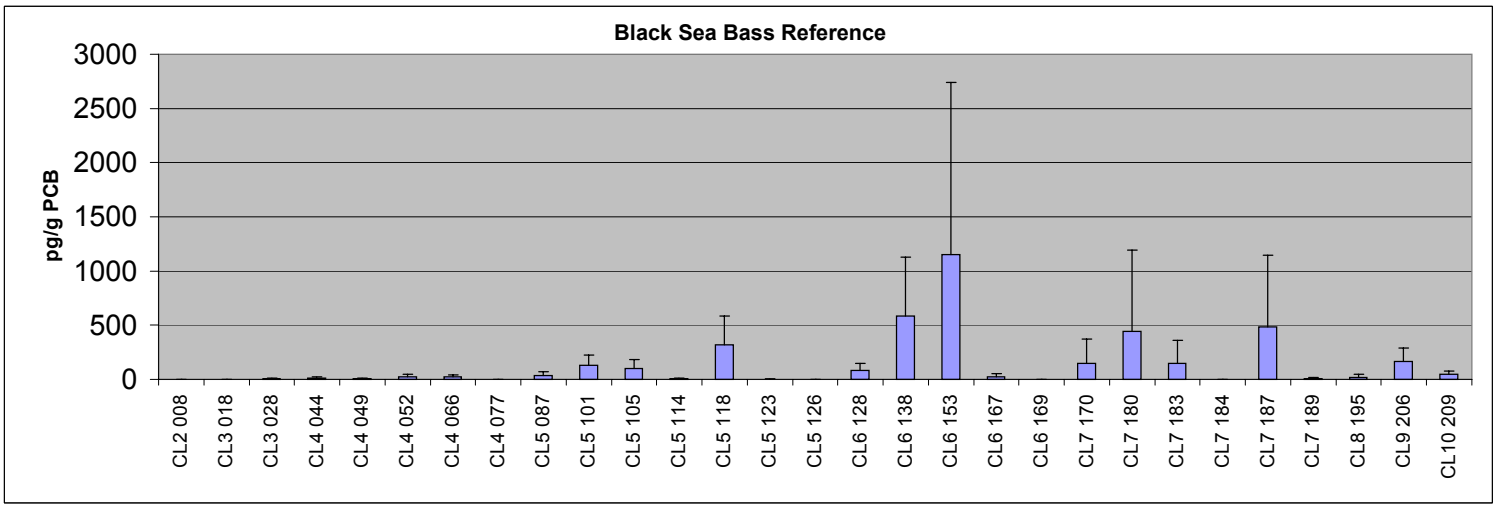


Figure A4E-7. Average homologs and congeners from reference and target reefs for white grunt.







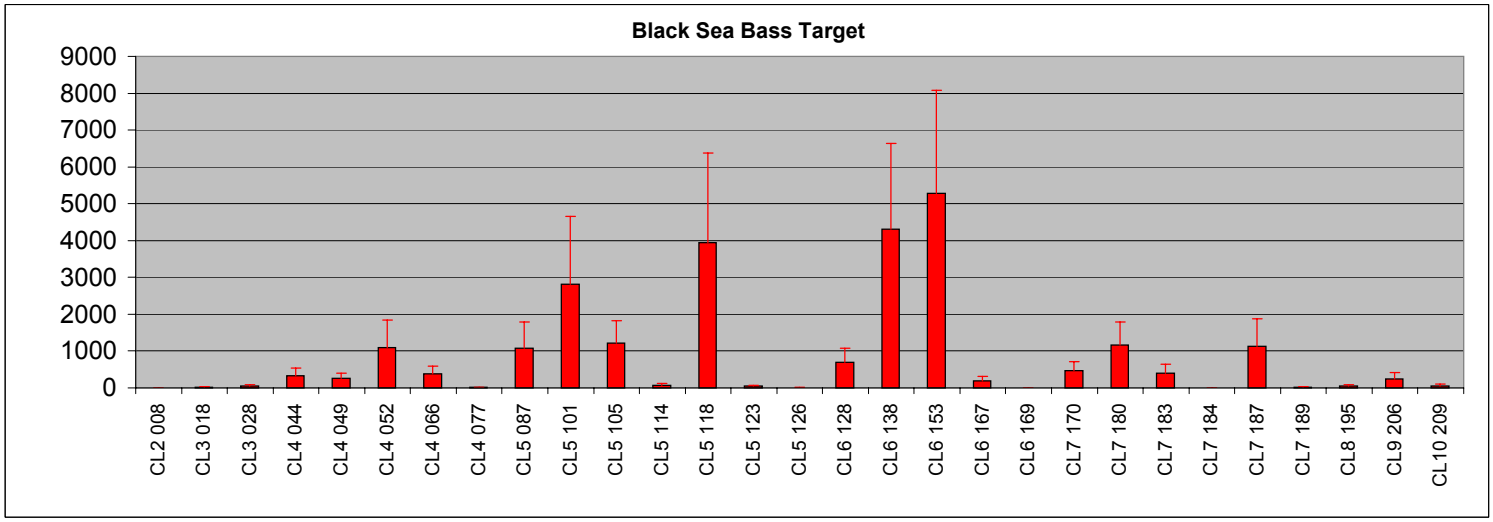
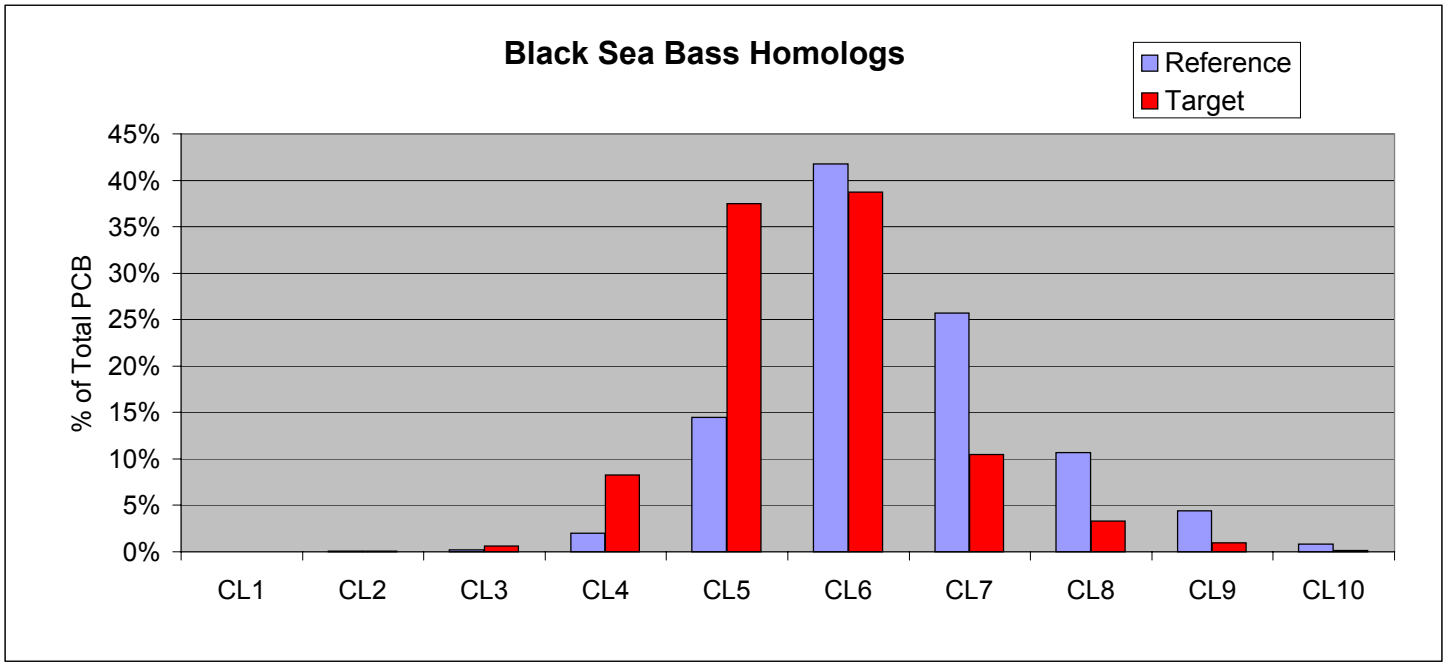


Fig. A4E-8. Distribution of homologs and congers from reference and target reefs for Black Seabass.



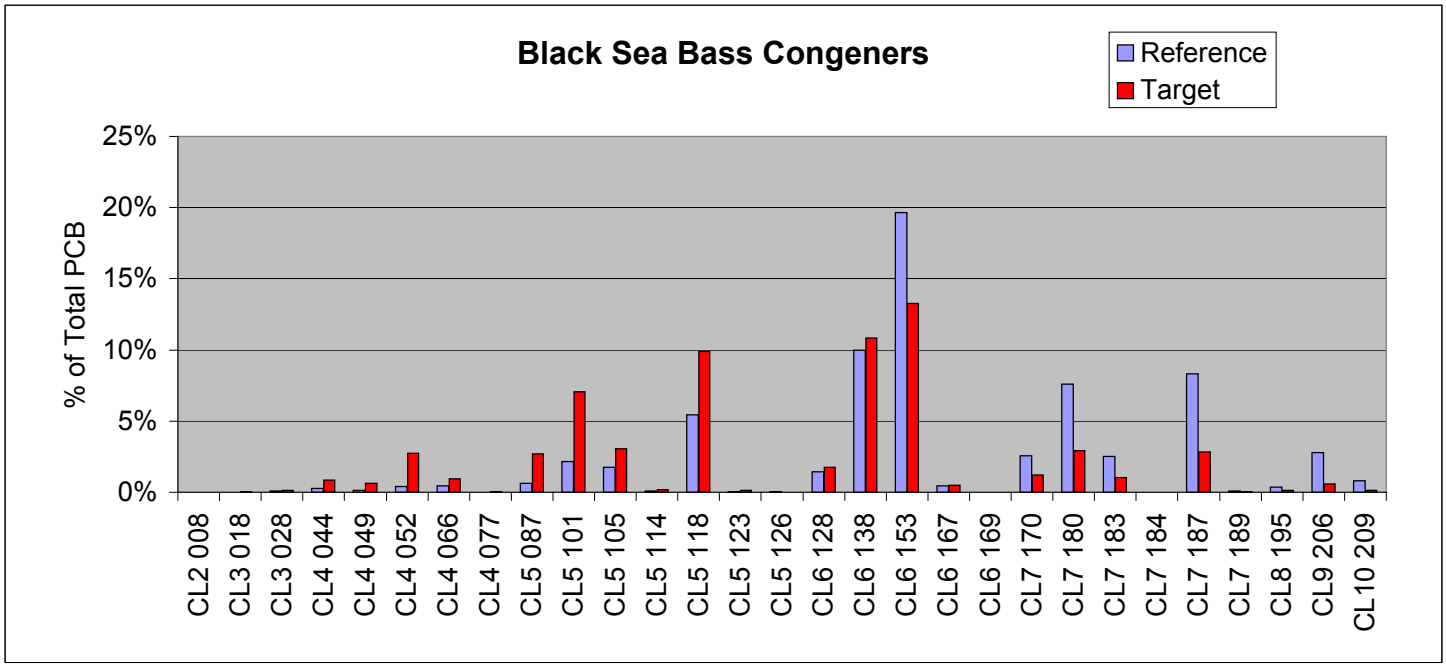


Figure A4E-9. Average homologs and congeners from reference and target reefs for black sea bass.

Principal components (PC) obtained from PCB congeners.
(Note only the first 9 principal components are listed.

EIGENVALUES / EIGENVECTORS BASED ON CORRELATION MATRIX

	EIGENVALUES	PERCENT OF VARIANCE	CUMULATIVE PERCENT OF VARIANCE
PC1	25.1506	86.7	86.7
PC2	2.17334	7.5	94.2
PC3	0.70159	2.4	96.6
PC4	0.34465	1.2	97.8
PC5	0.20916	0.7	98.5
PC6	0.14410	0.5	99.0
PC7	0.10635	0.4	99.4
PC8	0.07533	0.3	99.7
PC9	0.03033	0.1	99.8

Principal Component loading vectors.

	VECTORS						
FACTOR	1	2	3	4	5	6	7
PCB008	-0.1744	-0.2923	-0.1078	-0.0134	-0.2218	0.3387	0.2569
PCB018	-0.1637	-0.3200	-0.3205	-0.0129	-0.1587	0.3331	0.1025
PCB028	-0.1947	-0.0274	-0.1880	-0.1673	-0.1099	-0.0771	-0.1294
PCB044	-0.1933	0.1191	-0.1550	-0.1287	0.0245	-0.0488	0.0179
PCB049	-0.1882	0.1670	-0.1376	-0.2332	0.0264	-0.2479	0.0620
PCB052	-0.1883	0.1659	-0.1558	-0.2236	0.0095	-0.2450	-0.0508
PCB066	-0.1928	0.1408	-0.1215	-0.1376	0.0835	-0.0773	0.0754
PCB077	-0.1898	-0.1613	-0.1334	0.0690	-0.2295	0.2536	-0.0179
PCB087	-0.1939	0.1345	0.0425	0.0743	0.0004	0.1029	0.1441
PCB101	-0.1963	0.0894	-0.0303	-0.0600	-0.0461	-0.1299	0.0352
PCB105	-0.1962	0.1098	0.0049	0.0674	0.0140	0.0727	0.0245
PCB114	-0.1923	0.1703	-0.0231	-0.0060	0.0943	0.0459	0.0664
PCB118	-0.1953	0.1249	-0.0609	-0.0094	0.0551	0.0202	0.0002
PCB123	-0.1939	0.1544	0.0272	0.0033	0.0371	-0.0083	0.0531
PCB126	-0.1653	0.0810	0.5301	0.4905	-0.0467	0.0633	-0.0237
PCB128	-0.1958	0.0719	-0.0110	0.1742	-0.0757	0.1368	-0.1275
PCB138	-0.1965	0.0872	-0.0652	0.1009	-0.0352	0.1279	-0.0962
PCB153	-0.1974	0.0734	-0.0492	0.0279	0.0671	0.0721	0.0225
PCB167	-0.1962	0.1060	-0.0468	0.0430	-0.0016	0.1245	-0.0054
PCB169	-0.1726	0.2946	0.1932	0.0558	0.1672	0.1926	0.1829
PCB170	-0.1967	0.0208	-0.0276	0.1744	0.0005	-0.1672	-0.2572
PCB180	-0.1611	-0.3759	-0.0522	0.2194	-0.0766	-0.2731	-0.2668
PCB183	-0.1920	-0.1533	0.0676	0.0852	0.0839	-0.1858	0.1770
PCB184	-0.1598	0.0010	0.5248	-0.4878	-0.5970	-0.0137	-0.1855
PCB187	-0.1867	-0.2027	-0.0080	0.1482	0.0268	-0.2559	-0.2796
PCB189	-0.1976	0.0596	-0.0329	0.0998	0.0183	0.0329	-0.0728
PCB195	-0.1812	-0.2603	0.0380	0.1029	0.0849	-0.2971	0.1589
PCB206	-0.1599	-0.3336	0.2815	-0.1723	0.1806	-0.1783	0.5643
PCB209	-0.1588	-0.2787	0.2241	-0.3609	0.6205	0.3438	-0.4170

VECTORS

FACTOR	8	9	10	11	12	13	14
PCB008	0.2465	0.0382	-0.1122	0.2682	0.1293	0.2591	-0.2949
PCB018	-0.2191	-0.2944	0.2266	-0.1952	-0.2101	-0.2537	-0.2743
PCB028	0.1898	-0.1693	0.1097	-0.0536	-0.2581	0.2112	0.2186
PCB044	-0.0626	-0.3954	0.0652	-0.0400	0.4125	0.2122	0.2340
PCB049	0.2305	-0.1356	0.1120	0.2770	0.2663	0.2299	-0.1415
PCB052	0.2197	-0.1671	0.0054	0.0384	-0.2061	-0.1305	-0.1725
PCB066	-0.0907	0.0045	0.1783	-0.1278	-0.0718	-0.2054	-0.0805
PCB077	0.0334	0.0206	0.0747	0.2451	0.0615	-0.1595	0.5642
PCB087	-0.0442	-0.1781	-0.4798	-0.1146	0.2615	-0.2687	0.1838
PCB101	0.2635	0.0407	-0.1601	0.2209	-0.2483	-0.5006	0.0616
PCB105	0.0992	0.2019	-0.0377	-0.1655	-0.0452	0.1149	0.0745
PCB114	-0.0988	0.1056	0.0924	-0.3652	0.0276	0.1004	-0.0033
PCB118	-0.0358	0.1560	0.2181	-0.2410	-0.0516	0.0498	0.1301
PCB123	0.0755	0.1609	0.0385	-0.0892	-0.1601	-0.0859	0.0885
PCB126	0.3442	-0.3802	0.3806	-0.0587	0.0506	-0.0779	-0.0997
PCB128	0.1961	0.0752	-0.4080	-0.1797	-0.0541	0.1602	0.0359
PCB138	0.0270	0.0982	-0.2097	-0.1144	-0.0150	0.1022	-0.0992
PCB153	-0.2033	0.0670	0.0624	-0.1257	0.1233	-0.0197	-0.1751
PCB167	0.0214	0.2629	0.1188	0.0464	0.0564	0.0329	-0.1199
PCB169	-0.4181	-0.1740	-0.0557	0.4466	-0.4755	0.2973	0.0726
PCB170	-0.1007	0.2001	0.0052	0.2651	0.0959	-0.1532	-0.1931
PCB180	0.0101	0.1635	0.1371	0.0244	-0.1792	0.2074	0.2083
PCB183	-0.2601	0.0295	0.0378	0.1879	0.2199	-0.2486	0.0461
PCB184	-0.2273	0.0646	-0.0061	-0.0718	0.0407	-0.0032	-0.0373
PCB187	-0.1669	-0.2871	-0.3658	-0.0684	-0.0960	0.0864	-0.2767
PCB189	-0.0924	0.3149	0.1336	0.1800	0.2105	0.0148	-0.1712
PCB195	-0.2340	-0.0435	-0.0070	-0.1000	0.0741	0.0799	0.1691
PCB206	0.1939	0.1565	-0.0810	-0.1221	-0.1175	0.0733	-0.0276
PCB209	0.0999	-0.0335	0.0050	0.0516	0.0676	-0.0751	0.0444

VECTORS

FACTOR	15	16	17	18	19	20	21
PCB008	-0.2335	-0.3404	-0.0230	0.0550	0.1670	0.2545	0.0058
PCB018	0.4161	0.0285	0.0183	-0.0085	-0.0454	-0.1191	0.0159
PCB028	-0.3720	-0.2294	0.1754	0.3343	-0.1111	-0.2565	-0.0339
PCB044	0.0820	-0.2139	-0.2003	-0.1879	-0.0863	-0.1648	0.0508
PCB049	0.3488	0.3511	0.0455	0.0026	0.2091	0.1401	-0.0437
PCB052	-0.0309	0.0004	-0.0659	-0.0493	-0.3113	0.0093	0.0942
PCB066	-0.2158	0.2161	0.0072	0.4153	0.2831	0.0418	-0.2023
PCB077	-0.1661	0.4320	0.1554	-0.1914	0.0825	0.0033	-0.1781
PCB087	0.0933	-0.2186	0.0379	0.0367	0.0198	-0.2038	-0.0567
PCB101	0.0195	-0.1418	-0.0929	-0.1799	-0.0781	0.2354	0.0914
PCB105	0.2265	-0.0748	-0.0815	-0.0225	0.2433	0.1325	-0.1487
PCB114	-0.0868	-0.1425	0.0384	-0.0525	0.1653	0.0931	-0.0825
PCB118	-0.0483	-0.1555	-0.0229	-0.3271	-0.1553	0.2080	-0.2365
PCB123	0.1020	-0.1048	0.1059	-0.0467	0.5321	-0.1748	0.4312
PCB126	-0.0465	0.0285	0.0272	0.0431	-0.0180	0.0143	-0.0057

PCB128	0.2168	0.2355	-0.0958	0.3012	-0.2594	0.0344	-0.0331
PCB138	-0.0410	0.2214	-0.0547	0.1511	-0.0723	0.0509	0.1582
PCB153	-0.2833	0.1975	-0.3114	-0.0881	-0.1701	0.1793	-0.0813
PCB167	-0.0956	0.0310	0.1479	-0.2959	-0.2370	-0.0374	0.3787
PCB169	0.0759	-0.0151	-0.0450	0.0018	-0.0385	-0.0001	-0.0431
PCB170	0.1610	-0.2985	0.2203	0.0528	-0.0237	-0.0518	-0.5232
PCB180	0.2129	-0.0862	-0.4370	-0.0033	0.0619	-0.0482	0.0698
PCB183	-0.1653	-0.0373	-0.4001	0.2836	0.0233	0.0329	0.1993
PCB184	0.0586	-0.0025	-0.0125	0.0109	-0.0055	0.0355	0.0205
PCB187	-0.2948	0.1686	0.1124	-0.3769	0.2868	-0.0805	-0.0151
PCB189	-0.0048	0.0611	0.1714	0.0698	-0.1500	-0.5023	0.1281
PCB195	0.1129	-0.0314	0.5400	0.1633	-0.1988	0.4316	0.2358
PCB206	0.0154	0.1484	-0.0154	-0.1486	-0.1168	-0.3381	-0.2439
PCB209	0.0431	-0.0274	0.0179	0.0487	0.0091	0.0737	0.0411

VECTORS

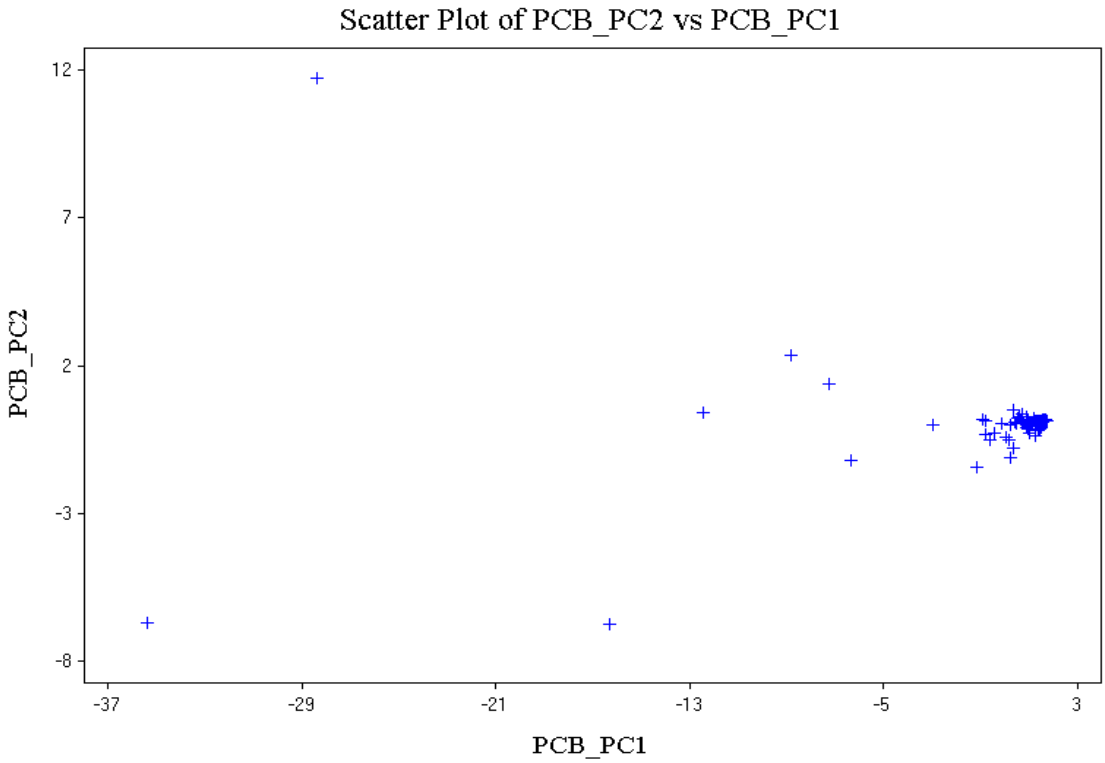
FACTOR	22	23	24	25	26	27	28
PCB008	-0.1381	-0.0252	0.1180	0.0472	0.1111	0.0148	0.0946
PCB018	0.1142	0.0109	-0.0607	-0.0486	-0.0482	0.0035	-0.0072
PCB028	0.3382	-0.0139	-0.1485	-0.0128	-0.2041	0.1383	-0.1162
PCB044	-0.2714	0.1744	-0.3272	0.0122	0.1445	-0.0781	0.1441
PCB049	0.2014	-0.1558	0.0285	-0.1005	-0.2063	0.1422	-0.0561
PCB052	-0.1088	0.2255	0.5503	0.1144	0.2456	-0.2459	-0.1383
PCB066	-0.4009	-0.3407	-0.1608	0.1972	0.1900	-0.0902	0.0485
PCB077	-0.0394	0.1480	0.1510	-0.0718	0.0789	-0.0814	-0.0712
PCB087	-0.0205	-0.3432	0.2989	0.1762	-0.2019	0.1167	-0.2016
PCB101	0.0111	-0.1465	-0.2763	-0.2296	-0.1324	0.1530	0.2814
PCB105	0.4537	0.0082	-0.0154	0.3213	0.0802	-0.3074	-0.0993
PCB114	-0.0477	-0.0277	0.2407	-0.7646	-0.0170	-0.0568	-0.1029
PCB118	0.1129	-0.1151	0.0373	0.2227	-0.0183	-0.0740	0.4064
PCB123	-0.0894	0.4021	-0.0089	0.1330	0.1049	0.2670	0.0126
PCB126	-0.0127	-0.0131	0.0172	0.0103	-0.0262	-0.0065	0.0058
PCB128	0.0339	0.0379	-0.1807	-0.1665	0.4634	0.1444	0.0784
PCB138	-0.2446	0.2573	-0.0675	0.0472	-0.6573	-0.3629	0.1353
PCB153	0.0777	0.2099	0.0527	0.1757	-0.1060	0.6148	-0.1643
PCB167	-0.0498	-0.3139	-0.3143	0.0327	0.0871	-0.1539	-0.5157
PCB169	-0.0423	-0.0524	0.0293	-0.0156	0.0024	0.0033	0.0016
PCB170	-0.1340	0.3122	-0.1612	-0.0248	-0.0227	-0.0022	-0.2255
PCB180	-0.2687	-0.2727	0.1788	0.0182	-0.0961	0.1064	-0.1030
PCB183	0.3677	0.1201	-0.0597	-0.1287	0.0868	-0.2886	-0.0290
PCB184	-0.0075	-0.0138	-0.0042	0.0032	0.0076	-0.0067	0.0106
PCB187	0.1312	-0.0834	-0.0674	-0.0063	0.1068	-0.0813	0.0987
PCB189	0.1060	-0.1509	0.2296	-0.0257	0.0545	0.0696	0.4758
PCB195	-0.0535	0.0338	0.0551	0.0915	0.0189	0.0830	0.0614
PCB206	-0.0874	0.0994	-0.1141	-0.0153	-0.0535	-0.0189	-0.0424
PCB209	0.0023	-0.0124	0.0305	-0.0007	-0.0007	0.0010	0.0003

VECTORS

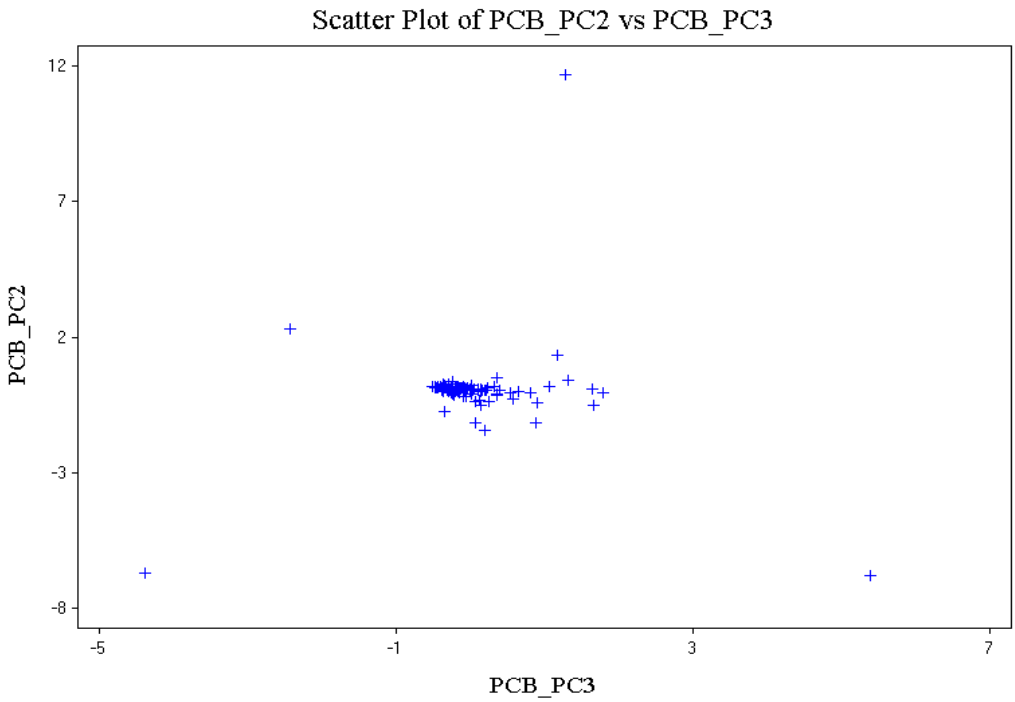
FACTOR	29
PCB008	0.0289

PCB018	0.0319
PCB028	0.0269
PCB044	-0.2110
PCB049	0.1970
PCB052	-0.0315
PCB066	-0.0600
PCB077	-0.0229
PCB087	0.1274
PCB101	-0.2551
PCB105	-0.5056
PCB114	-0.0996
PCB118	0.5296
PCB123	0.2177
PCB126	-0.0129
PCB128	0.1897
PCB138	0.0179
PCB153	-0.1971
PCB167	0.0878
PCB169	-0.0053
PCB170	0.0918
PCB180	-0.0255
PCB183	0.2558
PCB184	-0.0027
PCB187	0.0127
PCB189	-0.2388
PCB195	-0.1399
PCB206	-0.0050
PCB209	0.0035

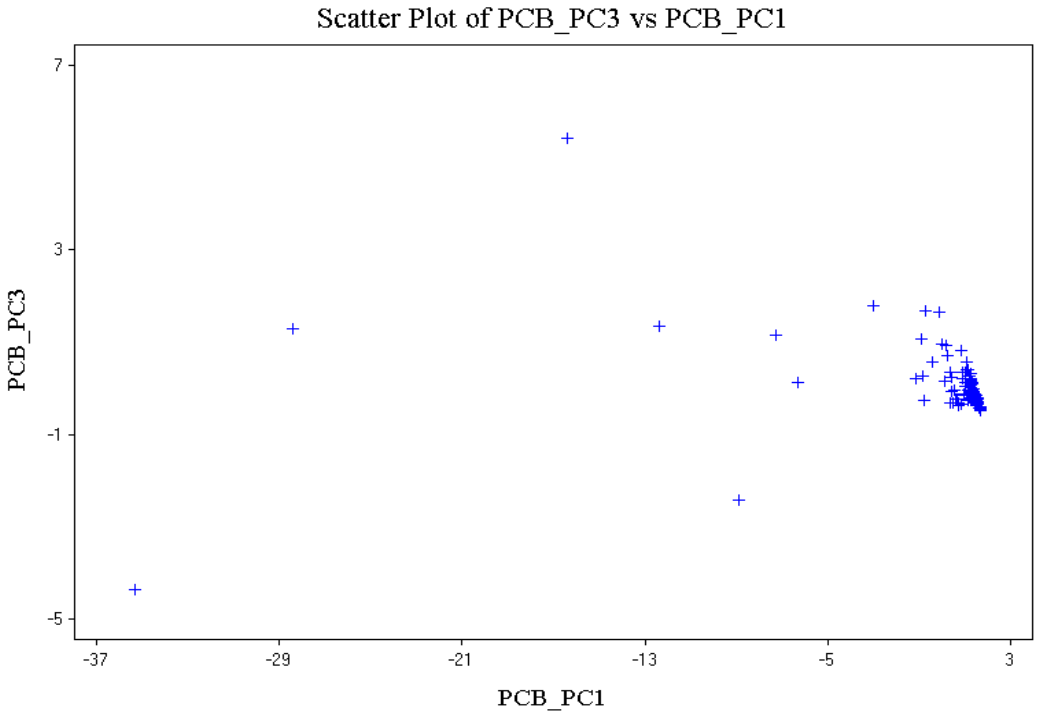
Figure AE4-10 Plots of principal component loading scores.
Scatter plot of PC1 vs PC2



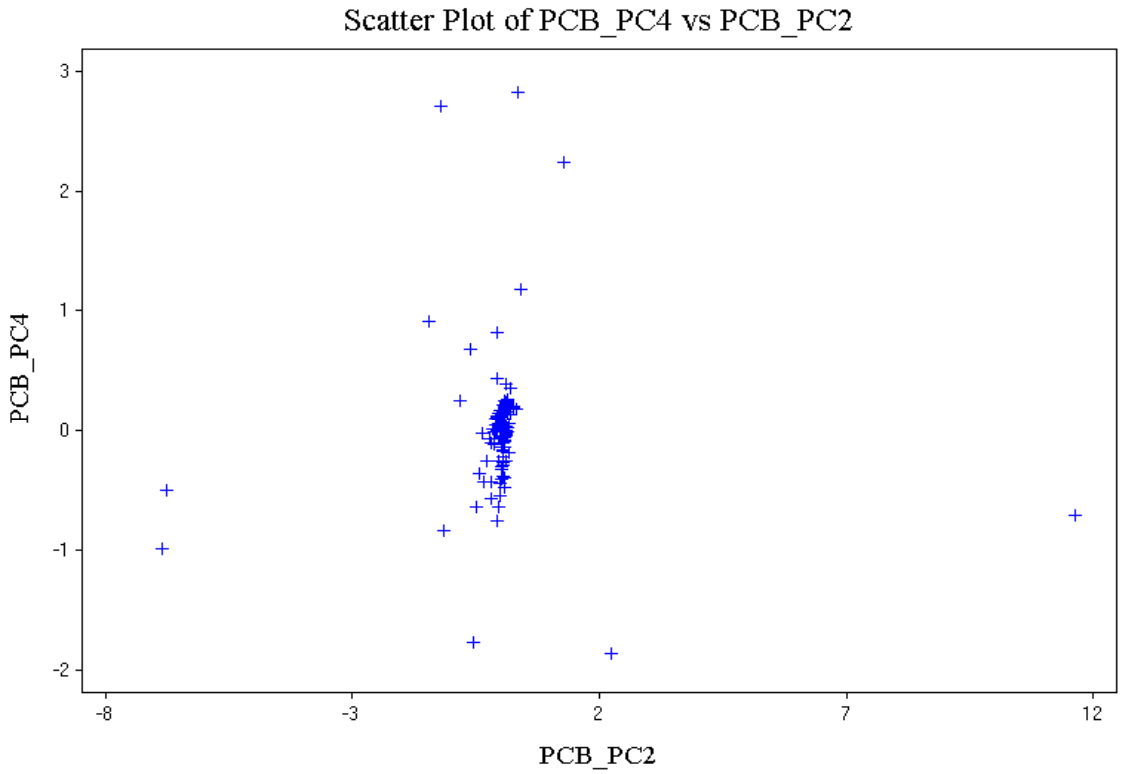
Scatter plot of PC3 vs PC2



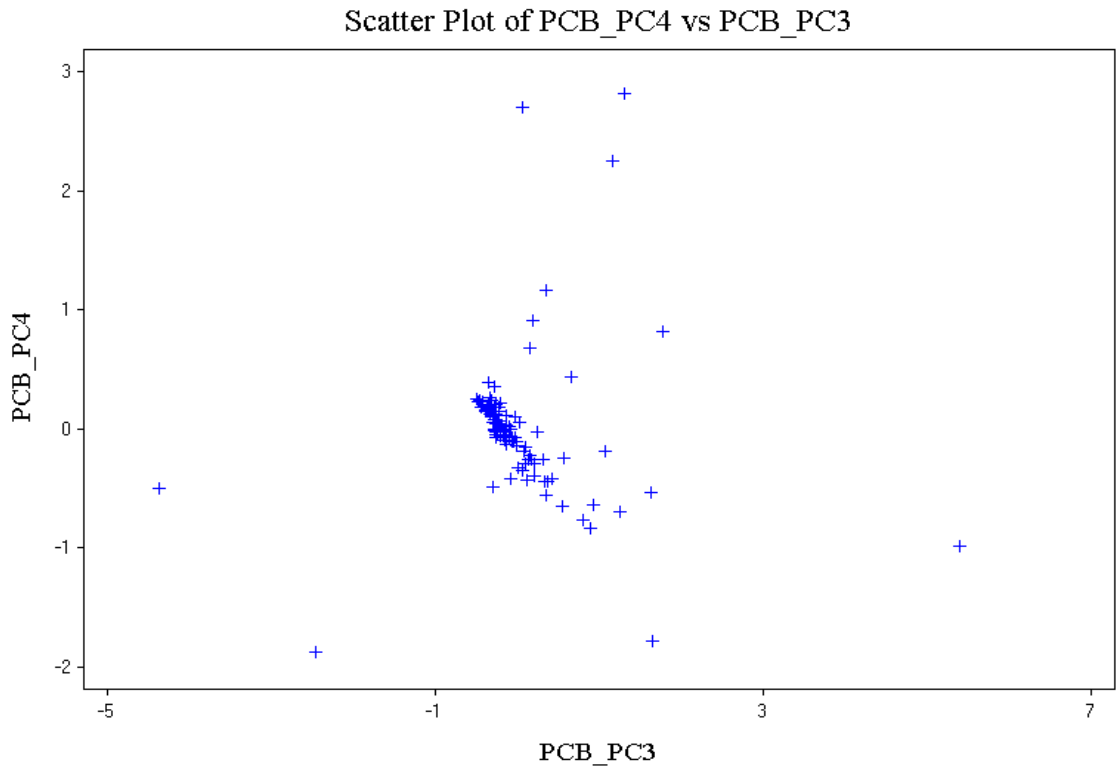
Scatter plot of PC1 vs PC3



Scatter plot of PC2 vs PC4



Scatter plot of PC3 vs PC4



Scatter plot of PC1 vs PC4

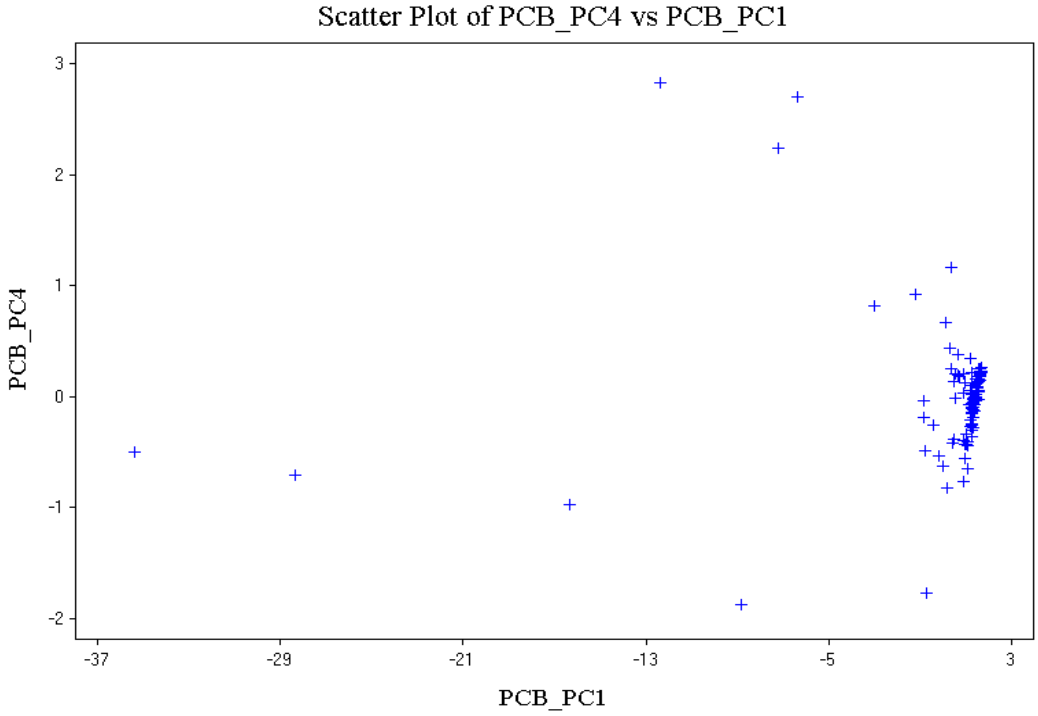


Table A4F.1 Parameters from the literature used for calcuating transfer from female to egg (A) and estimating concentrations of congeners (B) and the lip content of eggs (C).

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

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

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

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

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

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

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

Appendix A4F.2 The TECs for Fish using DL/2 for nondetected values

						wet weight fillet concentratio						
				Sex	%Lipid(wet	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
ID_to_use	Lab ID	Species	Site	SEX	LIPIDW	TECF077	TECF081	TECF105	TECF114	TECF118	TECF123	TECF126
NEHC-000	L3606-5	Black Seat	Reference	F	0.85	4.04E-04	1.61E-04	6.35E-04	3.64E-05	2.04E-03	2.21E-05	1.42E-02
NEHC-002	L3606-24	Black Seat	Reference	F	0.52	1.44E-04	5.72E-05	6.30E-04	3.22E-05	1.85E-03	1.32E-05	5.85E-03
NEHC-004	L3606-48R	Black Seat	Reference	F	0.33	5.60E-05	2.23E-05	2.81E-04	1.54E-05	9.60E-04	7.80E-06	3.73E-03
NEHC-000	L3606-7	Black Seat	Reference	F	0.36	8.66E-05	3.44E-05	3.30E-04	1.85E-05	9.40E-04	9.75E-06	2.07E-03
NEHC-002	L3606-23	Black Seat	Reference	F	0.76	8.86E-05	3.52E-05	4.25E-04	2.58E-05	1.32E-03	1.24E-05	3.63E-03
NEHC-000	L3606-2 i	Black Seat	Reference	F	0.20	2.16E-05	8.58E-06	2.29E-04	9.40E-06	6.90E-04	1.59E-06	1.20E-02
NEHC-003	L3606-34	Black Seat	Reference	F	0.32	6.38E-05	2.54E-05	3.48E-04	2.20E-05	1.09E-03	9.15E-06	5.35E-03
NEHC-000	L3606-4	Black Seat	Reference	F	0.21	3.66E-05	1.45E-05	3.72E-04	1.96E-05	1.17E-03	7.35E-06	3.63E-03
NEHC-004	L3606-42R	Black Seat	Reference	F	0.57	5.90E-05	2.34E-05	3.86E-04	1.55E-05	1.17E-03	1.70E-05	8.18E-03
NEHC-001	L3606-16	Black Seat	Reference	F	7.46	9.89E-05	3.93E-05	4.15E-04	2.08E-05	1.20E-03	1.13E-05	6.35E-03
NEHC-001	L3606-17	Black Seat	Reference	M	7.46	4.74E-05	1.88E-05	4.61E-04	2.54E-05	1.60E-03	7.30E-06	3.33E-03
NEHC-001	L3606-11 i	Black Seat	Reference	F	0.28	9.24E-05	3.67E-05	5.65E-04	2.78E-05	1.70E-03	1.96E-05	3.08E-03
NEHC-003	L3606-33 i	Black Seat	Reference	F	0.40	5.80E-05	2.30E-05	3.85E-04	2.13E-05	1.12E-03	1.23E-05	3.78E-03
NEHC-004	L3606-44R	Black Seat	Reference	F	0.83	1.94E-04	7.71E-05	5.80E-04	3.75E-05	1.73E-03	3.32E-05	6.40E-03
NEHC-000	L3606-3	Black Seat	Reference	F	0.25	5.83E-05	2.32E-05	2.86E-04	1.52E-05	8.60E-04	8.55E-06	2.49E-03
NEHC-004	L3606-46R	Black Seat	Reference	M	0.28	2.41E-05	9.56E-06	2.55E-04	1.89E-05	7.90E-04	6.00E-06	1.30E-02
NEHC-002	L3606-26	Black Seat	Reference	M	0.42	3.12E-05	1.24E-05	3.41E-04	1.92E-05	1.08E-03	3.10E-06	3.78E-03
NEHC-004	L3606-49R	Black Seat	Reference	M	0.36	4.28E-05	1.70E-05	4.48E-04	2.32E-05	1.32E-03	8.30E-06	3.85E-03
NEHC-004	L3606-41R	Black Seat	Reference	M	0.74	1.87E-04	7.43E-05	7.80E-04	5.40E-05	2.23E-03	3.32E-05	1.60E-02
NEHC-001	L3606-10 i	Black Seat	Reference	M	2.83	4.04E-04	1.61E-04	2.09E-03	1.11E-04	7.00E-03	4.32E-05	2.11E-02
NEHC-004	L3606-43R	Black Seat	Target	M	5.04	5.68E-04	2.26E-04	7.05E-03	3.97E-04	1.86E-02	2.68E-04	7.28E-02
NEHC-002	L3606-27	Black Seat	Target	F	7.78	1.30E-03	5.17E-04	5.70E-03	3.54E-04	1.83E-02	1.91E-04	3.68E-02
NEHC-003	L3606-36R	Black Seat	Target	F	6.30	7.68E-04	3.05E-04	4.13E-03	2.47E-04	1.23E-02	1.72E-04	2.82E-02
NEHC-005	L3606-53R	Black Seat	Target	F	3.67	1.69E-04	6.72E-05	1.70E-03	1.09E-04	4.75E-03	5.35E-05	1.64E-02
NEHC-002	L3606-21	Black Seat	Target	mmature	2.16	4.75E-04	1.89E-04	1.03E-02	5.95E-04	2.77E-02	3.48E-04	6.38E-03
NEHC-000	L3606-6	Black Seat	Target	F	1.24	4.10E-04	1.63E-04	2.04E-03	9.50E-05	6.40E-03	8.20E-05	1.10E-02
NEHC-004	L3606-47R	Black Seat	Target	M	5.93	7.96E-04	3.16E-04	8.10E-03	4.63E-04	2.25E-02	2.87E-04	1.37E-02
NEHC-005	L3606-50R	Black Seat	Target	F	9.05	1.63E-03	6.48E-04	7.55E-03	4.48E-04	2.22E-02	3.50E-04	1.13E-02
NEHC-003	L3606-31	Black Seat	Target	F	5.34	4.17E-04	1.66E-04	3.09E-03	1.99E-04	8.95E-03	1.01E-04	2.60E-02
NEHC-001	L3606-13	Black Seat	Target	F	7.46	1.57E-03	6.24E-04	6.80E-03	3.11E-04	2.86E-02	1.87E-04	1.85E-02
NEHC-002	L3606-22	Black Seat	Target	M	3.85	2.19E-03	8.70E-04	1.03E-02	9.40E-04	4.70E-02	4.93E-04	7.80E-02
FS-13-VS-	L2767-8	Vermilion S	Reference	F	7.20	6.65E-04	2.64E-04	5.75E-04	2.83E-05	1.53E-03	3.08E-05	1.33E-02
FS-17-VS-	L2767-12	Vermilion S	Reference	F	5.78	6.37E-04	2.53E-04	8.40E-04	4.98E-05	2.09E-03	3.01E-05	1.20E-02
NEHC-000	L3606-9 i	Vermilion S	Reference	F	5.92	6.46E-04	2.57E-04	5.40E-04	2.73E-05	1.33E-03	2.85E-05	1.21E-02
FS-21-VS-	L2767-14	Vermilion S	Reference	F	3.32	5.94E-04	2.36E-04	7.10E-04	4.11E-05	2.04E-03	3.00E-05	1.34E-02
NEHC-001	L3606-15	Vermilion S	Reference	F	6.49	7.36E-04	2.92E-04	7.35E-04	4.01E-05	2.01E-03	3.78E-05	1.54E-02
FS-05-VS-	L2767-3	Vermilion S	Reference	F	4.92	6.62E-04	2.63E-04	6.50E-04	3.60E-05	1.73E-03	3.50E-05	1.18E-02
FS-14-VS-	L2767-9	Vermilion S	Reference	F	10.63	8.65E-04	3.44E-04	7.40E-04	4.01E-05	1.89E-03	3.50E-05	1.59E-02
NEHC-003	L3606-35	Vermilion S	Reference	F	5.92	6.83E-04	2.71E-04	7.40E-04	4.70E-05	2.05E-03	3.76E-05	1.89E-02

A4F.2 TEC_fish

ID_to_use	Lab ID	Species	Site	SEX	LIPIDW	TECF077	TECF081	TECF105	TECF114	TECF118	TECF123	TECF126
FS-07-VS-	L2767-4	Vermilion S	Reference	M	4.00	5.36E-04	2.13E-04	5.80E-04	2.85E-05	1.61E-03	3.08E-05	1.21E-02
FS-18-VS-	L2767-13	Vermilion S	Reference	F	5.04	5.31E-04	2.11E-04	5.95E-04	3.20E-05	1.60E-03	2.48E-05	1.15E-02
NEHC-004	L3606-40R	Vermilion S	Reference	M	1.99	4.48E-04	1.78E-04	7.45E-04	3.60E-05	2.02E-03	4.15E-05	1.28E-02
FS-22-VS-	L2767-15	Vermilion S	Reference	F	1.12	4.33E-04	1.72E-04	1.23E-03	6.55E-05	3.25E-03	4.72E-05	5.05E-03
FS-02-VS-	L2767-2	Vermilion S	Reference	F	5.80	1.56E-03	6.20E-04	1.20E-03	5.65E-05	3.79E-03	6.85E-05	1.88E-02
FS-15-VS-	L2767-10	Vermilion S	Reference	M	4.83	9.61E-04	3.82E-04	1.36E-03	6.90E-05	4.13E-03	7.20E-05	2.22E-02
FS-11-VS-	L2767-7	Vermilion S	Reference	M	3.40	6.81E-04	2.71E-04	9.35E-04	4.87E-05	2.81E-03	4.15E-05	1.35E-02
NEHC-001	L3606-18	Vermilion S	Reference	F	5.59	8.54E-04	3.39E-04	1.16E-03	6.65E-05	3.41E-03	5.30E-05	1.02E-02
FS-10-VS-	L2767-6	Vermilion S	Reference	F	5.50	6.60E-04	2.62E-04	8.50E-04	4.73E-05	2.33E-03	4.04E-05	1.76E-02
FS-16-VS-	L2767-11	Vermilion S	Reference	F	4.56	6.65E-04	2.64E-04	9.10E-04	6.05E-05	3.31E-03	4.28E-05	1.75E-02
NEHC-003	L3606-30	Vermilion S	Reference	M	4.21	6.68E-04	2.65E-04	1.33E-03	8.50E-05	4.31E-03	6.60E-05	1.22E-02
FS-01-VS-	L2767-1	Vermilion S	Reference	F	5.90	6.03E-04	2.40E-04	5.75E-04	2.76E-05	1.59E-03	3.23E-05	5.93E-03
NEHC-001	L3606-19	Vermilion S	Reference	F	4.09	4.72E-04	1.88E-04	6.50E-04	3.64E-05	1.84E-03	2.98E-05	1.45E-02
FS-09-VS-	L2767-5	Vermilion S	Reference	F	3.48	4.21E-04	1.67E-04	4.73E-04	2.47E-05	1.29E-03	2.34E-05	8.95E-03
FS-17-VS-	L2767-28	Vermilion S	Target	F	5.60	6.57E-04	2.61E-04	2.02E-03	1.05E-04	5.60E-03	7.25E-05	9.45E-03
NEHC-005	L3606-52R	Vermilion S	Target	M	5.88	2.84E-04	1.13E-04	1.64E-03	9.20E-05	4.29E-03	6.45E-05	2.06E-02
FS-18-VS-	L2767-29	Vermilion S	Target	F	5.80	5.60E-04	2.23E-04	1.46E-03	7.40E-05	4.01E-03	5.50E-05	6.85E-03
FS-03-VS-	L2767-18	Vermilion S	Target	F	6.37	6.19E-04	2.46E-04	1.14E-03	6.10E-05	3.14E-03	3.73E-05	7.50E-03
FS-16-VS-	L2767-27	Vermilion S	Target	F	6.10	5.81E-04	2.31E-04	1.37E-03	7.30E-05	3.78E-03	5.40E-05	6.33E-03
NEHC-000	L3606-8	Vermilion S	Target	F	3.05	4.29E-04	1.70E-04	2.47E-03	1.57E-04	6.80E-03	9.25E-05	9.60E-03
FS-07-VS-	L2767-21	Vermilion S	Target	M	5.75	6.77E-04	2.69E-04	1.37E-03	7.35E-05	3.98E-03	5.80E-05	7.65E-03
FS-11-VS-	L2767-23	Vermilion S	Target	M	6.50	1.45E-03	5.76E-04	9.90E-03	5.50E-04	2.53E-02	4.10E-04	3.53E-02
FS-01-VS-	L2767-16	Vermilion S	Target	F	5.55	7.11E-04	2.83E-04	1.62E-03	8.45E-05	4.52E-03	4.86E-05	7.70E-03
FS-02-VS-	L2767-17	Vermilion S	Target	M	6.44	6.25E-04	2.48E-04	1.17E-03	6.30E-05	3.22E-03	4.20E-05	5.98E-03
NEHC-003	L3606-37R	Vermilion S	Target	F	3.80	5.46E-04	2.17E-04	1.47E-03	8.50E-05	4.07E-03	6.65E-05	1.34E-02
FS-13-VS-	L2767-25	Vermilion S	Target	F	5.80	6.19E-04	2.46E-04	1.47E-03	7.90E-05	3.97E-03	5.15E-05	5.55E-03
NEHC-002	L3606-29	Vermilion S	Target	F	6.85	5.01E-04	1.99E-04	1.86E-03	1.12E-04	4.86E-03	6.20E-05	1.40E-02
FS-12-VS-	L2767-24 i	Vermilion S	Target	F	1.70	2.47E-04	9.82E-05	4.34E-04	2.50E-05	1.17E-03	1.68E-05	2.15E-03
FS-04-VS-	L2767-19	Vermilion S	Target	F	4.30	6.23E-04	2.48E-04	2.01E-03	1.12E-04	5.70E-03	6.45E-05	9.40E-03
FS-06-VS-	L2767-20	Vermilion S	Target	M	4.86	5.52E-04	2.19E-04	1.23E-03	6.45E-05	3.30E-03	4.65E-05	5.85E-03
FS-09-VS-	L2767-22	Vermilion S	Target	M	4.92	9.37E-04	3.72E-04	3.08E-03	1.88E-04	9.05E-03	1.15E-04	1.51E-02
NEHC-003	L3606-38R	Vermilion S	Target	M	4.27	1.30E-03	5.17E-04	6.45E-03	4.11E-04	1.95E-02	2.81E-04	6.08E-02
FS-15-VS-	L2767-26 (	Vermilion S	Target	F	7.00	9.60E-04	3.81E-04	3.01E-03	1.64E-04	8.30E-03	1.02E-04	1.16E-02
FS-20-VS-	L2767-30	Vermilion S	Target	F	4.70	5.47E-04	2.17E-04	1.31E-03	6.55E-05	3.68E-03	4.77E-05	6.23E-03
FS-20-WG	L2767-45	White Grur	Reference	mmature	1.40	6.74E-05	2.68E-05	1.93E-04	1.18E-05	5.60E-04	5.80E-06	2.57E-03
FS-18-WG	L2767-43	White Grur	Reference	mmature	0.64	4.99E-05	1.98E-05	9.50E-05	5.45E-06	3.07E-04	2.84E-06	6.78E-04
NEHC-005	L3606-51R	White Grur	Reference	M	1.87	1.74E-04	6.91E-05	3.17E-04	1.48E-05	9.20E-04	1.10E-05	7.00E-03
FS-17-WG	L2767-42	White Grur	Reference	M	0.40	3.23E-05	1.28E-05	1.04E-04	6.40E-06	3.04E-04	3.88E-06	1.63E-03
FS-16-WG	L2767-41	White Grur	Reference	F	0.77	9.46E-05	3.76E-05	2.39E-04	1.23E-05	7.10E-04	9.80E-06	3.18E-03
FS-08-WG	L2767-35	White Grur	Reference	M	0.77	5.38E-05	2.14E-05	2.01E-04	1.27E-05	5.80E-04	5.50E-06	8.83E-04
NEHC-002	L3606-28	White Grur	Reference	M	1.26	4.60E-05	1.83E-05	1.78E-04	9.65E-06	5.10E-04	1.61E-06	1.84E-03
FS-09-WG	L2767-36	White Grur	Reference	F	0.61	9.75E-06	3.87E-06	1.19E-04	6.55E-06	3.58E-04	2.77E-06	6.45E-04

A4F.2 TEC_fish

ID_to_use	Lab ID	Species	Site	SEX	LIPIDW	TECF077	TECF081	TECF105	TECF114	TECF118	TECF123	TECF126
FS-10-WG	L2767-37	White Grur	Reference	M	0.74	4.44E-05	1.76E-05	1.92E-04	1.02E-05	5.65E-04	5.85E-06	1.86E-03
NEHC-003	L3606-39R	White Grur	Reference	F	1.29	4.11E-05	1.63E-05	3.88E-04	2.19E-05	1.18E-03	6.33E-06	7.68E-03
FS-06-WG	L2767-34	White Grur	Reference	M	0.46	6.15E-06	2.44E-06	1.45E-04	1.08E-05	4.26E-04	4.88E-06	1.48E-03
NEHC-002	L3606-25R	White Grur	Reference	F	1.49	3.38E-05	1.34E-05	3.96E-04	2.52E-05	1.18E-03	1.22E-05	4.63E-03
FS-14-WG	L2767-40	White Grur	Reference	F	0.37	3.31E-05	1.32E-05	1.53E-04	9.60E-06	4.64E-04	3.65E-06	2.24E-03
NEHC-000	L3606-1	White Grur	Reference	M	1.73	7.87E-04	3.13E-04	9.05E-03	5.65E-04	2.49E-02	2.82E-04	1.14E-02
FS-19-WG	L2767-44	White Grur	Reference	M	0.62	7.43E-05	2.95E-05	2.44E-04	1.33E-05	8.10E-04	6.95E-06	3.03E-03
FS-03-WG	L2767-33	White Grur	Reference	F	1.63	7.04E-05	2.80E-05	4.90E-04	3.19E-05	1.55E-03	7.65E-06	4.28E-03
FS-12-WG	L2767-38	White Grur	Reference	M	0.51	2.77E-05	1.10E-05	2.70E-04	1.60E-05	8.80E-04	2.84E-06	2.23E-03
FS-02-WG	L2767-32	White Grur	Reference	F	1.21	1.07E-04	4.25E-05	4.76E-04	3.14E-05	1.53E-03	1.38E-05	5.60E-03
FS-13-WG	L2767-39 (	White Grur	Reference	M	0.56	7.67E-05	3.05E-05	7.30E-04	4.50E-05	2.63E-03	1.46E-05	3.00E-03
FS-01-WG	L2767-31	White Grur	Reference	F	6.12	4.35E-04	1.73E-04	2.43E-03	1.45E-04	7.60E-03	6.40E-05	1.89E-02
NEHC-004	L3606-45R	White Grur	Target	F	1.56	5.05E-04	2.01E-04	1.27E-02	8.00E-04	3.44E-02	4.42E-04	8.20E-02
FS-14-WG	L2767-56	White Grur	Target	mmature	2.00	6.94E-04	2.76E-04	6.15E-03	3.50E-04	1.68E-02	1.61E-04	2.48E-02
FS-09-WG	L2767-53	White Grur	Target	mmature	2.70	6.88E-03	2.73E-03	4.24E-02	2.67E-03	1.38E-01	1.40E-03	1.30E-01
FS-16-WG	L2767-58	White Grur	Target	F	5.10	5.99E-03	2.38E-03	7.65E-02	4.51E-03	1.78E-01	2.23E-03	1.88E-01
FS-05-WG	L2767-50	White Grur	Target	F	3.70	3.65E-04	1.45E-04	5.80E-03	3.14E-04	1.54E-02	1.16E-04	1.68E-02
NEHC-001	L3606-14	White Grur	Target	mmature	3.68	7.98E-04	3.17E-04	3.98E-03	2.50E-04	1.27E-02	1.38E-04	8.05E-03
FS-08-WG	L2767-52	White Grur	Target	F	2.40	5.69E-04	2.26E-04	9.60E-03	6.85E-04	3.40E-02	1.35E-04	1.17E-02
FS-04-WG	L2767-49	White Grur	Target	F	5.44	1.92E-03	7.63E-04	1.10E-02	7.25E-04	3.69E-02	3.49E-04	3.83E-02
NEHC-001	L3606-12	White Grur	Target	M	2.68	7.26E-04	2.88E-04	7.75E-03	5.15E-04	2.15E-02	2.26E-04	8.55E-03
FS-03-WG	L2767-48	White Grur	Target	F	6.13	1.50E-03	5.96E-04	1.08E-02	6.05E-04	3.05E-02	3.46E-04	6.00E-02
FS-11-WG	L2767-55	White Grur	Target	M	4.41	1.44E-03	5.72E-04	7.85E-03	4.26E-04	2.34E-02	2.65E-04	3.43E-02
FS-07-WG	L2767-51	White Grur	Target	F	7.18	8.58E-04	3.41E-04	7.95E-03	4.66E-04	2.35E-02	2.55E-04	2.94E-02
NEHC-002	L3606-20	White Grur	Target	F	5.61	7.21E-03	2.87E-03	7.65E-02	4.89E-03	2.51E-01	2.83E-03	1.25E-02
FS-01-WG	L2767-46	White Grur	Target	F	4.76	2.05E-03	8.15E-04	1.23E-02	7.20E-04	3.81E-02	3.92E-04	3.90E-02
NEHC-003	L3606-32	White Grur	Target	0	3.01	1.31E-03	5.21E-04	1.41E-02	9.20E-04	4.00E-02	4.35E-04	3.81E-02
FS-10-WG	L2767-54	White Grur	Target	M	4.40	1.49E-02	5.92E-03	9.80E-02	5.25E-03	2.42E-01	3.19E-03	2.60E-01
FS-02-WG	L2767-47	White Grur	Target	M	7.09	3.89E-02	1.55E-02	2.30E-01	1.53E-02	7.20E-01	7.00E-03	3.27E-01
FS-15-WG	L2767-57	White Grur	Target	M	4.50	1.59E-02	6.32E-03	1.10E-01	5.55E-03	2.60E-01	3.24E-03	2.48E-01
FS-18-WG	L2767-60	White Grur	Target	F	7.31	1.48E-02	5.88E-03	2.51E-01	1.94E-02	7.80E-01	9.00E-03	3.20E-01
FS-17-WG	L2767-59	White Grur	Target	F	4.98	2.37E-03	9.42E-04	4.39E-02	3.01E-03	1.37E-01	1.35E-03	1.23E-01

Appendix

	on					whole body wet					TEC in
	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g				
ID_to_use	TECF156	TECF157	TECF167	TECF169	TECF189	FTEQ_W	FTEQ_L	TEGG077	TEGG081	TEGG105	TEGG114
NEHC-000	3.25E-04	9.65E-05	1.59E-04	2.83E-05	3.57E-05	2.18E-02	2.56E+00	2.85E-02	1.12E-02	4.78E-02	2.77E-03
NEHC-002	2.33E-04	8.00E-05	1.28E-04	1.51E-05	2.19E-05	1.25E-02	2.39E+00	1.65E-02	6.50E-03	7.71E-02	3.98E-03
NEHC-004	1.92E-04	5.95E-05	8.70E-05	4.20E-05	1.98E-05	1.06E-02	3.20E+00	1.02E-02	4.01E-03	5.45E-02	3.01E-03
NEHC-000	1.59E-04	4.49E-05	6.45E-05	2.05E-05	1.37E-05	6.86E-03	1.91E+00	1.44E-02	5.68E-03	5.86E-02	3.31E-03
NEHC-002	2.28E-04	6.00E-05	1.07E-04	1.26E-05	1.86E-05	7.57E-03	1.00E+00	7.04E-03	2.77E-03	3.60E-02	2.20E-03
NEHC-000	1.39E-04	4.19E-05	4.91E-05	1.59E-05	1.56E-05	2.17E-02	1.09E+01	6.48E-03	2.55E-03	7.31E-02	3.04E-03
NEHC-003	2.15E-04	5.45E-05	8.35E-05	1.13E-05	1.98E-05	1.20E-02	3.78E+00	1.21E-02	4.76E-03	7.04E-02	4.49E-03
NEHC-000	2.54E-04	6.50E-05	8.85E-05	1.33E-05	1.99E-05	8.87E-03	4.22E+00	1.05E-02	4.11E-03	1.13E-01	6.02E-03
NEHC-004	2.29E-04	6.70E-05	8.60E-05	2.88E-05	1.99E-05	1.41E-02	2.47E+00	6.22E-03	2.45E-03	4.34E-02	1.75E-03
NEHC-001	2.30E-04	6.45E-05	9.40E-05	1.99E-05	2.34E-05	1.76E-02	2.35E-01	7.95E-04	3.13E-04	3.56E-03	1.80E-04
NEHC-001	3.43E-04	1.03E-04	1.56E-04	2.43E-05	3.23E-05	1.48E-02	1.98E-01				
NEHC-001	2.67E-04	7.35E-05	1.23E-04	1.89E-05	2.25E-05	7.89E-03	2.82E+00	1.98E-02	7.79E-03	1.29E-01	6.41E-03
NEHC-003	1.74E-04	5.20E-05	7.90E-05	1.73E-05	1.66E-05	8.31E-03	2.09E+00	8.74E-03	3.44E-03	6.18E-02	3.45E-03
NEHC-004	3.12E-04	9.35E-05	1.45E-04	2.93E-05	3.29E-05	1.14E-02	1.37E+00	1.40E-02	5.51E-03	4.47E-02	2.92E-03
NEHC-000	1.48E-04	4.30E-05	6.85E-05	9.80E-06	1.55E-05	6.43E-03	2.57E+00	1.40E-02	5.50E-03	7.30E-02	3.92E-03
NEHC-004	1.86E-04	4.87E-05	5.50E-05	2.26E-05	1.51E-05	2.06E-02	7.30E+00				
NEHC-002	2.47E-04	6.65E-05	8.50E-05	2.12E-05	2.40E-05	7.87E-03	1.89E+00				
NEHC-004	2.42E-04	8.40E-05	1.14E-04	4.45E-05	2.91E-05	8.77E-03	2.47E+00				
NEHC-004	3.83E-04	1.07E-04	1.61E-04	4.10E-05	3.09E-05	2.54E-02	3.42E+00				
NEHC-001	1.86E-03	4.61E-04	6.55E-04	1.27E-05	2.11E-04	4.05E-02	1.43E+00				
NEHC-004	2.55E-03	6.95E-04	1.06E-03	1.03E-04	1.09E-04	1.18E-01	2.34E+00				
NEHC-002	2.33E-03	6.35E-04	1.13E-03	5.75E-05	1.28E-04	7.28E-02	9.36E-01	1.00E-02	3.95E-03	4.69E-02	2.94E-03
NEHC-003	1.47E-03	3.87E-04	5.75E-04	3.58E-05	6.55E-05	5.55E-02	8.80E-01	7.31E-03	2.88E-03	4.19E-02	2.53E-03
NEHC-005	5.75E-04	1.52E-04	2.20E-04	4.08E-05	2.64E-05	2.88E-02	7.85E-01	2.76E-03	1.09E-03	2.95E-02	1.91E-03
NEHC-002	4.69E-03	1.02E-03	1.56E-03	6.05E-05	1.57E-04	7.26E-02	3.37E+00				
NEHC-000	7.50E-04	2.32E-04	3.72E-04	2.20E-05	5.20E-05	2.79E-02	2.25E+00	1.98E-02	7.80E-03	1.05E-01	4.95E-03
NEHC-004	2.64E-03	7.00E-04	1.01E-03	8.00E-05	7.30E-05	5.62E-02	9.48E-01				
NEHC-005	2.62E-03	6.90E-04	1.16E-03	2.80E-04	1.55E-04	5.28E-02	5.84E-01	1.08E-02	4.25E-03	5.34E-02	3.20E-03
NEHC-003	1.00E-03	2.28E-04	3.63E-04	3.80E-05	3.90E-05	4.63E-02	8.67E-01	4.69E-03	1.84E-03	3.70E-02	2.40E-03
NEHC-001	2.08E-03	4.81E-04	1.11E-03	3.10E-05	7.60E-05	6.57E-02	8.81E-01	1.26E-02	4.97E-03	5.83E-02	2.69E-03
NEHC-002	5.25E-03	1.27E-03	2.23E-03	1.25E-04	1.74E-04	1.68E-01	4.37E+00				
FS-13-VS-	2.39E-04	6.88E-05	1.08E-04	1.14E-05	1.84E-05	1.82E-02	2.52E-01	5.54E-03	2.18E-03	5.11E-03	2.54E-04
FS-17-VS-	2.71E-04	7.81E-05	1.22E-04	1.21E-05	1.66E-05	1.75E-02	3.03E-01	6.61E-03	2.60E-03	9.29E-03	5.56E-04
NEHC-000	2.28E-04	7.10E-05	1.00E-04	1.32E-05	1.60E-05	1.61E-02	2.72E-01	6.54E-03	2.58E-03	5.83E-03	2.98E-04
FS-21-VS-	3.62E-04	1.04E-04	1.63E-04	2.29E-05	2.78E-05	1.97E-02	5.93E-01	1.07E-02	4.22E-03	1.37E-02	7.99E-04
NEHC-001	3.77E-04	1.06E-04	1.64E-04	1.88E-05	2.75E-05	2.13E-02	3.29E-01	6.80E-03	2.68E-03	7.24E-03	3.99E-04
FS-05-VS-	2.89E-04	8.40E-05	1.22E-04	2.60E-05	2.09E-05	1.65E-02	3.35E-01	8.07E-03	3.18E-03	8.45E-03	4.72E-04
FS-14-VS-	2.97E-04	8.58E-05	1.34E-04	1.78E-05	2.00E-05	2.12E-02	1.99E-01	4.88E-03	1.92E-03	4.45E-03	2.43E-04
NEHC-003	3.72E-04	1.10E-04	1.71E-04	1.93E-05	2.86E-05	2.48E-02	4.19E-01	6.92E-03	2.72E-03	7.99E-03	5.13E-04

A4F.2 TEC_fish

ID_to_use	TECF156	TECF157	TECF167	TECF169	TECF189	FTEQ_W	FTEQ_L	TEGG077	TEGG081	TEGG105	TEGG114
FS-07-VS-	3.51E-04	1.01E-04	1.58E-04	2.04E-05	2.36E-05	1.69E-02	4.21E-01				
FS-18-VS-	2.41E-04	6.94E-05	1.09E-04	1.02E-05	1.66E-05	1.60E-02	3.17E-01	6.32E-03	2.49E-03	7.55E-03	4.10E-04
NEHC-004	4.29E-04	1.22E-04	1.97E-04	4.15E-05	3.09E-05	1.90E-02	9.54E-01				
FS-22-VS-	3.69E-04	1.06E-04	1.66E-04	9.93E-06	2.33E-05	1.21E-02	1.08E+00	2.32E-02	9.12E-03	7.02E-02	3.78E-03
FS-02-VS-	5.81E-04	1.67E-04	2.62E-04	3.73E-05	4.83E-05	2.88E-02	4.96E-01	1.61E-02	6.35E-03	1.32E-02	6.30E-04
FS-15-VS-	7.26E-04	2.09E-04	3.27E-04	1.67E-05	4.27E-05	3.29E-02	6.82E-01				
FS-11-VS-	5.77E-04	1.66E-04	2.60E-04	1.57E-05	3.84E-05	2.07E-02	6.09E-01				
NEHC-001	5.80E-04	1.62E-04	2.63E-04	2.93E-05	3.92E-05	1.85E-02	3.30E-01	9.16E-03	3.60E-03	1.33E-02	7.68E-04
FS-10-VS-	3.83E-04	1.10E-04	1.73E-04	3.68E-05	2.91E-05	2.43E-02	4.42E-01	7.20E-03	2.83E-03	9.88E-03	5.55E-04
FS-16-VS-	5.19E-04	1.50E-04	2.34E-04	3.13E-05	3.25E-05	2.54E-02	5.56E-01	8.74E-03	3.44E-03	1.28E-02	8.57E-04
NEHC-003	8.10E-04	2.27E-04	3.91E-04	3.23E-05	5.45E-05	2.17E-02	5.15E-01				
FS-01-VS-	2.72E-04	7.84E-05	1.23E-04	2.20E-05	2.31E-05	1.01E-02	1.71E-01	6.13E-03	2.41E-03	6.23E-03	3.02E-04
NEHC-001	3.60E-04	1.06E-04	1.65E-04	2.10E-05	3.00E-05	2.02E-02	4.94E-01	6.92E-03	2.72E-03	1.02E-02	5.74E-04
FS-09-VS-	2.03E-04	5.86E-05	9.15E-05	2.06E-05	1.50E-05	1.28E-02	3.67E-01	7.25E-03	2.85E-03	8.68E-03	4.58E-04
FS-17-VS-	5.90E-04	1.40E-04	2.30E-04	1.60E-05	2.13E-05	2.09E-02	3.73E-01	7.04E-03	2.77E-03	2.31E-02	1.21E-03
NEHC-005	5.05E-04	1.30E-04	2.06E-04	4.00E-05	2.19E-05	2.96E-02	5.04E-01				
FS-18-VS-	4.87E-04	1.16E-04	1.90E-04	8.35E-06	1.83E-05	1.47E-02	2.54E-01	5.79E-03	2.28E-03	1.61E-02	8.25E-04
FS-03-VS-	3.57E-04	8.48E-05	1.39E-04	1.48E-05	1.55E-05	1.43E-02	2.24E-01	5.82E-03	2.29E-03	1.14E-02	6.19E-04
FS-16-VS-	4.12E-04	9.79E-05	1.61E-04	1.20E-05	1.65E-05	1.39E-02	2.28E-01	5.71E-03	2.25E-03	1.43E-02	7.73E-04
NEHC-000	1.02E-03	2.21E-04	3.82E-04	2.12E-05	3.49E-05	2.40E-02	7.86E-01	8.43E-03	3.32E-03	5.17E-02	3.33E-03
FS-07-VS-	5.81E-04	1.38E-04	2.26E-04	1.37E-05	2.47E-05	1.63E-02	2.83E-01				
FS-11-VS-	2.66E-03	6.31E-04	1.04E-03	4.08E-05	7.15E-05	8.33E-02	1.28E+00				
FS-01-VS-	4.96E-04	1.18E-04	1.93E-04	1.37E-05	2.01E-05	1.74E-02	3.13E-01	7.68E-03	3.02E-03	1.87E-02	9.84E-04
FS-02-VS-	3.89E-04	9.24E-05	1.52E-04	1.74E-05	2.01E-05	1.26E-02	1.96E-01				
NEHC-003	4.71E-04	1.19E-04	1.81E-04	3.68E-05	1.96E-05	2.30E-02	6.05E-01	8.62E-03	3.39E-03	2.48E-02	1.45E-03
FS-13-VS-	4.12E-04	9.79E-05	1.61E-04	1.39E-05	1.73E-05	1.38E-02	2.38E-01	6.40E-03	2.52E-03	1.62E-02	8.80E-04
NEHC-002	5.55E-04	1.34E-04	2.08E-04	2.63E-05	2.20E-05	2.41E-02	3.51E-01	4.38E-03	1.73E-03	1.73E-02	1.05E-03
FS-12-VS-	1.62E-04	3.84E-05	6.30E-05	6.23E-06	8.45E-06	6.50E-03	3.82E-01	8.71E-03	3.43E-03	1.63E-02	9.50E-04
FS-04-VS-	6.10E-04	1.45E-04	2.38E-04	1.42E-05	2.45E-05	2.15E-02	5.00E-01	8.70E-03	3.42E-03	2.98E-02	1.68E-03
FS-06-VS-	4.32E-04	1.02E-04	1.68E-04	1.06E-05	1.89E-05	1.27E-02	2.62E-01				
FS-09-VS-	1.06E-03	2.51E-04	4.12E-04	1.78E-05	4.62E-05	3.28E-02	6.67E-01				
NEHC-003	2.79E-03	6.45E-04	1.15E-03	1.08E-04	1.30E-04	9.96E-02	2.33E+00				
FS-15-VS-	8.73E-04	2.07E-04	3.40E-04	1.76E-05	3.59E-05	2.76E-02	3.94E-01	8.22E-03	3.24E-03	2.75E-02	1.51E-03
FS-20-VS-	4.60E-04	1.09E-04	1.79E-04	1.60E-05	2.23E-05	1.39E-02	2.96E-01	6.98E-03	2.75E-03	1.78E-02	9.01E-04
FS-20-WG	8.61E-05	2.67E-05	3.93E-05	6.25E-06	5.35E-06	4.21E-03	3.01E-01				
FS-18-WG	4.13E-05	1.28E-05	1.89E-05	3.48E-06	3.02E-06	1.56E-03	2.44E-01				
NEHC-005	1.33E-04	4.43E-05	6.65E-05	1.11E-05	9.60E-06	1.02E-02	5.43E-01				
FS-17-WG	4.42E-05	1.37E-05	2.02E-05	5.55E-06	3.30E-06	3.04E-03	7.61E-01				
FS-16-WG	1.08E-04	3.34E-05	4.92E-05	5.28E-06	8.75E-06	5.56E-03	7.23E-01	7.37E-03	2.90E-03	1.98E-02	1.03E-03
FS-08-WG	9.33E-05	2.90E-05	4.26E-05	4.10E-06	7.90E-06	2.44E-03	3.18E-01				
NEHC-002	8.63E-05	2.73E-05	4.54E-05	4.80E-06	1.15E-05	3.38E-03	2.68E-01				
FS-09-WG	4.45E-05	1.38E-05	2.03E-05	2.30E-06	4.16E-06	1.66E-03	2.71E-01	9.55E-04	3.76E-04	1.24E-02	6.92E-04

A4F.2 TEC_fish

ID_to_use	TECF156	TECF157	TECF167	TECF169	TECF189	FTEQ_W	FTEQ_L	TEGG077	TEGG081	TEGG105	TEGG114
FS-10-WG	7.51E-05	2.33E-05	3.43E-05	3.15E-06	6.55E-06	3.51E-03	4.74E-01				
NEHC-003	1.41E-04	5.25E-05	6.95E-05	7.28E-06	1.36E-05	1.16E-02	9.01E-01	1.91E-03	7.51E-04	1.92E-02	1.10E-03
FS-06-WG	6.21E-05	1.93E-05	2.84E-05	1.88E-06	6.05E-06	3.09E-03	6.75E-01				
NEHC-002	1.83E-04	5.80E-05	8.50E-05	1.38E-05	1.23E-05	7.89E-03	5.30E-01	1.36E-03	5.35E-04	1.70E-02	1.09E-03
FS-14-WG	6.37E-05	1.98E-05	2.91E-05	1.86E-06	8.00E-06	4.52E-03	1.22E+00	5.36E-03	2.11E-03	2.64E-02	1.68E-03
NEHC-000	3.35E-03	7.85E-04	1.16E-03	1.96E-05	1.02E-04	6.11E-02	3.53E+00				
FS-19-WG	1.40E-04	4.35E-05	6.40E-05	2.38E-06	1.25E-05	5.67E-03	9.15E-01				
FS-03-WG	2.14E-04	6.63E-05	9.75E-05	2.15E-05	2.03E-05	8.52E-03	5.23E-01	2.59E-03	1.02E-03	1.92E-02	1.26E-03
FS-12-WG	6.92E-05	2.15E-05	3.16E-05	4.39E-06	8.95E-06	4.60E-03	9.08E-01				
FS-02-WG	2.40E-04	7.45E-05	1.10E-04	1.63E-05	2.48E-05	9.58E-03	7.92E-01	5.30E-03	2.09E-03	2.52E-02	1.68E-03
FS-13-WG	3.14E-04	9.76E-05	1.44E-04	2.83E-06	1.93E-05	9.09E-03	1.62E+00				
FS-01-WG	9.30E-04	2.89E-04	4.25E-04	7.90E-05	6.55E-05	3.56E-02	5.82E-01	4.26E-03	1.68E-03	2.54E-02	1.53E-03
NEHC-004	3.99E-03	9.75E-04	1.40E-03	1.12E-04	1.24E-04	1.72E-01	1.10E+01	1.95E-02	7.66E-03	5.22E-01	3.32E-02
FS-14-WG	2.53E-03	5.30E-04	9.20E-04	1.22E-04	1.61E-04	6.25E-02	3.13E+00				
FS-09-WG	2.01E-02	3.61E-03	6.90E-03	3.03E-04	1.10E-03	3.91E-01	1.45E+01				
FS-16-WG	3.34E-02	6.55E-03	9.40E-03	3.65E-04	9.55E-04	5.68E-01	1.11E+01	7.04E-02	2.77E-02	9.59E-01	5.72E-02
FS-05-WG	1.58E-03	3.58E-04	5.60E-04	1.76E-05	4.42E-05	4.77E-02	1.29E+00	5.92E-03	2.33E-03	1.00E-01	5.48E-03
NEHC-001	1.72E-03	3.85E-04	6.15E-04	3.43E-05	1.16E-04	3.31E-02	9.00E-01				
FS-08-WG	2.94E-03	7.00E-04	1.07E-03	3.70E-05	1.18E-04	7.04E-02	2.93E+00	1.42E-02	5.59E-03	2.56E-01	1.84E-02
FS-04-WG	3.65E-03	8.30E-04	1.42E-03	5.25E-05	1.33E-04	1.11E-01	2.05E+00	2.12E-02	8.33E-03	1.29E-01	8.61E-03
NEHC-001	2.94E-03	6.50E-04	1.00E-03	3.00E-05	1.16E-04	5.27E-02	1.97E+00				
FS-03-WG	4.52E-03	8.15E-04	1.54E-03	8.75E-05	4.06E-04	1.26E-01	2.06E+00	1.47E-02	5.77E-03	1.12E-01	6.38E-03
FS-11-WG	2.40E-03	5.15E-04	9.35E-04	2.53E-04	9.55E-05	8.18E-02	1.85E+00				
FS-07-WG	2.70E-03	5.75E-04	1.06E-03	7.95E-05	1.17E-04	7.33E-02	1.02E+00	7.17E-03	2.82E-03	7.08E-02	4.19E-03
NEHC-002	3.40E-02	8.00E-03	1.26E-02	1.60E-04	1.23E-03	4.67E-01	8.32E+00	7.70E-02	3.03E-02	8.72E-01	5.63E-02
FS-01-WG	4.28E-03	1.04E-03	1.81E-03	6.25E-05	1.78E-04	1.13E-01	2.37E+00	2.58E-02	1.02E-02	1.65E-01	9.78E-03
NEHC-003	6.10E-03	1.39E-03	2.13E-03	5.18E-05	2.95E-04	1.18E-01	3.92E+00				
FS-10-WG	3.86E-02	7.35E-03	1.34E-02	4.70E-04	1.57E-03	8.07E-01	1.84E+01				
FS-02-WG	9.55E-02	1.83E-02	3.88E-02	9.03E-04	4.13E-03	1.66E+00	2.34E+01				
FS-15-WG	5.35E-02	9.80E-03	1.83E-02	7.08E-04	1.94E-03	8.20E-01	1.82E+01				
FS-18-WG	1.14E-01	2.20E-02	3.99E-02	2.23E-03	3.84E-03	1.76E+00	2.40E+01	1.21E-01	4.78E-02	2.20E+00	1.72E-01
FS-17-WG	1.70E-02	3.48E-03	6.70E-03	1.80E-04	7.50E-04	3.87E-01	7.76E+00	2.85E-02	1.12E-02	5.63E-01	3.91E-02

Appendix

	Egg calculated from PCBs measured in female (lipid-based)								TEQ for Egg		
									pg/lipid	pg/wet	pg/wet
ID_to_use	TEGG118	TEGG123	TEGG126	TEGG156c	TEGG157	TEGG167	TEGG169	TEGG189	TEQ_EGGL	TEQ_EGGw	TEQ_EGGx
NEHC-000	1.51E-01	1.29E-03	9.17E-01	1.98E-02	6.06E-03	9.32E-03	1.21E-03	1.62E-03	1.198	0.131	0.0010
NEHC-002	2.23E-01	1.25E-03	6.14E-01	2.31E-02	8.17E-03	1.22E-02	1.04E-03	1.62E-03	0.989	0.108	0.0005
NEHC-004	1.83E-01	1.17E-03	6.20E-01	3.02E-02	9.63E-03	1.32E-02	4.62E-03	2.32E-03	0.936	0.102	0.0003
NEHC-000	1.64E-01	1.34E-03	3.16E-01	2.28E-02	6.65E-03	8.95E-03	2.07E-03	1.47E-03	0.605	0.066	0.0002
NEHC-002	1.10E-01	8.14E-04	2.64E-01	1.56E-02	4.24E-03	7.05E-03	6.05E-04	9.51E-04	0.451	0.049	0.0003
NEHC-000	2.17E-01	3.93E-04	3.28E+00	3.60E-02	1.12E-02	1.23E-02	2.88E-03	3.01E-03	3.648	0.398	0.0007
NEHC-003	2.16E-01	1.44E-03	9.29E-01	3.51E-02	9.21E-03	1.32E-02	1.29E-03	2.42E-03	1.300	0.142	0.0004
NEHC-000	3.49E-01	1.73E-03	9.49E-01	6.26E-02	1.65E-02	2.11E-02	2.29E-03	3.66E-03	1.540	0.168	0.0003
NEHC-004	1.29E-01	1.48E-03	7.89E-01	2.08E-02	6.29E-03	7.55E-03	1.83E-03	1.35E-03	1.011	0.110	0.0006
NEHC-001	1.01E-02	7.51E-05	4.67E-02	1.59E-03	4.62E-04	6.30E-04	9.65E-05	1.21E-04	0.065	0.007	0.0005
NEHC-001											
NEHC-001	3.82E-01	3.46E-03	6.03E-01	4.94E-02	1.40E-02	2.19E-02	2.45E-03	3.11E-03	1.242	0.136	0.0003
NEHC-003	1.76E-01	1.53E-03	5.21E-01	2.26E-02	6.97E-03	9.92E-03	1.58E-03	1.61E-03	0.819	0.089	0.0003
NEHC-004	1.31E-01	1.98E-03	4.23E-01	1.95E-02	6.01E-03	8.73E-03	1.28E-03	1.53E-03	0.660	0.072	0.0005
NEHC-000	2.17E-01	1.70E-03	5.46E-01	3.07E-02	9.18E-03	1.37E-02	1.42E-03	2.39E-03	0.918	0.100	0.0002
NEHC-004											
NEHC-002											
NEHC-004											
NEHC-004											
NEHC-001											
NEHC-004											
NEHC-002	1.48E-01	1.22E-03	2.59E-01	1.55E-02	4.36E-03	7.23E-03	2.68E-04	6.37E-04	0.501	0.055	0.0039
NEHC-003	1.23E-01	1.35E-03	2.46E-01	1.20E-02	3.28E-03	4.56E-03	2.06E-04	4.02E-04	0.445	0.049	0.0028
NEHC-005	8.15E-02	7.23E-04	2.45E-01	8.11E-03	2.20E-03	2.99E-03	4.03E-04	2.78E-04	0.376	0.041	0.0014
NEHC-002											
NEHC-000	3.25E-01	3.28E-03	4.87E-01	3.13E-02	9.97E-03	1.50E-02	6.44E-04	1.62E-03	1.011	0.110	0.0013
NEHC-004											
NEHC-005	1.54E-01	1.92E-03	6.82E-02	1.50E-02	4.07E-03	6.41E-03	1.12E-03	6.60E-04	0.323	0.035	0.0029
NEHC-003	1.06E-01	9.38E-04	2.67E-01	9.70E-03	2.28E-03	3.40E-03	2.58E-04	2.83E-04	0.436	0.048	0.0023
NEHC-001	2.41E-01	1.24E-03	1.36E-01	1.44E-02	3.44E-03	7.40E-03	1.51E-04	3.94E-04	0.483	0.053	0.0036
NEHC-002											
FS-13-VS-	1.33E-02	2.12E-04	1.01E-01	1.72E-03	5.10E-04	7.46E-04	5.72E-05	9.86E-05	0.131	0.014	0.0009
FS-17-VS-	2.27E-02	2.58E-04	1.14E-01	2.43E-03	7.21E-04	1.05E-03	7.58E-05	1.11E-04	0.160	0.018	0.0009
NEHC-000	1.41E-02	2.38E-04	1.12E-01	1.99E-03	6.40E-04	8.44E-04	8.06E-05	1.05E-04	0.145	0.016	0.0009
FS-21-VS-	3.86E-02	4.48E-04	2.22E-01	5.64E-03	1.68E-03	2.45E-03	2.50E-04	3.23E-04	0.300	0.033	0.0010
NEHC-001	1.94E-02	2.88E-04	1.30E-01	3.01E-03	8.72E-04	1.26E-03	1.05E-04	1.64E-04	0.173	0.019	0.0011
FS-05-VS-	2.21E-02	3.53E-04	1.32E-01	3.04E-03	9.11E-04	1.24E-03	1.91E-04	1.64E-04	0.180	0.020	0.0009
FS-14-VS-	1.12E-02	1.63E-04	8.21E-02	1.45E-03	4.31E-04	6.30E-04	6.06E-05	7.26E-05	0.108	0.012	0.0011
NEHC-003	2.17E-02	3.14E-04	1.75E-01	3.25E-03	9.91E-04	1.44E-03	1.18E-04	1.87E-04	0.221	0.024	0.0013

A4F.2 TEC_fish

ID_to_use	TEGG118	TEGG123	TEGG126	TEGG156c	TEGG157	TEGG167	TEGG169	TEGG189	TEQ_EGGL	TEQ_EGGw	TEQ_EGGx
FS-07-VS-											
FS-18-VS-	2.00E-02	2.43E-04	1.25E-01	2.47E-03	7.35E-04	1.08E-03	7.32E-05	1.27E-04	0.167	0.018	0.0008
NEHC-004											
FS-22-VS-	1.82E-01	2.09E-03	2.47E-01	1.70E-02	5.06E-03	7.41E-03	3.21E-04	8.05E-04	0.569	0.062	0.0006
FS-02-VS-	4.11E-02	5.85E-04	1.77E-01	5.18E-03	1.54E-03	2.25E-03	2.33E-04	3.22E-04	0.265	0.029	0.0015
FS-15-VS-											
FS-11-VS-											
NEHC-001	3.84E-02	4.70E-04	9.96E-02	5.37E-03	1.54E-03	2.35E-03	1.90E-04	2.71E-04	0.175	0.019	0.0010
FS-10-VS-	2.67E-02	3.64E-04	1.76E-01	3.61E-03	1.07E-03	1.57E-03	2.42E-04	2.05E-04	0.230	0.025	0.0013
FS-16-VS-	4.56E-02	4.65E-04	2.11E-01	5.90E-03	1.75E-03	2.56E-03	2.49E-04	2.75E-04	0.293	0.032	0.0013
NEHC-003											
FS-01-VS-	1.70E-02	2.71E-04	5.51E-02	2.39E-03	7.09E-04	1.04E-03	1.35E-04	1.51E-04	0.092	0.010	0.0005
NEHC-001	2.83E-02	3.60E-04	1.94E-01	4.55E-03	1.38E-03	2.01E-03	1.86E-04	2.84E-04	0.252	0.027	0.0010
FS-09-VS-	2.32E-02	3.33E-04	1.41E-01	3.02E-03	8.98E-04	1.31E-03	2.15E-04	1.66E-04	0.190	0.021	0.0007
FS-17-VS-	6.29E-02	6.42E-04	9.26E-02	5.45E-03	1.33E-03	2.05E-03	1.04E-04	1.47E-04	0.199	0.022	0.0011
NEHC-005											
FS-18-VS-	4.35E-02	4.70E-04	6.48E-02	4.35E-03	1.06E-03	1.63E-03	5.22E-05	1.22E-04	0.141	0.015	0.0008
FS-03-VS-	3.10E-02	2.90E-04	6.46E-02	2.90E-03	7.10E-04	1.09E-03	8.42E-05	9.38E-05	0.121	0.013	0.0008
FS-16-VS-	3.90E-02	4.39E-04	5.69E-02	3.50E-03	8.57E-04	1.31E-03	7.14E-05	1.05E-04	0.125	0.014	0.0008
NEHC-000	1.40E-01	1.50E-03	1.73E-01	1.73E-02	3.87E-03	6.26E-03	2.52E-04	4.43E-04	0.409	0.045	0.0012
FS-07-VS-											
FS-11-VS-											
FS-01-VS-	5.13E-02	4.34E-04	7.61E-02	4.63E-03	1.13E-03	1.74E-03	8.94E-05	1.40E-04	0.166	0.018	0.0009
FS-02-VS-											
NEHC-003	6.75E-02	8.68E-04	1.94E-01	6.42E-03	1.67E-03	2.38E-03	3.51E-04	1.99E-04	0.312	0.034	0.0012
FS-13-VS-	4.30E-02	4.40E-04	5.25E-02	3.68E-03	9.01E-04	1.38E-03	8.66E-05	1.15E-04	0.128	0.014	0.0007
NEHC-002	4.46E-02	4.48E-04	1.12E-01	4.19E-03	1.04E-03	1.51E-03	1.39E-04	1.24E-04	0.188	0.021	0.0013
FS-12-VS-	4.33E-02	4.88E-04	6.95E-02	4.93E-03	1.21E-03	1.85E-03	1.33E-04	1.92E-04	0.151	0.016	0.0003
FS-04-VS-	8.35E-02	7.44E-04	1.20E-01	7.36E-03	1.80E-03	2.76E-03	1.20E-04	2.20E-04	0.260	0.028	0.0011
FS-06-VS-											
FS-09-VS-											
NEHC-003											
FS-15-VS-	7.46E-02	7.22E-04	9.12E-02	6.45E-03	1.58E-03	2.42E-03	9.12E-05	1.98E-04	0.218	0.024	0.0015
FS-20-VS-	4.92E-02	5.03E-04	7.27E-02	5.07E-03	1.24E-03	1.90E-03	1.24E-04	1.84E-04	0.159	0.017	0.0007
FS-20-WG											
FS-18-WG											
NEHC-005											
FS-17-WG											
FS-16-WG	5.80E-02	6.31E-04	2.27E-01	7.24E-03	2.32E-03	3.19E-03	2.48E-04	4.40E-04	0.330	0.036	0.0003
FS-08-WG											
NEHC-002											
FS-09-WG	3.68E-02	2.24E-04	5.78E-02	3.76E-03	1.20E-03	1.66E-03	1.36E-04	2.63E-04	0.116	0.013	0.0001

A4F.2 TEC_fish

ID_to_use	TEGG118	TEGG123	TEGG126	TEGG156c	TEGG157	TEGG167	TEGG169	TEGG189	TEQ_EGGL	TEQ_EGGw	TEQ_EGGx
FS-10-WG											
NEHC-003	5.73E-02	2.43E-04	3.27E-01	5.64E-03	2.17E-03	2.69E-03	2.05E-04	4.08E-04	0.418	0.046	0.0005
FS-06-WG											
NEHC-002	4.96E-02	4.04E-04	1.70E-01	6.34E-03	2.08E-03	2.85E-03	3.35E-04	3.19E-04	0.252	0.028	0.0004
FS-14-WG	7.88E-02	4.89E-04	3.32E-01	8.92E-03	2.85E-03	3.93E-03	1.82E-04	8.36E-04	0.463	0.051	0.0002
NEHC-000											
FS-19-WG											
FS-03-WG	5.99E-02	2.33E-04	1.44E-01	6.78E-03	2.17E-03	2.99E-03	4.78E-04	4.81E-04	0.241	0.026	0.0004
FS-12-WG											
FS-02-WG	7.93E-02	5.65E-04	2.54E-01	1.03E-02	3.28E-03	4.52E-03	4.87E-04	7.93E-04	0.387	0.042	0.0005
FS-13-WG											
FS-01-WG	7.82E-02	5.18E-04	1.70E-01	7.87E-03	2.52E-03	3.47E-03	4.68E-04	4.14E-04	0.296	0.032	0.0018
NEHC-004	1.39E+00	1.41E-02	2.89E+00	1.33E-01	3.34E-02	4.49E-02	2.60E-03	3.08E-03	5.093	0.556	0.0079
FS-14-WG											
FS-09-WG											
FS-16-WG	2.19E+00	2.17E-02	2.02E+00	3.39E-01	6.86E-02	9.21E-02	2.60E-03	7.24E-03	5.857	0.639	0.0299
FS-05-WG	2.61E-01	1.55E-03	2.49E-01	2.21E-02	5.16E-03	7.56E-03	1.72E-04	4.62E-04	0.661	0.072	0.0024
NEHC-001											
FS-08-WG	8.92E-01	2.78E-03	2.66E-01	6.34E-02	1.56E-02	2.23E-02	5.59E-04	1.90E-03	1.559	0.170	0.0037
FS-04-WG	4.26E-01	3.18E-03	3.86E-01	3.47E-02	8.14E-03	1.30E-02	3.50E-04	9.46E-04	1.040	0.114	0.0057
NEHC-001											
FS-03-WG	3.13E-01	2.79E-03	5.37E-01	3.81E-02	7.10E-03	1.26E-02	5.18E-04	2.56E-03	1.053	0.115	0.0065
FS-11-WG											
FS-07-WG	2.06E-01	1.76E-03	2.25E-01	1.94E-02	4.27E-03	7.34E-03	4.02E-04	6.28E-04	0.549	0.060	0.0039
NEHC-002	2.81E+00	2.50E-02	1.22E-01	3.14E-01	7.61E-02	1.12E-01	1.03E-03	8.48E-03	4.504	0.492	0.0253
FS-01-WG	5.04E-01	4.08E-03	4.50E-01	4.66E-02	1.16E-02	1.90E-02	4.76E-04	1.45E-03	1.248	0.136	0.0059
NEHC-003											
FS-10-WG											
FS-02-WG											
FS-15-WG											
FS-18-WG	6.72E+00	6.10E-02	2.40E+00	8.07E-01	1.60E-01	2.72E-01	1.10E-02	2.03E-02	12.988	1.417	0.0949
FS-17-WG	1.73E+00	1.34E-02	1.35E+00	1.76E-01	3.73E-02	6.72E-02	1.31E-03	5.83E-03	4.025	0.439	0.0200

Table A4F.2 Summary stats for the fish data TEQs

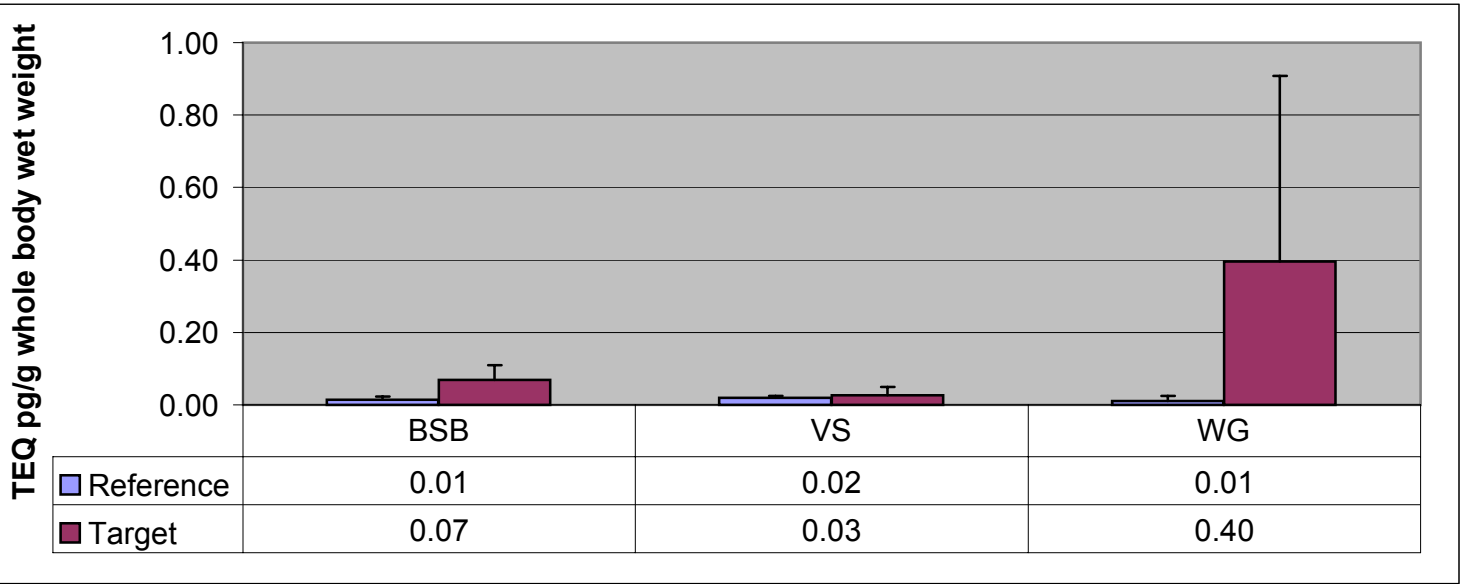
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	0.01	0.01	0.01	0.04	Target	11	0.07	0.04	0.03	0.17
VS	Reference	22	0.02	0.01	0.01	0.03	Target	20	0.03	0.02	0.01	0.10
WG	Reference	20	0.01	0.01	0.00	0.06	Target	20	0.40	0.51	0.03	1.76

species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	2.91	2.43	0.20	10.87	Target	11	1.65	1.26	0.58	4.37
VS	Reference	22	0.46	0.23	0.17	1.08	Target	20	0.52	0.50	0.20	2.33
WG	Reference	20	0.81	0.73	0.24	3.53	Target	20	8.01	7.80	0.90	24.02

species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	14	1.099	0.825	0.065	3.648	Target	7	0.511	0.229	0.323	1.011
VS	Reference	17	0.215	0.110	0.092	0.569	Target	13	0.198	0.085	0.121	0.409
WG	Reference	8	0.313	0.112	0.116	0.463	Target	11	3.507	3.702	0.549	12.988

site	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	14	0.12	0.09	0.01	0.40	Target	7	0.06	0.02	0.04	0.11
VS	Reference	17	0.02	0.01	0.01	0.06	Target	13	0.02	0.01	0.01	0.04
WG	Reference	8	0.03	0.01	0.01	0.05	Target	11	0.38	0.40	0.06	1.42

A



B

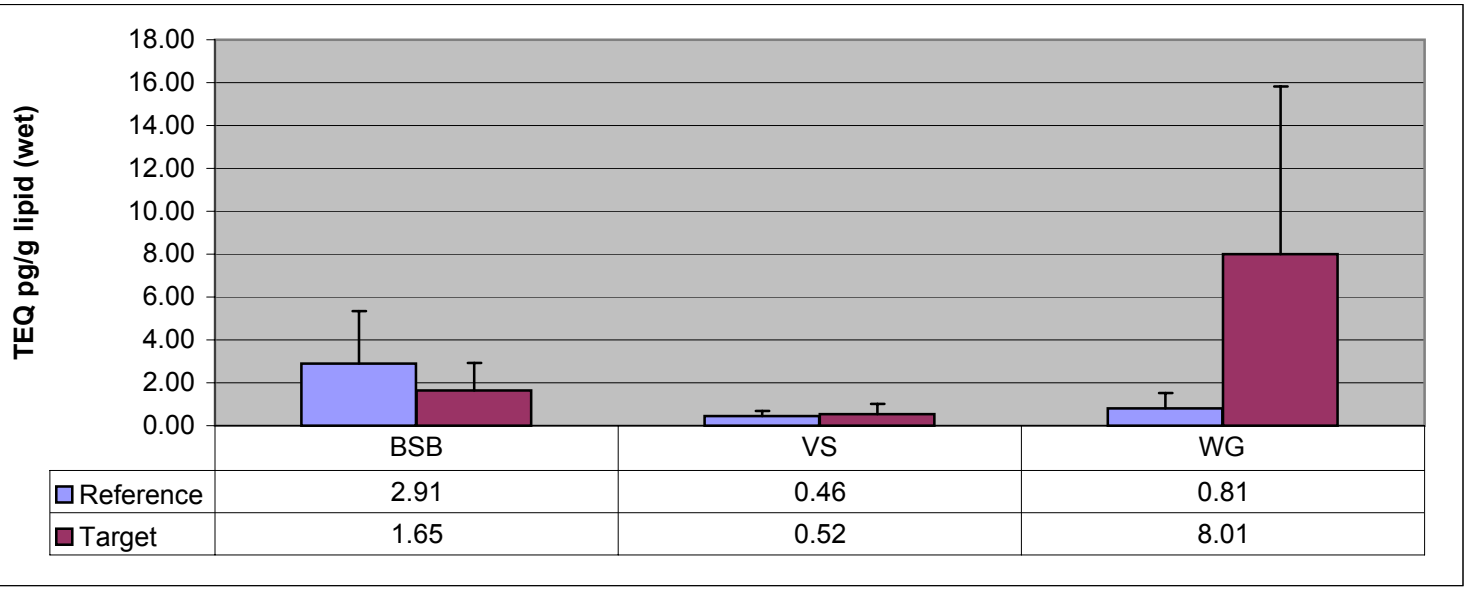


Figure A4F-1 Plot of fish TEQs based on whole body (A) and lipid (B) concentrations.

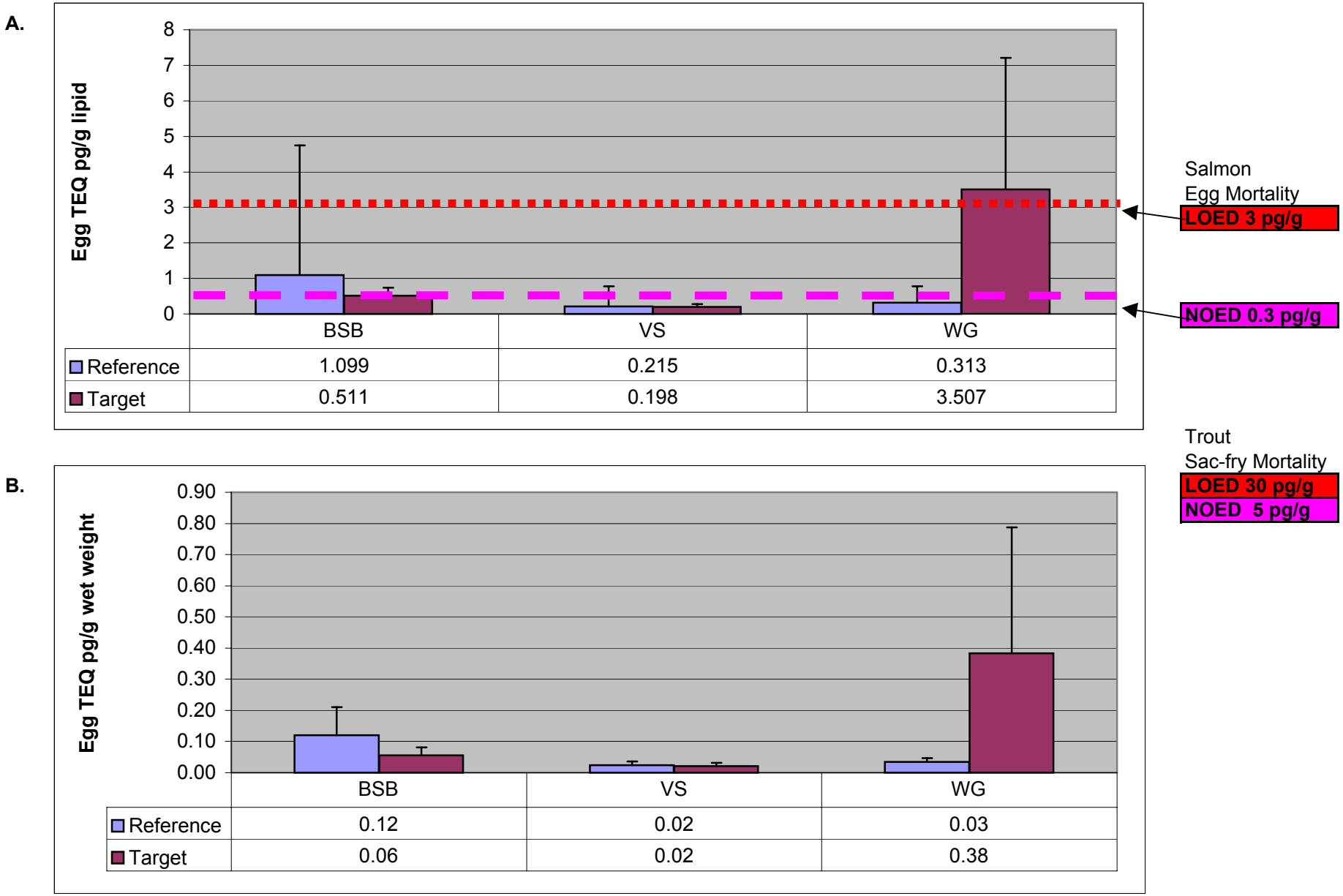
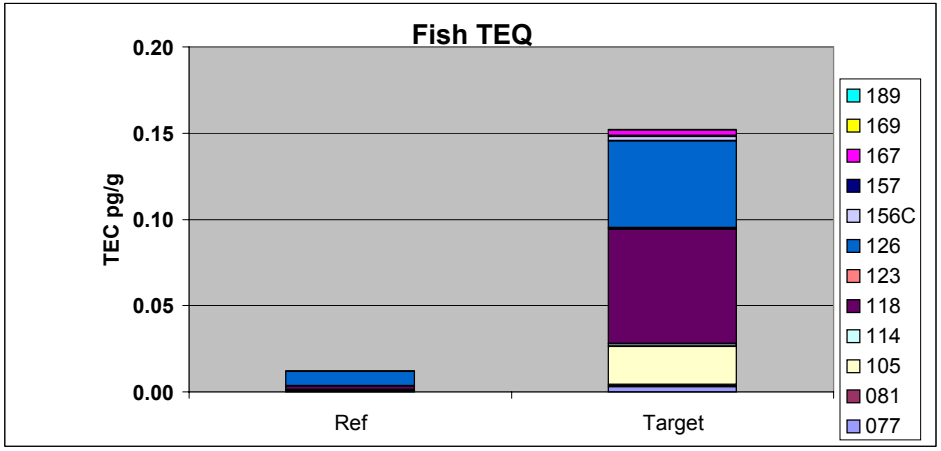
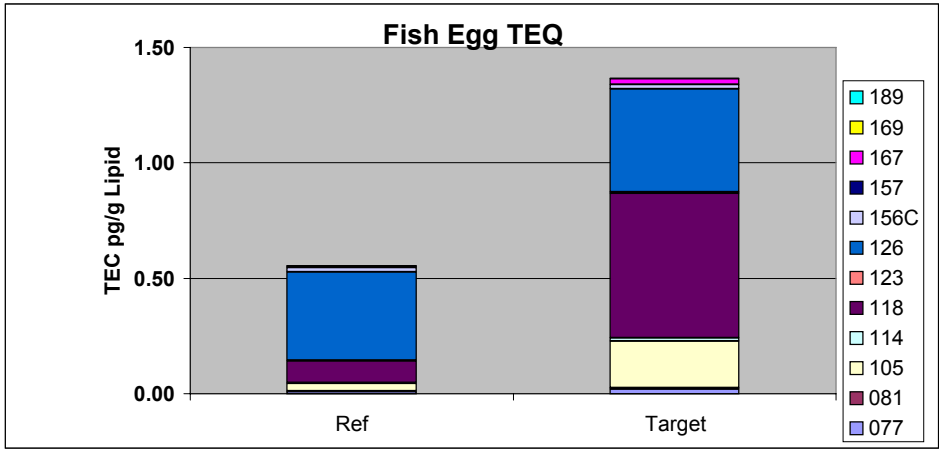
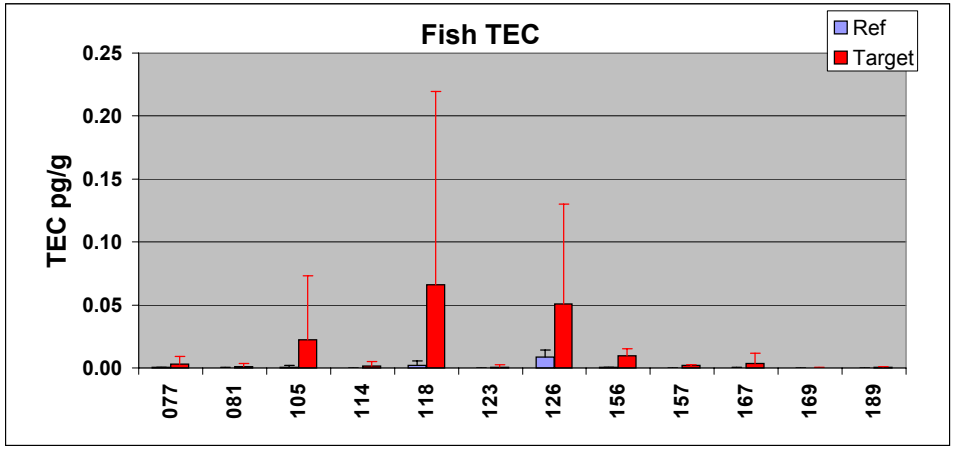


Figure A4F-2 Plot of fish egg TEQs based on lipid (A) and wet weight (B) concentrations. Benchmarks for salmon egg mortality (A) and trout sac-fry mortality are also shown.







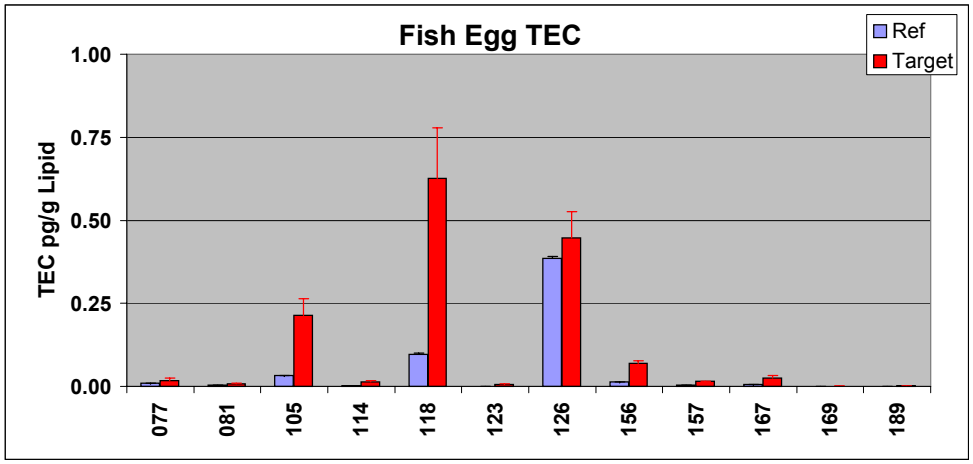


Figure A4F-3 Plots show data from all fish for the average sum of TEC (TEQ) for fish and fish eggs and the mean and standard deviation of TECs for dioxin-like co-planar PCBs measured in fish and estimated for eggs.

Appendix A4F.4 Dietary TECs for Birds from fish data using DL/2 for nondetected values

The data will be used to address dietary exp				wet weight fillet concentration								
				pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
ID_to_use	Lab ID	Species	Site	TECB077	TECB081	TECB105	TECB114	TECB118	TECB123	TECB126	TECB156c	TECB157
NEHC-000	L3606-5	Black Seat	Reference	2.02E-01	3.21E-02	1.27E-02	7.28E-04	4.08E-03	4.42E-05	2.84E-01	6.49E-03	1.93E-03
NEHC-002	L3606-24	Black Seat	Reference	7.20E-02	1.14E-02	1.26E-02	6.43E-04	3.70E-03	2.64E-05	1.17E-01	4.66E-03	1.60E-03
NEHC-004	L3606-48R	Black Seat	Reference	2.80E-02	4.45E-03	5.62E-03	3.07E-04	1.92E-03	1.56E-05	7.45E-02	3.84E-03	1.19E-03
NEHC-000	L3606-7	Black Seat	Reference	4.33E-02	6.88E-03	6.60E-03	3.69E-04	1.88E-03	1.95E-05	4.14E-02	3.17E-03	8.97E-04
NEHC-002	L3606-23	Black Seat	Reference	4.43E-02	7.04E-03	8.49E-03	5.15E-04	2.64E-03	2.48E-05	7.25E-02	4.56E-03	1.20E-03
NEHC-000	L3606-2 i	Black Seat	Reference	1.08E-02	1.72E-03	4.57E-03	1.88E-04	1.38E-03	3.18E-06	2.39E-01	2.78E-03	8.37E-04
NEHC-003	L3606-34	Black Seat	Reference	3.19E-02	5.07E-03	6.96E-03	4.39E-04	2.17E-03	1.83E-05	1.07E-01	4.29E-03	1.09E-03
NEHC-000	L3606-4	Black Seat	Reference	1.83E-02	2.91E-03	7.43E-03	3.91E-04	2.33E-03	1.47E-05	7.26E-02	5.08E-03	1.30E-03
NEHC-004	L3606-42R	Black Seat	Reference	2.95E-02	4.69E-03	7.72E-03	3.09E-04	2.34E-03	3.39E-05	1.64E-01	4.58E-03	1.34E-03
NEHC-001	L3606-16	Black Seat	Reference	4.95E-02	7.86E-03	8.30E-03	4.15E-04	2.40E-03	2.26E-05	1.27E-01	4.59E-03	1.29E-03
NEHC-001	L3606-17	Black Seat	Reference	2.37E-02	3.77E-03	9.21E-03	5.07E-04	3.19E-03	1.46E-05	6.65E-02	6.85E-03	2.06E-03
NEHC-001	L3606-11 i	Black Seat	Reference	4.62E-02	7.34E-03	1.13E-02	5.55E-04	3.40E-03	3.91E-05	6.15E-02	5.34E-03	1.47E-03
NEHC-003	L3606-33 i	Black Seat	Reference	2.90E-02	4.61E-03	7.69E-03	4.25E-04	2.23E-03	2.46E-05	7.55E-02	3.48E-03	1.04E-03
NEHC-004	L3606-44R	Black Seat	Reference	9.70E-02	1.54E-02	1.16E-02	7.50E-04	3.46E-03	6.64E-05	1.28E-01	6.24E-03	1.87E-03
NEHC-000	L3606-3	Black Seat	Reference	2.92E-02	4.63E-03	5.71E-03	3.03E-04	1.72E-03	1.71E-05	4.97E-02	2.96E-03	8.60E-04
NEHC-004	L3606-46R	Black Seat	Reference	1.20E-02	1.91E-03	5.10E-03	3.77E-04	1.58E-03	1.20E-05	2.59E-01	3.71E-03	9.73E-04
NEHC-002	L3606-26	Black Seat	Reference	1.56E-02	2.48E-03	6.81E-03	3.83E-04	2.16E-03	6.20E-06	7.55E-02	4.93E-03	1.33E-03
NEHC-004	L3606-49R	Black Seat	Reference	2.14E-02	3.40E-03	8.96E-03	4.63E-04	2.63E-03	1.66E-05	7.70E-02	4.83E-03	1.68E-03
NEHC-004	L3606-41R	Black Seat	Reference	9.35E-02	1.49E-02	1.56E-02	1.08E-03	4.46E-03	6.63E-05	3.19E-01	7.65E-03	2.14E-03
NEHC-001	L3606-10 i	Black Seat	Reference	2.02E-01	3.21E-02	4.17E-02	2.21E-03	1.40E-02	8.64E-05	4.21E-01	3.72E-02	9.21E-03
NEHC-004	L3606-43R	Black Seat	Target	2.84E-01	4.51E-02	1.41E-01	7.94E-03	3.71E-02	5.36E-04	1.46E+00	5.10E-02	1.39E-02
NEHC-002	L3606-27	Black Seat	Target	6.50E-01	1.03E-01	1.14E-01	7.07E-03	3.66E-02	3.82E-04	7.35E-01	4.66E-02	1.27E-02
NEHC-003	L3606-36R	Black Seat	Target	3.84E-01	6.10E-02	8.26E-02	4.93E-03	2.46E-02	3.43E-04	5.64E-01	2.93E-02	7.74E-03
NEHC-005	L3606-53R	Black Seat	Target	8.45E-02	1.34E-02	3.39E-02	2.17E-03	9.50E-03	1.07E-04	3.27E-01	1.15E-02	3.03E-03
NEHC-002	L3606-21	Black Seat	Target	2.38E-01	3.78E-02	2.06E-01	1.19E-02	5.53E-02	6.95E-04	1.28E-01	9.37E-02	2.04E-02
NEHC-000	L3606-6	Black Seat	Target	2.05E-01	3.26E-02	4.07E-02	1.90E-03	1.28E-02	1.64E-04	2.20E-01	1.50E-02	4.63E-03
NEHC-004	L3606-47R	Black Seat	Target	3.98E-01	6.33E-02	1.62E-01	9.25E-03	4.49E-02	5.74E-04	2.75E-01	5.28E-02	1.40E-02
NEHC-005	L3606-50R	Black Seat	Target	8.15E-01	1.30E-01	1.51E-01	8.95E-03	4.43E-02	7.00E-04	2.25E-01	5.24E-02	1.38E-02
NEHC-003	L3606-31	Black Seat	Target	2.09E-01	3.31E-02	6.17E-02	3.97E-03	1.79E-02	2.02E-04	5.20E-01	2.00E-02	4.56E-03
NEHC-001	L3606-13	Black Seat	Target	7.85E-01	1.25E-01	1.36E-01	6.22E-03	5.72E-02	3.73E-04	3.69E-01	4.15E-02	9.61E-03
NEHC-002	L3606-22	Black Seat	Target	1.10E+00	1.74E-01	2.06E-01	1.88E-02	9.39E-02	9.86E-04	1.56E+00	1.05E-01	2.53E-02
FS-13-VS-	L2767-8	Vermilion S	Reference	3.33E-01	5.29E-02	1.15E-02	5.65E-04	3.05E-03	6.16E-05	2.66E-01	4.77E-03	1.38E-03
FS-17-VS-	L2767-12	Vermilion S	Reference	3.19E-01	5.06E-02	1.68E-02	9.95E-04	4.17E-03	6.02E-05	2.40E-01	5.42E-03	1.56E-03
NEHC-000	L3606-9 i	Vermilion S	Reference	3.23E-01	5.13E-02	1.08E-02	5.46E-04	2.65E-03	5.69E-05	2.42E-01	4.56E-03	1.42E-03
FS-21-VS-	L2767-14	Vermilion S	Reference	2.97E-01	4.72E-02	1.42E-02	8.21E-04	4.07E-03	6.00E-05	2.68E-01	7.24E-03	2.09E-03
NEHC-001	L3606-15	Vermilion S	Reference	3.68E-01	5.85E-02	1.47E-02	8.01E-04	4.01E-03	7.55E-05	3.08E-01	7.54E-03	2.12E-03
FS-05-VS-	L2767-3	Vermilion S	Reference	3.31E-01	5.26E-02	1.30E-02	7.19E-04	3.45E-03	7.00E-05	2.36E-01	5.78E-03	1.68E-03
FS-14-VS-	L2767-9	Vermilion S	Reference	4.33E-01	6.87E-02	1.48E-02	8.01E-04	3.78E-03	6.99E-05	3.18E-01	5.95E-03	1.72E-03
NEHC-003	L3606-35	Vermilion S	Reference	3.42E-01	5.43E-02	1.48E-02	9.40E-04	4.09E-03	7.51E-05	3.78E-01	7.43E-03	2.20E-03

A4F.4 TEC_bird

ID_to_use	Lab ID	Species	Site	TECB077	TECB081	TECB105	TECB114	TECB118	TECB123	TECB126	TECB156c	TECB157
FS-07-VS-	L2767-4	Vermilion S	Reference	2.68E-01	4.26E-02	1.16E-02	5.70E-04	3.22E-03	6.16E-05	2.42E-01	7.02E-03	2.02E-03
FS-18-VS-	L2767-13	Vermilion S	Reference	2.66E-01	4.22E-02	1.19E-02	6.39E-04	3.20E-03	4.95E-05	2.30E-01	4.82E-03	1.39E-03
NEHC-004	L3606-40R	Vermilion S	Reference	2.24E-01	3.56E-02	1.49E-02	7.20E-04	4.03E-03	8.29E-05	2.57E-01	8.57E-03	2.44E-03
FS-22-VS-	L2767-15	Vermilion S	Reference	2.17E-01	3.44E-02	2.46E-02	1.31E-03	6.49E-03	9.43E-05	1.01E-01	7.37E-03	2.12E-03
FS-02-VS-	L2767-2	Vermilion S	Reference	7.80E-01	1.24E-01	2.40E-02	1.13E-03	7.58E-03	1.37E-04	3.75E-01	1.16E-02	3.35E-03
FS-15-VS-	L2767-10	Vermilion S	Reference	4.81E-01	7.64E-02	2.71E-02	1.38E-03	8.26E-03	1.44E-04	4.44E-01	1.45E-02	4.19E-03
FS-11-VS-	L2767-7	Vermilion S	Reference	3.41E-01	5.41E-02	1.87E-02	9.73E-04	5.61E-03	8.30E-05	2.70E-01	1.15E-02	3.33E-03
NEHC-001	L3606-18	Vermilion S	Reference	4.27E-01	6.79E-02	2.32E-02	1.33E-03	6.82E-03	1.06E-04	2.03E-01	1.16E-02	3.23E-03
FS-10-VS-	L2767-6	Vermilion S	Reference	3.30E-01	5.25E-02	1.70E-02	9.45E-04	4.66E-03	8.08E-05	3.52E-01	7.66E-03	2.21E-03
FS-16-VS-	L2767-11	Vermilion S	Reference	3.33E-01	5.29E-02	1.82E-02	1.21E-03	6.61E-03	8.56E-05	3.50E-01	1.04E-02	3.00E-03
NEHC-003	L3606-30	Vermilion S	Reference	3.34E-01	5.31E-02	2.66E-02	1.70E-03	8.62E-03	1.32E-04	2.44E-01	1.62E-02	4.54E-03
FS-01-VS-	L2767-1	Vermilion S	Reference	3.02E-01	4.79E-02	1.15E-02	5.52E-04	3.18E-03	6.46E-05	1.19E-01	5.44E-03	1.57E-03
NEHC-001	L3606-19	Vermilion S	Reference	2.36E-01	3.75E-02	1.30E-02	7.27E-04	3.68E-03	5.95E-05	2.90E-01	7.19E-03	2.11E-03
FS-09-VS-	L2767-5	Vermilion S	Reference	2.11E-01	3.35E-02	9.45E-03	4.93E-04	2.57E-03	4.68E-05	1.79E-01	4.06E-03	1.17E-03
FS-17-VS-	L2767-28	Vermilion S	Target	3.29E-01	5.22E-02	4.04E-02	2.10E-03	1.12E-02	1.45E-04	1.89E-01	1.18E-02	2.80E-03
NEHC-005	L3606-52R	Vermilion S	Target	1.42E-01	2.26E-02	3.28E-02	1.84E-03	8.58E-03	1.29E-04	4.12E-01	1.01E-02	2.59E-03
FS-18-VS-	L2767-29	Vermilion S	Target	2.80E-01	4.45E-02	2.92E-02	1.48E-03	8.01E-03	1.10E-04	1.37E-01	9.74E-03	2.31E-03
FS-03-VS-	L2767-18	Vermilion S	Target	3.10E-01	4.92E-02	2.27E-02	1.22E-03	6.28E-03	7.46E-05	1.50E-01	7.14E-03	1.70E-03
FS-16-VS-	L2767-27	Vermilion S	Target	2.91E-01	4.62E-02	2.73E-02	1.46E-03	7.55E-03	1.08E-04	1.27E-01	8.25E-03	1.96E-03
NEHC-000	L3606-8	Vermilion S	Target	2.15E-01	3.41E-02	4.93E-02	3.14E-03	1.36E-02	1.85E-04	1.92E-01	2.04E-02	4.42E-03
FS-07-VS-	L2767-21	Vermilion S	Target	3.39E-01	5.38E-02	2.74E-02	1.47E-03	7.95E-03	1.16E-04	1.53E-01	1.16E-02	2.76E-03
FS-11-VS-	L2767-23	Vermilion S	Target	7.25E-01	1.15E-01	1.98E-01	1.10E-02	5.06E-02	8.19E-04	7.05E-01	5.32E-02	1.26E-02
FS-01-VS-	L2767-16	Vermilion S	Target	3.56E-01	5.65E-02	3.24E-02	1.69E-03	9.04E-03	9.71E-05	1.54E-01	9.92E-03	2.35E-03
FS-02-VS-	L2767-17	Vermilion S	Target	3.13E-01	4.97E-02	2.33E-02	1.26E-03	6.43E-03	8.39E-05	1.20E-01	7.79E-03	1.85E-03
NEHC-003	L3606-37R	Vermilion S	Target	2.73E-01	4.34E-02	2.94E-02	1.70E-03	8.14E-03	1.33E-04	2.69E-01	9.42E-03	2.37E-03
FS-13-VS-	L2767-25	Vermilion S	Target	3.10E-01	4.92E-02	2.93E-02	1.58E-03	7.93E-03	1.03E-04	1.11E-01	8.25E-03	1.96E-03
NEHC-002	L3606-29	Vermilion S	Target	2.51E-01	3.98E-02	3.71E-02	2.23E-03	9.72E-03	1.24E-04	2.80E-01	1.11E-02	2.67E-03
FS-12-VS-	L2767-24 i	Vermilion S	Target	1.24E-01	1.96E-02	8.67E-03	5.00E-04	2.34E-03	3.35E-05	4.31E-02	3.24E-03	7.69E-04
FS-04-VS-	L2767-19	Vermilion S	Target	3.12E-01	4.95E-02	4.01E-02	2.24E-03	1.14E-02	1.29E-04	1.88E-01	1.22E-02	2.90E-03
FS-06-VS-	L2767-20	Vermilion S	Target	2.76E-01	4.39E-02	2.45E-02	1.29E-03	6.60E-03	9.30E-05	1.17E-01	8.64E-03	2.05E-03
FS-09-VS-	L2767-22	Vermilion S	Target	4.69E-01	7.45E-02	6.15E-02	3.76E-03	1.81E-02	2.29E-04	3.03E-01	2.12E-02	5.02E-03
NEHC-003	L3606-38R	Vermilion S	Target	6.50E-01	1.03E-01	1.29E-01	8.21E-03	3.89E-02	5.61E-04	1.22E+00	5.57E-02	1.29E-02
FS-15-VS-	L2767-26 (	Vermilion S	Target	4.80E-01	7.63E-02	6.02E-02	3.28E-03	1.66E-02	2.04E-04	2.33E-01	1.75E-02	4.14E-03
FS-20-VS-	L2767-30	Vermilion S	Target	2.74E-01	4.35E-02	2.61E-02	1.31E-03	7.35E-03	9.53E-05	1.25E-01	9.20E-03	2.18E-03
FS-20-WG	L2767-45	White Grur	Reference	3.37E-02	5.36E-03	3.85E-03	2.36E-04	1.12E-03	1.16E-05	5.14E-02	1.72E-03	5.34E-04
FS-18-WG	L2767-43	White Grur	Reference	2.50E-02	3.97E-03	1.90E-03	1.09E-04	6.14E-04	5.67E-06	1.36E-02	8.26E-04	2.56E-04
NEHC-005	L3606-51R	White Grur	Reference	8.70E-02	1.38E-02	6.33E-03	2.95E-04	1.84E-03	2.20E-05	1.40E-01	2.66E-03	8.86E-04
FS-17-WG	L2767-42	White Grur	Reference	1.62E-02	2.57E-03	2.07E-03	1.28E-04	6.08E-04	7.75E-06	3.25E-02	8.85E-04	2.75E-04
FS-16-WG	L2767-41	White Grur	Reference	4.73E-02	7.52E-03	4.77E-03	2.45E-04	1.42E-03	1.96E-05	6.36E-02	2.15E-03	6.68E-04
FS-08-WG	L2767-35	White Grur	Reference	2.69E-02	4.28E-03	4.01E-03	2.54E-04	1.16E-03	1.10E-05	1.77E-02	1.87E-03	5.79E-04
NEHC-002	L3606-28	White Grur	Reference	2.30E-02	3.66E-03	3.56E-03	1.93E-04	1.02E-03	3.21E-06	3.67E-02	1.73E-03	5.46E-04
FS-09-WG	L2767-36	White Grur	Reference	4.88E-03	7.75E-04	2.38E-03	1.31E-04	7.15E-04	5.53E-06	1.29E-02	8.89E-04	2.76E-04

A4F.4 TEC_bird

ID_to_use	Lab ID	Species	Site	TECB077	TECB081	TECB105	TECB114	TECB118	TECB123	TECB126	TECB156c	TECB157
FS-10-WG	L2767-37	White Grur	Reference	2.22E-02	3.53E-03	3.83E-03	2.03E-04	1.13E-03	1.17E-05	3.71E-02	1.50E-03	4.66E-04
NEHC-003	L3606-39R	White Grur	Reference	2.05E-02	3.26E-03	7.76E-03	4.38E-04	2.35E-03	1.27E-05	1.54E-01	2.81E-03	1.05E-03
FS-06-WG	L2767-34	White Grur	Reference	3.08E-03	4.89E-04	2.90E-03	2.15E-04	8.52E-04	9.76E-06	2.96E-02	1.24E-03	3.86E-04
NEHC-002	L3606-25R	White Grur	Reference	1.69E-02	2.68E-03	7.91E-03	5.04E-04	2.35E-03	2.43E-05	9.25E-02	3.65E-03	1.16E-03
FS-14-WG	L2767-40	White Grur	Reference	1.66E-02	2.63E-03	3.06E-03	1.92E-04	9.27E-04	7.30E-06	4.47E-02	1.27E-03	3.96E-04
NEHC-000	L3606-1	White Grur	Reference	3.94E-01	6.25E-02	1.81E-01	1.13E-02	4.97E-02	5.64E-04	2.28E-01	6.69E-02	1.57E-02
FS-19-WG	L2767-44	White Grur	Reference	3.72E-02	5.91E-03	4.88E-03	2.65E-04	1.62E-03	1.39E-05	6.05E-02	2.80E-03	8.70E-04
FS-03-WG	L2767-33	White Grur	Reference	3.52E-02	5.60E-03	9.80E-03	6.38E-04	3.10E-03	1.53E-05	8.55E-02	4.27E-03	1.33E-03
FS-12-WG	L2767-38	White Grur	Reference	1.39E-02	2.20E-03	5.39E-03	3.20E-04	1.76E-03	5.68E-06	4.45E-02	1.38E-03	4.30E-04
FS-02-WG	L2767-32	White Grur	Reference	5.35E-02	8.50E-03	9.52E-03	6.28E-04	3.05E-03	2.76E-05	1.12E-01	4.80E-03	1.49E-03
FS-13-WG	L2767-39 (	White Grur	Reference	3.84E-02	6.10E-03	1.46E-02	8.99E-04	5.26E-03	2.91E-05	6.00E-02	6.29E-03	1.95E-03
FS-01-WG	L2767-31	White Grur	Reference	2.18E-01	3.46E-02	4.86E-02	2.89E-03	1.52E-02	1.28E-04	3.78E-01	1.86E-02	5.77E-03
NEHC-004	L3606-45R	White Grur	Target	2.53E-01	4.01E-02	2.54E-01	1.60E-02	6.87E-02	8.84E-04	1.64E+00	7.97E-02	1.95E-02
FS-14-WG	L2767-56	White Grur	Target	3.47E-01	5.52E-02	1.23E-01	6.99E-03	3.35E-02	3.22E-04	4.96E-01	5.05E-02	1.06E-02
FS-09-WG	L2767-53	White Grur	Target	3.44E+00	5.47E-01	8.48E-01	5.34E-02	2.76E-01	2.79E-03	2.60E+00	4.01E-01	7.22E-02
FS-16-WG	L2767-58	White Grur	Target	3.00E+00	4.76E-01	1.53E+00	9.02E-02	3.55E-01	4.46E-03	3.76E+00	6.68E-01	1.31E-01
FS-05-WG	L2767-50	White Grur	Target	1.83E-01	2.90E-02	1.16E-01	6.27E-03	3.07E-02	2.31E-04	3.36E-01	3.16E-02	7.15E-03
NEHC-001	L3606-14	White Grur	Target	3.99E-01	6.34E-02	7.96E-02	5.00E-03	2.53E-02	2.76E-04	1.61E-01	3.43E-02	7.70E-03
FS-08-WG	L2767-52	White Grur	Target	2.85E-01	4.52E-02	1.92E-01	1.37E-02	6.80E-02	2.69E-04	2.33E-01	5.88E-02	1.40E-02
FS-04-WG	L2767-49	White Grur	Target	9.60E-01	1.53E-01	2.20E-01	1.45E-02	7.37E-02	6.98E-04	7.65E-01	7.30E-02	1.66E-02
NEHC-001	L3606-12	White Grur	Target	3.63E-01	5.77E-02	1.55E-01	1.03E-02	4.30E-02	4.51E-04	1.71E-01	5.87E-02	1.30E-02
FS-03-WG	L2767-48	White Grur	Target	7.50E-01	1.19E-01	2.15E-01	1.21E-02	6.10E-02	6.91E-04	1.20E+00	9.03E-02	1.63E-02
FS-11-WG	L2767-55	White Grur	Target	7.20E-01	1.14E-01	1.57E-01	8.51E-03	4.67E-02	5.29E-04	6.85E-01	4.80E-02	1.03E-02
FS-07-WG	L2767-51	White Grur	Target	4.29E-01	6.82E-02	1.59E-01	9.32E-03	4.69E-02	5.09E-04	5.88E-01	5.39E-02	1.15E-02
NEHC-002	L3606-20	White Grur	Target	3.61E+00	5.73E-01	1.53E+00	9.77E-02	5.01E-01	5.65E-03	2.50E-01	6.80E-01	1.60E-01
FS-01-WG	L2767-46	White Grur	Target	1.03E+00	1.63E-01	2.46E-01	1.44E-02	7.62E-02	7.84E-04	7.80E-01	8.56E-02	2.07E-02
NEHC-003	L3606-32	White Grur	Target	6.55E-01	1.04E-01	2.82E-01	1.84E-02	7.99E-02	8.70E-04	7.62E-01	1.22E-01	2.77E-02
FS-10-WG	L2767-54	White Grur	Target	7.45E+00	1.18E+00	1.96E+00	1.05E-01	4.83E-01	6.37E-03	5.20E+00	7.72E-01	1.47E-01
FS-02-WG	L2767-47	White Grur	Target	1.95E+01	3.09E+00	4.60E+00	3.05E-01	1.44E+00	1.40E-02	6.54E+00	1.91E+00	3.66E-01
FS-15-WG	L2767-57	White Grur	Target	7.95E+00	1.26E+00	2.19E+00	1.11E-01	5.19E-01	6.48E-03	4.96E+00	1.07E+00	1.96E-01
FS-18-WG	L2767-60	White Grur	Target	7.40E+00	1.18E+00	5.02E+00	3.88E-01	1.56E+00	1.80E-02	6.40E+00	2.28E+00	4.39E-01
FS-17-WG	L2767-59	White Grur	Target	1.19E+00	1.88E-01	8.77E-01	6.02E-02	2.74E-01	2.70E-03	2.45E+00	3.39E-01	6.96E-02

Appendix

The data w	pg/g	pg/g	pg/g	whole body wet pg/g	pg/g
ID_to_use	TECB167	TECB169	TECB189	BTEQ_W	BTEQ_L
NEHC-000	3.17E-04	5.65E-04	7.13E-05	0.654	76.946
NEHC-002	2.56E-04	3.01E-04	4.38E-05	0.309	59.215
NEHC-004	1.74E-04	8.40E-04	3.96E-05	0.233	70.778
NEHC-000	1.29E-04	4.10E-04	2.73E-05	0.190	52.834
NEHC-002	2.13E-04	2.52E-04	3.71E-05	0.180	23.848
NEHC-000	9.82E-05	3.18E-04	3.11E-05	0.432	215.921
NEHC-003	1.67E-04	2.26E-04	3.95E-05	0.261	82.711
NEHC-000	1.77E-04	2.66E-04	3.97E-05	0.173	82.336
NEHC-004	1.72E-04	5.75E-04	3.98E-05	0.294	51.718
NEHC-001	1.88E-04	3.97E-04	4.68E-05	0.414	5.550
NEHC-001	3.11E-04	4.87E-04	6.46E-05	0.281	3.769
NEHC-001	2.45E-04	3.78E-04	4.50E-05	0.181	64.478
NEHC-003	1.58E-04	3.47E-04	3.32E-05	0.181	45.371
NEHC-004	2.90E-04	5.85E-04	6.57E-05	0.313	37.709
NEHC-000	1.37E-04	1.96E-04	3.09E-05	0.153	61.067
NEHC-004	1.10E-04	4.52E-04	3.02E-05	0.408	144.835
NEHC-002	1.70E-04	4.24E-04	4.80E-05	0.152	36.356
NEHC-004	2.27E-04	8.90E-04	5.81E-05	0.171	48.269
NEHC-004	3.21E-04	8.20E-04	6.18E-05	0.584	78.552
NEHC-001	1.31E-03	2.54E-04	4.22E-04	0.906	32.021
NEHC-004	2.12E-03	2.07E-03	2.18E-04	2.305	45.769
NEHC-002	2.25E-03	1.15E-03	2.56E-04	1.846	23.741
NEHC-003	1.15E-03	7.15E-04	1.31E-04	1.323	21.000
NEHC-005	4.39E-04	8.15E-04	5.28E-05	0.579	15.773
NEHC-002	3.11E-03	1.21E-03	3.13E-04	1.082	50.165
NEHC-000	7.43E-04	4.41E-04	1.04E-04	0.689	55.560
NEHC-004	2.01E-03	1.60E-03	1.46E-04	1.136	19.150
NEHC-005	2.32E-03	5.60E-03	3.09E-04	1.565	17.291
NEHC-003	7.25E-04	7.60E-04	7.80E-05	0.994	18.621
NEHC-001	2.21E-03	6.20E-04	1.52E-04	1.671	22.394
NEHC-002	4.46E-03	2.50E-03	3.48E-04	3.714	96.414
FS-13-VS-	2.15E-04	2.27E-04	3.67E-05	0.727	10.097
FS-17-VS-	2.44E-04	2.42E-04	3.32E-05	0.683	11.823
NEHC-000	2.00E-04	2.63E-04	3.20E-05	0.669	11.296
FS-21-VS-	3.26E-04	4.57E-04	5.55E-05	0.712	21.448
NEHC-001	3.28E-04	3.76E-04	5.50E-05	0.818	12.604
FS-05-VS-	2.44E-04	5.19E-04	4.17E-05	0.677	13.768
FS-14-VS-	2.68E-04	3.55E-04	3.99E-05	0.881	8.287
NEHC-003	3.42E-04	3.85E-04	5.72E-05	0.852	14.392

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ID_to_use	TECB167	TECB169	TECB189	BTEQ_W	BTEQ_L
FS-07-VS-	3.16E-04	4.07E-04	4.72E-05	0.618	15.458
FS-18-VS-	2.17E-04	2.04E-04	3.32E-05	0.599	11.892
NEHC-004	3.93E-04	8.30E-04	6.17E-05	0.608	30.574
FS-22-VS-	3.32E-04	1.99E-04	4.66E-05	0.438	39.096
FS-02-VS-	5.23E-04	7.45E-04	9.66E-05	1.408	24.273
FS-15-VS-	6.54E-04	3.34E-04	8.54E-05	1.142	23.647
FS-11-VS-	5.20E-04	3.14E-04	7.68E-05	0.755	22.211
NEHC-001	5.26E-04	5.85E-04	7.84E-05	0.805	14.393
FS-10-VS-	3.45E-04	7.35E-04	5.82E-05	0.830	15.084
FS-16-VS-	4.68E-04	6.25E-04	6.49E-05	0.830	18.209
NEHC-003	7.81E-04	6.45E-04	1.09E-04	0.732	17.392
FS-01-VS-	2.45E-04	4.40E-04	4.62E-05	0.520	8.821
NEHC-001	3.30E-04	4.19E-04	6.00E-05	0.650	15.888
FS-09-VS-	1.83E-04	4.13E-04	2.99E-05	0.481	13.825
FS-17-VS-	4.59E-04	3.21E-04	4.25E-05	0.696	12.437
NEHC-005	4.12E-04	8.00E-04	4.37E-05	0.671	11.412
FS-18-VS-	3.79E-04	1.67E-04	3.65E-05	0.539	9.286
FS-03-VS-	2.78E-04	2.96E-04	3.09E-05	0.587	9.208
FS-16-VS-	3.21E-04	2.40E-04	3.30E-05	0.541	8.869
NEHC-000	7.64E-04	4.23E-04	6.98E-05	0.597	19.569
FS-07-VS-	4.52E-04	2.73E-04	4.94E-05	0.645	11.222
FS-11-VS-	2.07E-03	8.15E-04	1.43E-04	2.006	30.857
FS-01-VS-	3.86E-04	2.74E-04	4.02E-05	0.684	12.330
FS-02-VS-	3.03E-04	3.47E-04	4.02E-05	0.549	8.526
NEHC-003	3.61E-04	7.35E-04	3.91E-05	0.707	18.629
FS-13-VS-	3.21E-04	2.77E-04	3.46E-05	0.566	9.762
NEHC-002	4.15E-04	5.25E-04	4.40E-05	0.678	9.894
FS-12-VS-	1.26E-04	1.25E-04	1.69E-05	0.297	17.467
FS-04-VS-	4.75E-04	2.84E-04	4.89E-05	0.693	16.132
FS-06-VS-	3.36E-04	2.13E-04	3.78E-05	0.509	10.494
FS-09-VS-	8.23E-04	3.55E-04	9.23E-05	1.023	20.815
NEHC-003	2.29E-03	2.15E-03	2.59E-04	2.351	55.111
FS-15-VS-	6.79E-04	3.52E-04	7.17E-05	0.945	13.504
FS-20-VS-	3.58E-04	3.21E-04	4.46E-05	0.528	11.224
FS-20-WG	7.86E-05	1.25E-04	1.07E-05	0.115	8.202
FS-18-WG	3.77E-05	6.95E-05	6.04E-06	0.058	9.113
NEHC-005	1.33E-04	2.22E-04	1.92E-05	0.294	15.684
FS-17-WG	4.04E-05	1.11E-04	6.59E-06	0.077	19.372
FS-16-WG	9.83E-05	1.06E-04	1.75E-05	0.159	20.599
FS-08-WG	8.52E-05	8.20E-05	1.58E-05	0.072	9.358
NEHC-002	9.07E-05	9.60E-05	2.30E-05	0.086	6.819
FS-09-WG	4.06E-05	4.60E-05	8.31E-06	0.031	5.083

A4F.4 TEC_bird

ID_to_use	TECB167	TECB169	TECB189	BTEQ_W	BTEQ_L
FS-10-WG	6.86E-05	6.30E-05	1.31E-05	0.087	11.733
NEHC-003	1.39E-04	1.46E-04	2.72E-05	0.232	18.011
FS-06-WG	5.67E-05	3.75E-05	1.21E-05	0.055	11.968
NEHC-002	1.70E-04	2.76E-04	2.46E-05	0.152	10.233
FS-14-WG	5.82E-05	3.72E-05	1.60E-05	0.104	28.128
NEHC-000	2.31E-03	3.91E-04	2.04E-04	1.174	67.864
FS-19-WG	1.28E-04	4.76E-05	2.50E-05	0.145	23.394
FS-03-WG	1.95E-04	4.30E-04	4.05E-05	0.181	11.115
FS-12-WG	6.32E-05	8.77E-05	1.79E-05	0.090	17.813
FS-02-WG	2.19E-04	3.25E-04	4.96E-05	0.225	18.609
FS-13-WG	2.87E-04	5.65E-05	3.86E-05	0.171	30.595
FS-01-WG	8.49E-04	1.58E-03	1.31E-04	0.818	13.365
NEHC-004	2.80E-03	2.24E-03	2.48E-04	2.971	190.849
FS-14-WG	1.84E-03	2.45E-03	3.21E-04	1.319	65.969
FS-09-WG	1.38E-02	6.05E-03	2.19E-03	9.083	336.405
FS-16-WG	1.88E-02	7.30E-03	1.91E-03	11.237	220.327
FS-05-WG	1.12E-03	3.52E-04	8.84E-05	0.852	23.032
NEHC-001	1.23E-03	6.85E-04	2.31E-04	0.887	24.093
FS-08-WG	2.14E-03	7.40E-04	2.36E-04	1.040	43.349
FS-04-WG	2.84E-03	1.05E-03	2.66E-04	2.645	48.623
NEHC-001	2.00E-03	6.00E-04	2.31E-04	1.041	38.852
FS-03-WG	3.08E-03	1.75E-03	8.11E-04	2.791	45.536
FS-11-WG	1.87E-03	5.06E-03	1.91E-04	2.031	46.061
FS-07-WG	2.11E-03	1.59E-03	2.33E-04	1.494	20.802
NEHC-002	2.52E-02	3.20E-03	2.46E-03	8.400	149.680
FS-01-WG	3.62E-03	1.25E-03	3.56E-04	2.707	56.867
NEHC-003	4.25E-03	1.04E-03	5.89E-04	2.305	76.597
FS-10-WG	2.67E-02	9.40E-03	3.13E-03	20.296	461.267
FS-02-WG	7.75E-02	1.81E-02	8.26E-03	41.602	586.776
FS-15-WG	3.66E-02	1.42E-02	3.88E-03	20.519	455.983
FS-18-WG	7.97E-02	4.45E-02	7.68E-03	27.543	376.779
FS-17-WG	1.34E-02	3.60E-03	1.50E-03	6.229	125.087

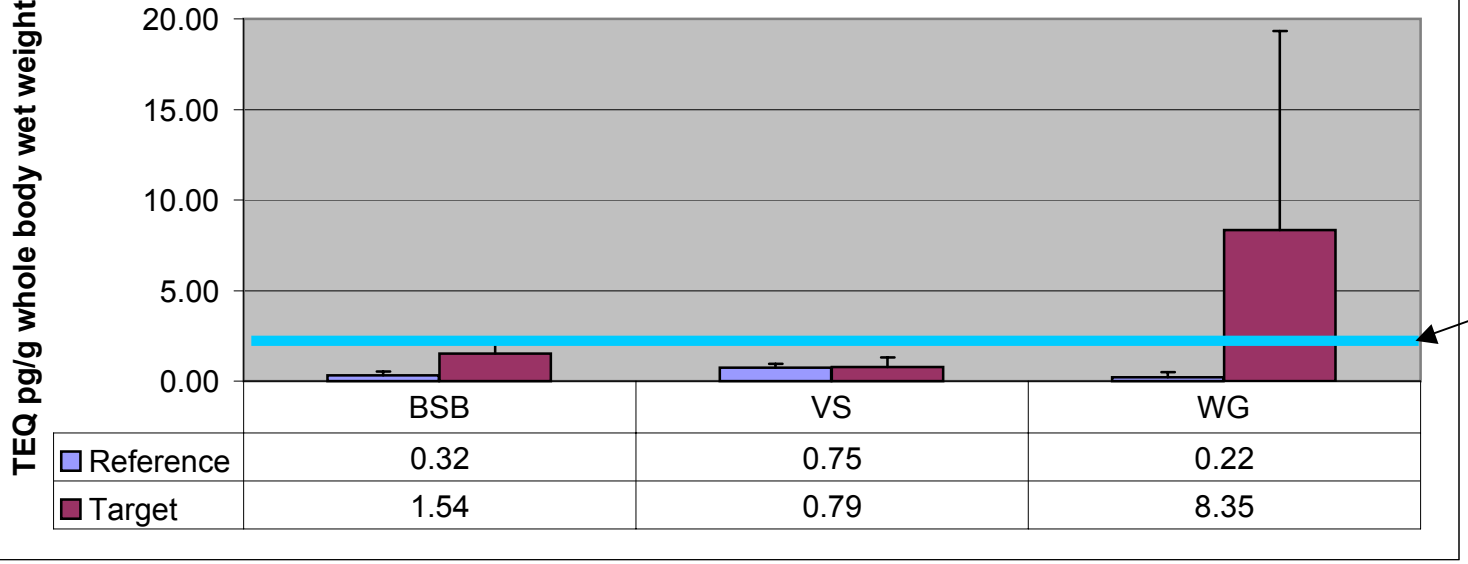
Table A4F-3 Summary stats for the avian dietary TEQs calculated from fish data

		Bird TEQ pg/g whole body wet weight										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	0.32	0.20	0.15	0.91	Target	11	1.54	0.88	0.58	3.71
VS	Reference	22	0.75	0.21	0.44	1.41	Target	20	0.79	0.50	0.30	2.35
WG	Reference	20	0.22	0.28	0.03	1.17	Target	20	8.35	10.99	0.85	41.60

		Bird TEQ pg/g whole body lipid weight (wet)										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	63.71	47.44	3.77	215.92	Target	11	35.08	24.95	15.77	96.41
VS	Reference	22	17.02	7.42	8.29	39.10	Target	20	15.84	10.76	8.53	55.11
WG	Reference	20	17.85	13.64	5.08	67.86	Target	20	169.65	176.59	20.80	586.78

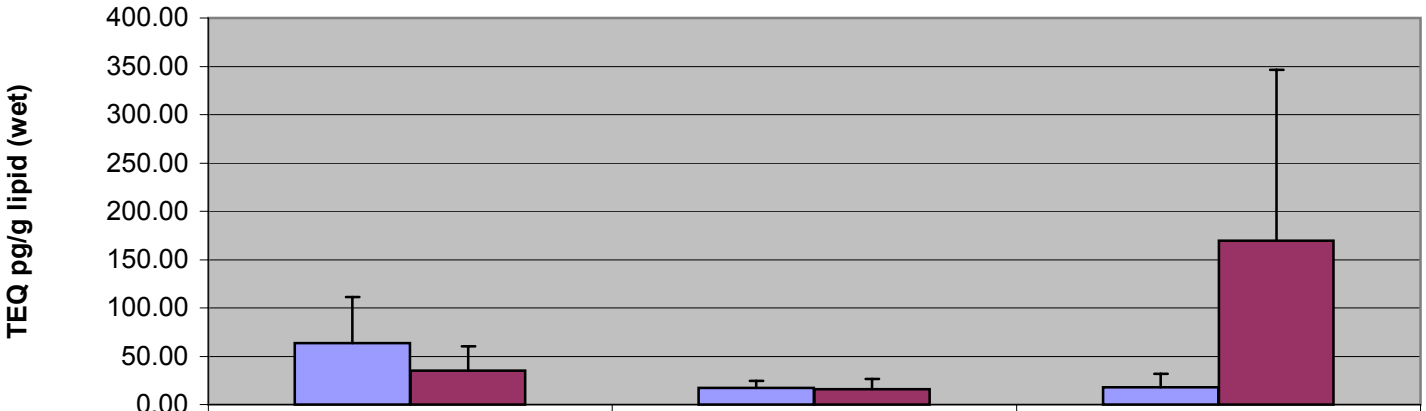
Gull NOAEL 64.8 pg/g
Cormorant NOAEL 62.2 pg/g

A.



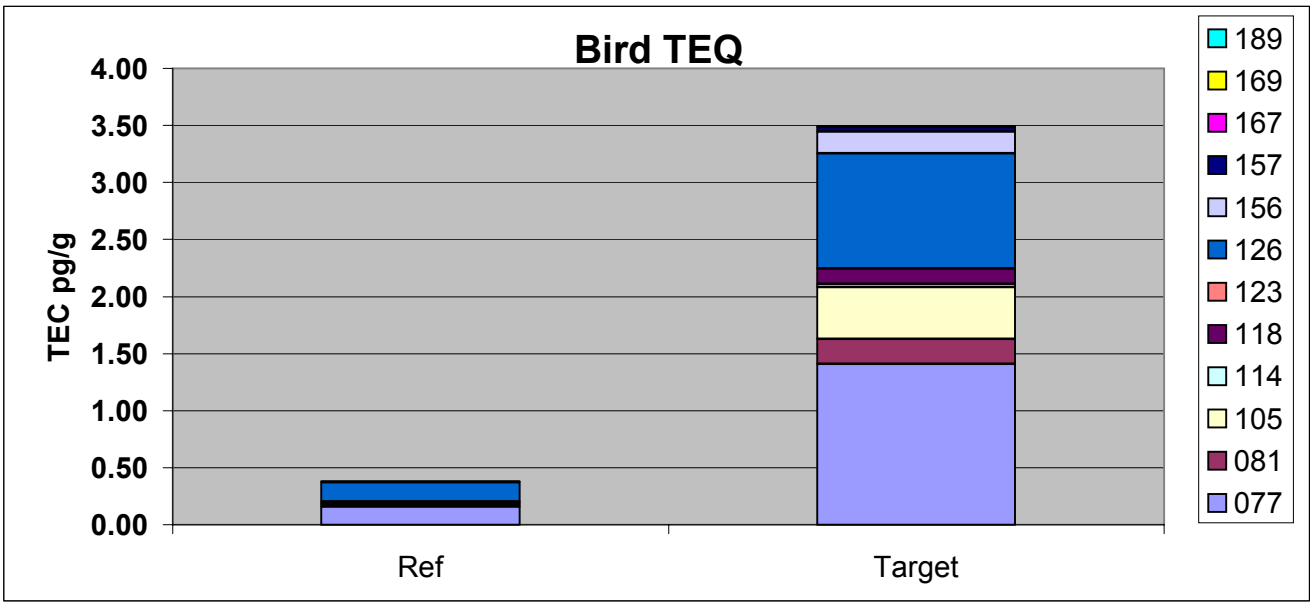
	BSB	VS	WG
Reference	0.32	0.75	0.22
Target	1.54	0.79	8.35

B.



	BSB	VS	WG
Reference	63.71	17.02	17.85
Target	35.08	15.84	169.65

Figure A4F-4. Plot of brid dietary TEQs based on wet weight (A) and lipid weight (B) concentrations.



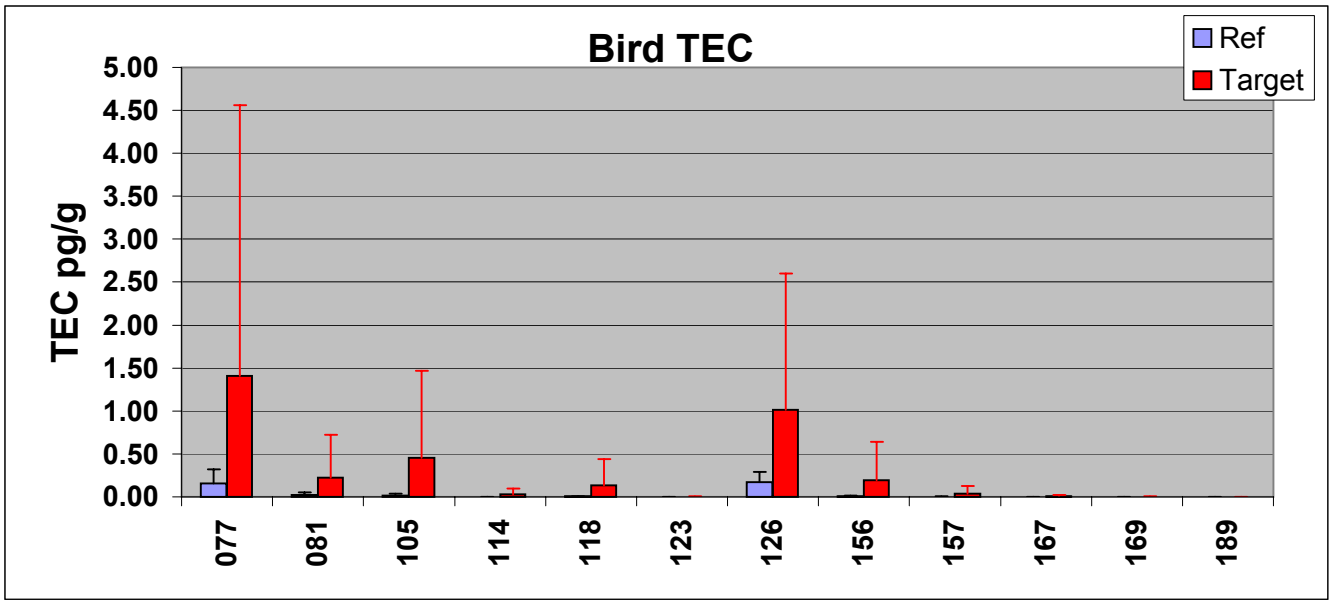


Figure A4F-5. Plots show data from all fish for the average sum of TEC (TEQ) for birds and the mean and standard deviation of TECs for dietary exposure to dioxin-like co-planar PCBs exposure to birds.

Appendix A4F.6. Dietary TECs for Mammals calculated from fish data using DL/2 for nondetected values

				wet weight fillet concentration								
The data will be used to address dietary expos				pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
ID_to_use	Lab ID	Species	Site	TECM077	TECM081	TECM105	TECM114	TECM118	TECM123	TECM126	TECM156c	TECM157
NEHC-0005	L3606-5	Black Seat	Reference	4.04E-04	3.21E-05	1.27E-02	3.64E-03	4.08E-02	4.42E-04	2.84E-01	3.25E-02	9.65E-03
NEHC-0024	L3606-24	Black Seat	Reference	1.44E-04	1.14E-05	1.26E-02	3.22E-03	3.70E-02	2.64E-04	1.17E-01	2.33E-02	8.00E-03
NEHC-0048	L3606-48R	Black Seat	Reference	5.60E-05	4.45E-06	5.62E-03	1.54E-03	1.92E-02	1.56E-04	7.45E-02	1.92E-02	5.95E-03
NEHC-0007	L3606-7	Black Seat	Reference	8.66E-05	6.88E-06	6.60E-03	1.85E-03	1.88E-02	1.95E-04	4.14E-02	1.59E-02	4.49E-03
NEHC-0023	L3606-23	Black Seat	Reference	8.86E-05	7.04E-06	8.49E-03	2.58E-03	2.64E-02	2.48E-04	7.25E-02	2.28E-02	6.00E-03
NEHC-0002	L3606-2 i	Black Seat	Reference	2.16E-05	1.72E-06	4.57E-03	9.40E-04	1.38E-02	3.18E-05	2.39E-01	1.39E-02	4.19E-03
NEHC-0034	L3606-34	Black Seat	Reference	6.38E-05	5.07E-06	6.96E-03	2.20E-03	2.17E-02	1.83E-04	1.07E-01	2.15E-02	5.45E-03
NEHC-0004	L3606-4	Black Seat	Reference	3.66E-05	2.91E-06	7.43E-03	1.96E-03	2.33E-02	1.47E-04	7.26E-02	2.54E-02	6.50E-03
NEHC-0042	L3606-42R	Black Seat	Reference	5.90E-05	4.69E-06	7.72E-03	1.55E-03	2.34E-02	3.39E-04	1.64E-01	2.29E-02	6.70E-03
NEHC-0016	L3606-16	Black Seat	Reference	9.89E-05	7.86E-06	8.30E-03	2.08E-03	2.40E-02	2.26E-04	1.27E-01	2.30E-02	6.45E-03
NEHC-0017	L3606-17	Black Seat	Reference	4.74E-05	3.77E-06	9.21E-03	2.54E-03	3.19E-02	1.46E-04	6.65E-02	3.43E-02	1.03E-02
NEHC-0011	L3606-11 i	Black Seat	Reference	9.24E-05	7.34E-06	1.13E-02	2.78E-03	3.40E-02	3.91E-04	6.15E-02	2.67E-02	7.35E-03
NEHC-0033	L3606-33 i	Black Seat	Reference	5.80E-05	4.61E-06	7.69E-03	2.13E-03	2.23E-02	2.46E-04	7.55E-02	1.74E-02	5.20E-03
NEHC-0044	L3606-44R	Black Seat	Reference	1.94E-04	1.54E-05	1.16E-02	3.75E-03	3.46E-02	6.64E-04	1.28E-01	3.12E-02	9.35E-03
NEHC-0003	L3606-3	Black Seat	Reference	5.83E-05	4.63E-06	5.71E-03	1.52E-03	1.72E-02	1.71E-04	4.97E-02	1.48E-02	4.30E-03
NEHC-0046	L3606-46R	Black Seat	Reference	2.41E-05	1.91E-06	5.10E-03	1.89E-03	1.58E-02	1.20E-04	2.59E-01	1.86E-02	4.87E-03
NEHC-0026	L3606-26	Black Seat	Reference	3.12E-05	2.48E-06	6.81E-03	1.92E-03	2.16E-02	6.20E-05	7.55E-02	2.47E-02	6.65E-03
NEHC-0049	L3606-49R	Black Seat	Reference	4.28E-05	3.40E-06	8.96E-03	2.32E-03	2.63E-02	1.66E-04	7.70E-02	2.42E-02	8.40E-03
NEHC-0041	L3606-41R	Black Seat	Reference	1.87E-04	1.49E-05	1.56E-02	5.40E-03	4.46E-02	6.63E-04	3.19E-01	3.83E-02	1.07E-02
NEHC-0010	L3606-10 i	Black Seat	Reference	4.04E-04	3.21E-05	4.17E-02	1.11E-02	1.40E-01	8.64E-04	4.21E-01	1.86E-01	4.61E-02
NEHC-0043	L3606-43R	Black Seat	Target	5.68E-04	4.51E-05	1.41E-01	3.97E-02	3.71E-01	5.36E-03	1.46E+00	2.55E-01	6.95E-02
NEHC-0027	L3606-27	Black Seat	Target	1.30E-03	1.03E-04	1.14E-01	3.54E-02	3.66E-01	3.82E-03	7.35E-01	2.33E-01	6.35E-02
NEHC-0036	L3606-36R	Black Seat	Target	7.68E-04	6.10E-05	8.26E-02	2.47E-02	2.46E-01	3.43E-03	5.64E-01	1.47E-01	3.87E-02
NEHC-0053	L3606-53R	Black Seat	Target	1.69E-04	1.34E-05	3.39E-02	1.09E-02	9.50E-02	1.07E-03	3.27E-01	5.75E-02	1.52E-02
NEHC-0021	L3606-21	Black Seat	Target	4.75E-04	3.78E-05	2.06E-01	5.95E-02	5.53E-01	6.95E-03	1.28E-01	4.69E-01	1.02E-01
NEHC-0006	L3606-6	Black Seat	Target	4.10E-04	3.26E-05	4.07E-02	9.50E-03	1.28E-01	1.64E-03	2.20E-01	7.50E-02	2.32E-02
NEHC-0047	L3606-47R	Black Seat	Target	7.96E-04	6.33E-05	1.62E-01	4.63E-02	4.49E-01	5.74E-03	2.75E-01	2.64E-01	7.00E-02
NEHC-0050	L3606-50R	Black Seat	Target	1.63E-03	1.30E-04	1.51E-01	4.48E-02	4.43E-01	7.00E-03	2.25E-01	2.62E-01	6.90E-02
NEHC-0031	L3606-31	Black Seat	Target	4.17E-04	3.31E-05	6.17E-02	1.99E-02	1.79E-01	2.02E-03	5.20E-01	1.00E-01	2.28E-02
NEHC-0013	L3606-13	Black Seat	Target	1.57E-03	1.25E-04	1.36E-01	3.11E-02	5.72E-01	3.73E-03	3.69E-01	2.08E-01	4.81E-02
NEHC-0022	L3606-22	Black Seat	Target	2.19E-03	1.74E-04	2.06E-01	9.40E-02	9.39E-01	9.86E-03	1.56E+00	5.25E-01	1.27E-01
FS-13-VS-R	L2767-8	Vermilion S	Reference	6.65E-04	5.29E-05	1.15E-02	2.83E-03	3.05E-02	6.16E-04	2.66E-01	2.39E-02	6.88E-03
FS-17-VS-R	L2767-12	Vermilion S	Reference	6.37E-04	5.06E-05	1.68E-02	4.98E-03	4.17E-02	6.02E-04	2.40E-01	2.71E-02	7.81E-03
NEHC-0009	L3606-9 i	Vermilion S	Reference	6.46E-04	5.13E-05	1.08E-02	2.73E-03	2.65E-02	5.69E-04	2.42E-01	2.28E-02	7.10E-03
FS-21-VS-R	L2767-14	Vermilion S	Reference	5.94E-04	4.72E-05	1.42E-02	4.11E-03	4.07E-02	6.00E-04	2.68E-01	3.62E-02	1.04E-02
NEHC-0015	L3606-15	Vermilion S	Reference	7.36E-04	5.85E-05	1.47E-02	4.01E-03	4.01E-02	7.55E-04	3.08E-01	3.77E-02	1.06E-02
FS-05-VS-R	L2767-3	Vermilion S	Reference	6.62E-04	5.26E-05	1.30E-02	3.60E-03	3.45E-02	7.00E-04	2.36E-01	2.89E-02	8.40E-03
FS-14-VS-R	L2767-9	Vermilion S	Reference	8.65E-04	6.87E-05	1.48E-02	4.01E-03	3.78E-02	6.99E-04	3.18E-01	2.97E-02	8.58E-03
NEHC-0035	L3606-35	Vermilion S	Reference	6.83E-04	5.43E-05	1.48E-02	4.70E-03	4.09E-02	7.51E-04	3.78E-01	3.72E-02	1.10E-02

A4F.6 TEC_mammal

ID_to_use	Lab ID	Species	Site	TECM077	TECM081	TECM105	TECM114	TECM118	TECM123	TECM126	TECM156c	TECM157
FS-07-VS-R	L2767-4	Vermilion S	Reference	5.36E-04	4.26E-05	1.16E-02	2.85E-03	3.22E-02	6.16E-04	2.42E-01	3.51E-02	1.01E-02
FS-18-VS-R	L2767-13	Vermilion S	Reference	5.31E-04	4.22E-05	1.19E-02	3.20E-03	3.20E-02	4.95E-04	2.30E-01	2.41E-02	6.94E-03
NEHC-0040	L3606-40R	Vermilion S	Reference	4.48E-04	3.56E-05	1.49E-02	3.60E-03	4.03E-02	8.29E-04	2.57E-01	4.29E-02	1.22E-02
FS-22-VS-R	L2767-15	Vermilion S	Reference	4.33E-04	3.44E-05	2.46E-02	6.55E-03	6.49E-02	9.43E-04	1.01E-01	3.69E-02	1.06E-02
FS-02-VS-R	L2767-2	Vermilion S	Reference	1.56E-03	1.24E-04	2.40E-02	5.65E-03	7.58E-02	1.37E-03	3.75E-01	5.81E-02	1.67E-02
FS-15-VS-R	L2767-10	Vermilion S	Reference	9.61E-04	7.64E-05	2.71E-02	6.90E-03	8.26E-02	1.44E-03	4.44E-01	7.26E-02	2.09E-02
FS-11-VS-R	L2767-7	Vermilion S	Reference	6.81E-04	5.41E-05	1.87E-02	4.87E-03	5.61E-02	8.30E-04	2.70E-01	5.77E-02	1.66E-02
NEHC-0018	L3606-18	Vermilion S	Reference	8.54E-04	6.79E-05	2.32E-02	6.65E-03	6.82E-02	1.06E-03	2.03E-01	5.80E-02	1.62E-02
FS-10-VS-R	L2767-6	Vermilion S	Reference	6.60E-04	5.25E-05	1.70E-02	4.73E-03	4.66E-02	8.08E-04	3.52E-01	3.83E-02	1.10E-02
FS-16-VS-R	L2767-11	Vermilion S	Reference	6.65E-04	5.29E-05	1.82E-02	6.05E-03	6.61E-02	8.56E-04	3.50E-01	5.19E-02	1.50E-02
NEHC-0030	L3606-30	Vermilion S	Reference	6.68E-04	5.31E-05	2.66E-02	8.50E-03	8.62E-02	1.32E-03	2.44E-01	8.10E-02	2.27E-02
FS-01-VS-R	L2767-1	Vermilion S	Reference	6.03E-04	4.79E-05	1.15E-02	2.76E-03	3.18E-02	6.46E-04	1.19E-01	2.72E-02	7.84E-03
NEHC-0019	L3606-19	Vermilion S	Reference	4.72E-04	3.75E-05	1.30E-02	3.64E-03	3.68E-02	5.95E-04	2.90E-01	3.60E-02	1.06E-02
FS-09-VS-R	L2767-5	Vermilion S	Reference	4.21E-04	3.35E-05	9.45E-03	2.47E-03	2.57E-02	4.68E-04	1.79E-01	2.03E-02	5.86E-03
FS-17-VS-T	L2767-28	Vermilion S	Target	6.57E-04	5.22E-05	4.04E-02	1.05E-02	1.12E-01	1.45E-03	1.89E-01	5.90E-02	1.40E-02
NEHC-0052	L3606-52R	Vermilion S	Target	2.84E-04	2.26E-05	3.28E-02	9.20E-03	8.58E-02	1.29E-03	4.12E-01	5.05E-02	1.30E-02
FS-18-VS-T	L2767-29	Vermilion S	Target	5.60E-04	4.45E-05	2.92E-02	7.40E-03	8.01E-02	1.10E-03	1.37E-01	4.87E-02	1.16E-02
FS-03-VS-T	L2767-18	Vermilion S	Target	6.19E-04	4.92E-05	2.27E-02	6.10E-03	6.28E-02	7.46E-04	1.50E-01	3.57E-02	8.48E-03
FS-16-VS-T	L2767-27	Vermilion S	Target	5.81E-04	4.62E-05	2.73E-02	7.30E-03	7.55E-02	1.08E-03	1.27E-01	4.12E-02	9.79E-03
NEHC-0008	L3606-8	Vermilion S	Target	4.29E-04	3.41E-05	4.93E-02	1.57E-02	1.36E-01	1.85E-03	1.92E-01	1.02E-01	2.21E-02
FS-07-VS-T	L2767-21	Vermilion S	Target	6.77E-04	5.38E-05	2.74E-02	7.35E-03	7.95E-02	1.16E-03	1.53E-01	5.81E-02	1.38E-02
FS-11-VS-T	L2767-23	Vermilion S	Target	1.45E-03	1.15E-04	1.98E-01	5.50E-02	5.06E-01	8.19E-03	7.05E-01	2.66E-01	6.31E-02
FS-01-VS-T	L2767-16	Vermilion S	Target	7.11E-04	5.65E-05	3.24E-02	8.45E-03	9.04E-02	9.71E-04	1.54E-01	4.96E-02	1.18E-02
FS-02-VS-T	L2767-17	Vermilion S	Target	6.25E-04	4.97E-05	2.33E-02	6.30E-03	6.43E-02	8.39E-04	1.20E-01	3.89E-02	9.24E-03
NEHC-0037	L3606-37R	Vermilion S	Target	5.46E-04	4.34E-05	2.94E-02	8.50E-03	8.14E-02	1.33E-03	2.69E-01	4.71E-02	1.19E-02
FS-13-VS-T	L2767-25	Vermilion S	Target	6.19E-04	4.92E-05	2.93E-02	7.90E-03	7.93E-02	1.03E-03	1.11E-01	4.12E-02	9.79E-03
NEHC-0029	L3606-29	Vermilion S	Target	5.01E-04	3.98E-05	3.71E-02	1.12E-02	9.72E-02	1.24E-03	2.80E-01	5.55E-02	1.34E-02
FS-12-VS-T	L2767-24 i	Vermilion S	Target	2.47E-04	1.96E-05	8.67E-03	2.50E-03	2.34E-02	3.35E-04	4.31E-02	1.62E-02	3.84E-03
FS-04-VS-T	L2767-19	Vermilion S	Target	6.23E-04	4.95E-05	4.01E-02	1.12E-02	1.14E-01	1.29E-03	1.88E-01	6.10E-02	1.45E-02
FS-06-VS-T	L2767-20	Vermilion S	Target	5.52E-04	4.39E-05	2.45E-02	6.45E-03	6.60E-02	9.30E-04	1.17E-01	4.32E-02	1.02E-02
FS-09-VS-T	L2767-22	Vermilion S	Target	9.37E-04	7.45E-05	6.15E-02	1.88E-02	1.81E-01	2.29E-03	3.03E-01	1.06E-01	2.51E-02
NEHC-0038	L3606-38R	Vermilion S	Target	1.30E-03	1.03E-04	1.29E-01	4.11E-02	3.89E-01	5.61E-03	1.22E+00	2.79E-01	6.45E-02
FS-15-VS-T	L2767-26 (	Vermilion S	Target	9.60E-04	7.63E-05	6.02E-02	1.64E-02	1.66E-01	2.04E-03	2.33E-01	8.73E-02	2.07E-02
FS-20-VS-T	L2767-30	Vermilion S	Target	5.47E-04	4.35E-05	2.61E-02	6.55E-03	7.35E-02	9.53E-04	1.25E-01	4.60E-02	1.09E-02
FS-20-WG-F	L2767-45	White Grur	Reference	6.74E-05	5.36E-06	3.85E-03	1.18E-03	1.12E-02	1.16E-04	5.14E-02	8.61E-03	2.67E-03
FS-18-WG-F	L2767-43	White Grur	Reference	4.99E-05	3.97E-06	1.90E-03	5.45E-04	6.14E-03	5.67E-05	1.36E-02	4.13E-03	1.28E-03
NEHC-0051	L3606-51R	White Grur	Reference	1.74E-04	1.38E-05	6.33E-03	1.48E-03	1.84E-02	2.20E-04	1.40E-01	1.33E-02	4.43E-03
FS-17-WG-F	L2767-42	White Grur	Reference	3.23E-05	2.57E-06	2.07E-03	6.40E-04	6.08E-03	7.75E-05	3.25E-02	4.42E-03	1.37E-03
FS-16-WG-F	L2767-41	White Grur	Reference	9.46E-05	7.52E-06	4.77E-03	1.23E-03	1.42E-02	1.96E-04	6.36E-02	1.08E-02	3.34E-03
FS-08-WG-F	L2767-35	White Grur	Reference	5.38E-05	4.28E-06	4.01E-03	1.27E-03	1.16E-02	1.10E-04	1.77E-02	9.33E-03	2.90E-03
NEHC-0028	L3606-28	White Grur	Reference	4.60E-05	3.66E-06	3.56E-03	9.65E-04	1.02E-02	3.21E-05	3.67E-02	8.63E-03	2.73E-03
FS-09-WG-F	L2767-36	White Grur	Reference	9.75E-06	7.75E-07	2.38E-03	6.55E-04	7.15E-03	5.53E-05	1.29E-02	4.45E-03	1.38E-03

A4F.6 TEC_mammal

ID_to_use	Lab ID	Species	Site	TECM077	TECM081	TECM105	TECM114	TECM118	TECM123	TECM126	TECM156c	TECM157
FS-10-WG-F	L2767-37	White Grur	Reference	4.44E-05	3.53E-06	3.83E-03	1.02E-03	1.13E-02	1.17E-04	3.71E-02	7.51E-03	2.33E-03
NEHC-0039	L3606-39R	White Grur	Reference	4.11E-05	3.26E-06	7.76E-03	2.19E-03	2.35E-02	1.27E-04	1.54E-01	1.41E-02	5.25E-03
FS-06-WG-F	L2767-34	White Grur	Reference	6.15E-06	4.89E-07	2.90E-03	1.08E-03	8.52E-03	9.76E-05	2.96E-02	6.21E-03	1.93E-03
NEHC-0025	L3606-25R	White Grur	Reference	3.38E-05	2.68E-06	7.91E-03	2.52E-03	2.35E-02	2.43E-04	9.25E-02	1.83E-02	5.80E-03
FS-14-WG-F	L2767-40	White Grur	Reference	3.31E-05	2.63E-06	3.06E-03	9.60E-04	9.27E-03	7.30E-05	4.47E-02	6.37E-03	1.98E-03
NEHC-0001	L3606-1	White Grur	Reference	7.87E-04	6.25E-05	1.81E-01	5.65E-02	4.97E-01	5.64E-03	2.28E-01	3.35E-01	7.85E-02
FS-19-WG-F	L2767-44	White Grur	Reference	7.43E-05	5.91E-06	4.88E-03	1.33E-03	1.62E-02	1.39E-04	6.05E-02	1.40E-02	4.35E-03
FS-03-WG-F	L2767-33	White Grur	Reference	7.04E-05	5.60E-06	9.80E-03	3.19E-03	3.10E-02	1.53E-04	8.55E-02	2.14E-02	6.63E-03
FS-12-WG-F	L2767-38	White Grur	Reference	2.77E-05	2.20E-06	5.39E-03	1.60E-03	1.76E-02	5.68E-05	4.45E-02	6.92E-03	2.15E-03
FS-02-WG-F	L2767-32	White Grur	Reference	1.07E-04	8.50E-06	9.52E-03	3.14E-03	3.05E-02	2.76E-04	1.12E-01	2.40E-02	7.45E-03
FS-13-WG-F	L2767-39 (	White Grur	Reference	7.67E-05	6.10E-06	1.46E-02	4.50E-03	5.26E-02	2.91E-04	6.00E-02	3.14E-02	9.76E-03
FS-01-WG-F	L2767-31	White Grur	Reference	4.35E-04	3.46E-05	4.86E-02	1.45E-02	1.52E-01	1.28E-03	3.78E-01	9.30E-02	2.89E-02
NEHC-0045	L3606-45R	White Grur	Target	5.05E-04	4.01E-05	2.54E-01	8.00E-02	6.87E-01	8.84E-03	1.64E+00	3.99E-01	9.75E-02
FS-14-WG-T	L2767-56	White Grur	Target	6.94E-04	5.52E-05	1.23E-01	3.50E-02	3.35E-01	3.22E-03	4.96E-01	2.53E-01	5.30E-02
FS-09-WG-T	L2767-53	White Grur	Target	6.88E-03	5.47E-04	8.48E-01	2.67E-01	2.76E+00	2.79E-02	2.60E+00	2.01E+00	3.61E-01
FS-16-WG-T	L2767-58	White Grur	Target	5.99E-03	4.76E-04	1.53E+00	4.51E-01	3.55E+00	4.46E-02	3.76E+00	3.34E+00	6.55E-01
FS-05-WG-T	L2767-50	White Grur	Target	3.65E-04	2.90E-05	1.16E-01	3.14E-02	3.07E-01	2.31E-03	3.36E-01	1.58E-01	3.58E-02
NEHC-0014	L3606-14	White Grur	Target	7.98E-04	6.34E-05	7.96E-02	2.50E-02	2.53E-01	2.76E-03	1.61E-01	1.72E-01	3.85E-02
FS-08-WG-T	L2767-52	White Grur	Target	5.69E-04	4.52E-05	1.92E-01	6.85E-02	6.80E-01	2.69E-03	2.33E-01	2.94E-01	7.00E-02
FS-04-WG-T	L2767-49	White Grur	Target	1.92E-03	1.53E-04	2.20E-01	7.25E-02	7.37E-01	6.98E-03	7.65E-01	3.65E-01	8.30E-02
NEHC-0012	L3606-12	White Grur	Target	7.26E-04	5.77E-05	1.55E-01	5.15E-02	4.30E-01	4.51E-03	1.71E-01	2.94E-01	6.50E-02
FS-03-WG-T	L2767-48	White Grur	Target	1.50E-03	1.19E-04	2.15E-01	6.05E-02	6.10E-01	6.91E-03	1.20E+00	4.52E-01	8.15E-02
FS-11-WG-T	L2767-55	White Grur	Target	1.44E-03	1.14E-04	1.57E-01	4.26E-02	4.67E-01	5.29E-03	6.85E-01	2.40E-01	5.15E-02
FS-07-WG-T	L2767-51	White Grur	Target	8.58E-04	6.82E-05	1.59E-01	4.66E-02	4.69E-01	5.09E-03	5.88E-01	2.70E-01	5.75E-02
NEHC-0020	L3606-20	White Grur	Target	7.21E-03	5.73E-04	1.53E+00	4.89E-01	5.01E+00	5.65E-02	2.50E-01	3.40E+00	8.00E-01
FS-01-WG-T	L2767-46	White Grur	Target	2.05E-03	1.63E-04	2.46E-01	7.20E-02	7.62E-01	7.84E-03	7.80E-01	4.28E-01	1.04E-01
NEHC-0032	L3606-32	White Grur	Target	1.31E-03	1.04E-04	2.82E-01	9.20E-02	7.99E-01	8.70E-03	7.62E-01	6.10E-01	1.39E-01
FS-10-WG-T	L2767-54	White Grur	Target	1.49E-02	1.18E-03	1.96E+00	5.25E-01	4.83E+00	6.37E-02	5.20E+00	3.86E+00	7.35E-01
FS-02-WG-T	L2767-47	White Grur	Target	3.89E-02	3.09E-03	4.60E+00	1.53E+00	1.44E+01	1.40E-01	6.54E+00	9.55E+00	1.83E+00
FS-15-WG-T	L2767-57	White Grur	Target	1.59E-02	1.26E-03	2.19E+00	5.55E-01	5.19E+00	6.48E-02	4.96E+00	5.35E+00	9.80E-01
FS-18-WG-T	L2767-60	White Grur	Target	1.48E-02	1.18E-03	5.02E+00	1.94E+00	1.56E+01	1.80E-01	6.40E+00	1.14E+01	2.20E+00
FS-17-WG-T	L2767-59	White Grur	Target	2.37E-03	1.88E-04	8.77E-01	3.01E-01	2.74E+00	2.70E-02	2.45E+00	1.70E+00	3.48E-01

Appendix A

The data will ID_to_use	pg/g TECM167	pg/g TECM169	pg/g TECM189	whole body wet pg/g MTEQ_W	pg/g lipid MTEQ_L
NEHC-0005	3.17E-04	5.65E-03	7.13E-04	0.469	55.171
NEHC-0024	2.56E-04	3.01E-03	4.38E-04	0.283	54.189
NEHC-0048	1.74E-04	8.40E-03	3.96E-04	0.261	79.146
NEHC-0007	1.29E-04	4.10E-03	2.73E-04	0.170	47.146
NEHC-0023	2.13E-04	2.52E-03	3.71E-04	0.181	23.922
NEHC-0002	9.82E-05	3.18E-03	3.11E-04	0.462	231.032
NEHC-0034	1.67E-04	2.26E-03	3.95E-04	0.275	87.098
NEHC-0004	1.77E-04	2.66E-03	3.97E-04	0.219	104.446
NEHC-0042	1.72E-04	5.75E-03	3.98E-04	0.319	55.977
NEHC-0016	1.88E-04	3.97E-03	4.68E-04	0.401	5.379
NEHC-0017	3.11E-04	4.87E-03	6.46E-04	0.387	5.192
NEHC-0011	2.45E-04	3.78E-03	4.50E-04	0.195	69.519
NEHC-0033	1.58E-04	3.47E-03	3.32E-04	0.195	48.993
NEHC-0044	2.90E-04	5.85E-03	6.57E-04	0.267	32.141
NEHC-0003	1.37E-04	1.96E-03	3.09E-04	0.153	61.354
NEHC-0046	1.10E-04	4.52E-03	3.02E-04	0.444	157.526
NEHC-0026	1.70E-04	4.24E-03	4.80E-04	0.196	47.035
NEHC-0049	2.27E-04	8.90E-03	5.81E-04	0.221	62.376
NEHC-0041	3.21E-04	8.20E-03	6.18E-04	0.563	75.816
NEHC-0010	1.31E-03	2.54E-03	4.22E-03	1.018	35.959
NEHC-0043	2.12E-03	2.07E-02	2.18E-03	2.669	52.995
NEHC-0027	2.25E-03	1.15E-02	2.56E-03	1.694	21.783
NEHC-0036	1.15E-03	7.15E-03	1.31E-03	1.273	20.200
NEHC-0053	4.39E-04	8.15E-03	5.28E-04	0.654	17.826
NEHC-0021	3.11E-03	1.21E-02	3.13E-03	2.098	97.273
NEHC-0006	7.43E-04	4.41E-03	1.04E-03	0.651	52.497
NEHC-0047	2.01E-03	1.60E-02	1.46E-03	1.434	24.181
NEHC-0050	2.32E-03	5.60E-02	3.09E-03	1.366	15.095
NEHC-0031	7.25E-04	7.60E-03	7.80E-04	1.043	19.548
NEHC-0013	2.21E-03	6.20E-03	1.52E-03	1.503	20.149
NEHC-0022	4.46E-03	2.50E-02	3.48E-03	3.950	102.554
FS-13-VS-R	2.15E-04	2.27E-03	3.67E-04	0.373	5.186
FS-17-VS-R	2.44E-04	2.42E-03	3.32E-04	0.367	6.343
NEHC-0009	2.00E-04	2.63E-03	3.20E-04	0.332	5.611
FS-21-VS-R	3.26E-04	4.57E-03	5.55E-04	0.422	12.715
NEHC-0015	3.28E-04	3.76E-03	5.50E-04	0.451	6.946
FS-05-VS-R	2.44E-04	5.19E-03	4.17E-04	0.348	7.078
FS-14-VS-R	2.68E-04	3.55E-03	3.99E-04	0.436	4.097
NEHC-0035	3.42E-04	3.85E-03	5.72E-04	0.522	8.820

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ID_to_use	TECM167	TECM169	TECM189	MTEQ_W	MTEQ_L
FS-07-VS-R	3.16E-04	4.07E-03	4.72E-04	0.364	9.092
FS-18-VS-R	2.17E-04	2.04E-03	3.32E-04	0.334	6.619
NEHC-0040	3.93E-04	8.30E-03	6.17E-04	0.423	21.250
FS-22-VS-R	3.32E-04	1.99E-03	4.66E-04	0.276	24.650
FS-02-VS-R	5.23E-04	7.45E-03	9.66E-04	0.601	10.367
FS-15-VS-R	6.54E-04	3.34E-03	8.54E-04	0.714	14.790
FS-11-VS-R	5.20E-04	3.14E-03	7.68E-04	0.460	13.533
NEHC-0018	5.26E-04	5.85E-03	7.84E-04	0.415	7.422
FS-10-VS-R	3.45E-04	7.35E-03	5.82E-04	0.518	9.415
FS-16-VS-R	4.68E-04	6.25E-03	6.49E-04	0.552	12.113
NEHC-0030	7.81E-04	6.45E-03	1.09E-03	0.508	12.075
FS-01-VS-R	2.45E-04	4.40E-03	4.62E-04	0.218	3.701
NEHC-0019	3.30E-04	4.19E-03	6.00E-04	0.436	10.649
FS-09-VS-R	1.83E-04	4.13E-03	2.99E-04	0.271	7.778
FS-17-VS-T	4.59E-04	3.21E-03	4.25E-04	0.470	8.392
NEHC-0052	4.12E-04	8.00E-03	4.37E-04	0.650	11.049
FS-18-VS-T	3.79E-04	1.67E-03	3.65E-04	0.334	5.758
FS-03-VS-T	2.78E-04	2.96E-03	3.09E-04	0.311	4.882
FS-16-VS-T	3.21E-04	2.40E-03	3.30E-04	0.310	5.081
NEHC-0008	7.64E-04	4.23E-03	6.98E-04	0.588	19.283
FS-07-VS-T	4.52E-04	2.73E-03	4.94E-04	0.372	6.475
FS-11-VS-T	2.07E-03	8.15E-03	1.43E-03	1.942	29.870
FS-01-VS-T	3.86E-04	2.74E-03	4.02E-04	0.387	6.973
FS-02-VS-T	3.03E-04	3.47E-03	4.02E-04	0.281	4.356
NEHC-0037	3.61E-04	7.35E-03	3.91E-04	0.507	13.354
FS-13-VS-T	3.21E-04	2.77E-03	3.46E-04	0.309	5.331
NEHC-0029	4.15E-04	5.25E-03	4.40E-04	0.537	7.832
FS-12-VS-T	1.26E-04	1.25E-03	1.69E-04	0.147	8.629
FS-04-VS-T	4.75E-04	2.84E-03	4.89E-04	0.487	11.330
FS-06-VS-T	3.36E-04	2.13E-03	3.78E-04	0.288	5.933
FS-09-VS-T	8.23E-04	3.55E-03	9.23E-04	0.752	15.304
NEHC-0038	2.29E-03	2.15E-02	2.59E-03	2.279	53.425
FS-15-VS-T	6.79E-04	3.52E-03	7.17E-04	0.627	8.950
FS-20-VS-T	3.58E-04	3.21E-03	4.46E-04	0.317	6.736
FS-20-WG-F	7.86E-05	1.25E-03	1.07E-04	0.094	6.730
FS-18-WG-F	3.77E-05	6.95E-04	6.04E-05	0.036	5.601
NEHC-0051	1.33E-04	2.22E-03	1.92E-04	0.217	11.574
FS-17-WG-F	4.04E-05	1.11E-03	6.59E-05	0.068	16.946
FS-16-WG-F	9.83E-05	1.06E-03	1.75E-04	0.123	16.028
FS-08-WG-F	8.52E-05	8.20E-04	1.58E-04	0.060	7.894
NEHC-0028	9.07E-05	9.60E-04	2.30E-04	0.078	6.194
FS-09-WG-F	4.06E-05	4.60E-04	8.31E-05	0.040	6.521

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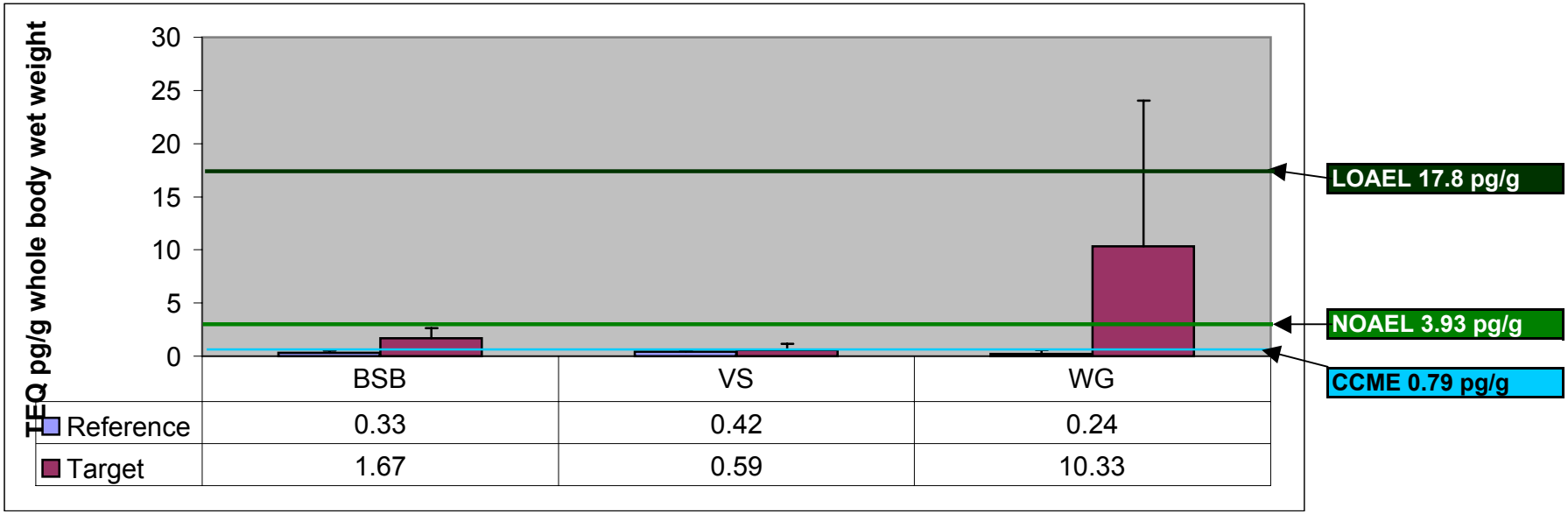
ID_to_use	TECM167	TECM169	TECM189	MTEQ_W	MTEQ_L
FS-10-WG-F	6.86E-05	6.30E-04	1.31E-04	0.079	10.724
NEHC-0039	1.39E-04	1.46E-03	2.72E-04	0.252	19.537
FS-06-WG-F	5.67E-05	3.75E-04	1.21E-04	0.072	15.667
NEHC-0025	1.70E-04	2.76E-03	2.46E-04	0.183	12.294
FS-14-WG-F	5.82E-05	3.72E-04	1.60E-04	0.100	26.997
NEHC-0001	2.31E-03	3.91E-03	2.04E-03	1.613	93.219
FS-19-WG-F	1.28E-04	4.76E-04	2.50E-04	0.130	20.964
FS-03-WG-F	1.95E-04	4.30E-03	4.05E-04	0.202	12.370
FS-12-WG-F	6.32E-05	8.77E-04	1.79E-04	0.102	20.193
FS-02-WG-F	2.19E-04	3.25E-03	4.96E-04	0.221	18.305
FS-13-WG-F	2.87E-04	5.65E-04	3.86E-04	0.223	39.884
FS-01-WG-F	8.49E-04	1.58E-02	1.31E-03	0.830	13.564
NEHC-0045	2.80E-03	2.24E-02	2.48E-03	3.993	256.479
FS-14-WG-T	1.84E-03	2.45E-02	3.21E-03	1.554	77.683
FS-09-WG-T	1.38E-02	6.05E-02	2.19E-02	9.864	365.344
FS-16-WG-T	1.88E-02	7.30E-02	1.91E-02	15.056	295.218
FS-05-WG-T	1.12E-03	3.52E-03	8.84E-04	1.141	30.842
NEHC-0014	1.23E-03	6.85E-03	2.31E-03	0.847	23.005
FS-08-WG-T	2.14E-03	7.40E-03	2.36E-03	1.770	73.753
FS-04-WG-T	2.84E-03	1.05E-02	2.66E-03	2.630	48.352
NEHC-0012	2.00E-03	6.00E-03	2.31E-03	1.406	52.467
FS-03-WG-T	3.08E-03	1.75E-02	8.11E-03	3.001	48.955
FS-11-WG-T	1.87E-03	5.06E-02	1.91E-03	1.926	43.670
FS-07-WG-T	2.11E-03	1.59E-02	2.33E-03	1.761	24.532
NEHC-0020	2.52E-02	3.20E-02	2.46E-02	13.136	234.079
FS-01-WG-T	3.62E-03	1.25E-02	3.56E-03	2.712	56.970
NEHC-0032	4.25E-03	1.04E-02	5.89E-03	3.040	101.023
FS-10-WG-T	2.67E-02	9.40E-02	3.13E-02	20.290	461.134
FS-02-WG-T	7.75E-02	1.81E-01	8.26E-02	42.864	604.575
FS-15-WG-T	3.66E-02	1.42E-01	3.88E-02	21.867	485.927
FS-18-WG-T	7.97E-02	4.45E-01	7.68E-02	48.121	658.293
FS-17-WG-T	1.34E-02	3.60E-02	1.50E-02	9.695	194.686

Table A4F-4. Summary stats for the mammalian dietary TEQs calculated from fish data

		Mammal TEQ pg/g whole body wet weight										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	0.33	0.20	0.15	1.02	Target	11	1.67	0.96	0.65	3.95
VS	Reference	22	0.42	0.12	0.22	0.71	Target	20	0.59	0.54	0.15	2.28
WG	Reference	20	0.24	0.37	0.04	1.61	Target	20	10.33	13.69	0.85	48.12

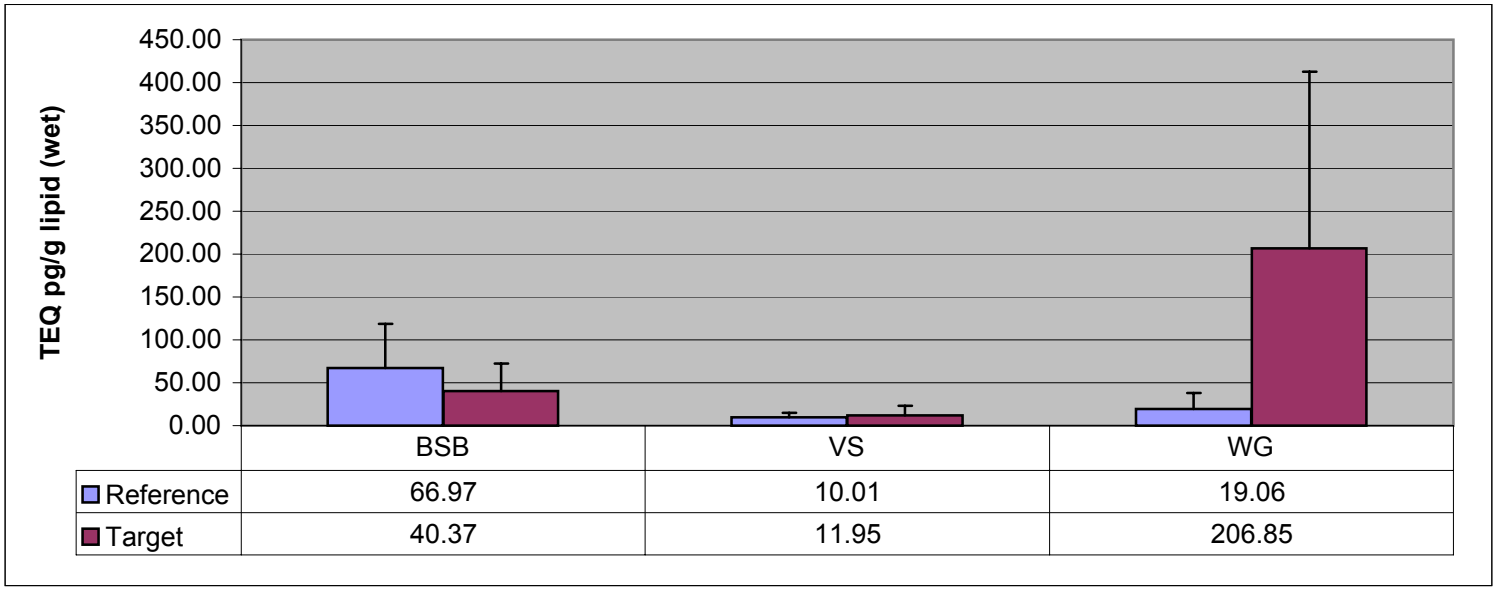
		Mammal TEQ pg/g whole body lipid weight (wet)										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	66.97	51.50	5.19	231.03	Target	11	40.37	32.27	15.10	102.55
VS	Reference	22	10.01	5.20	3.70	24.65	Target	20	11.95	11.50	4.36	53.43
WG	Reference	20	19.06	19.27	5.60	93.22	Target	20	206.85	206.14	23.00	658.29

A.



	BSB	VS	WG
Reference	0.33	0.42	0.24
Target	1.67	0.59	10.33

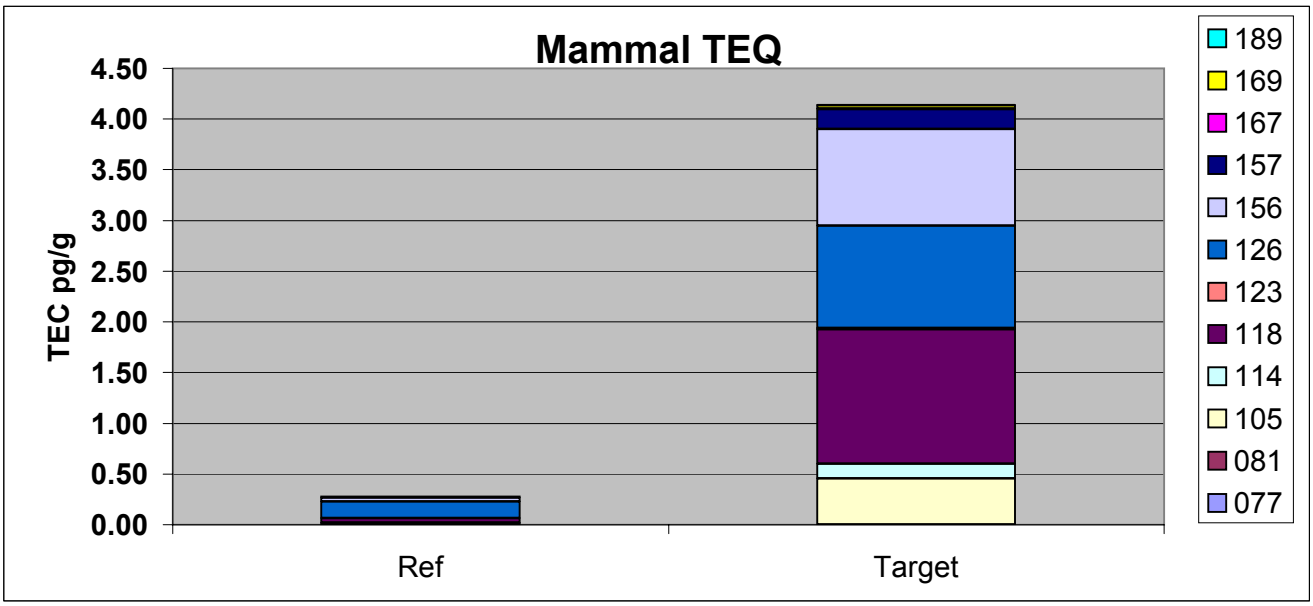
B.



	BSB	VS	WG
Reference	66.97	10.01	19.06
Target	40.37	11.95	206.85

Figure A4F-6. Plot of mammalian dietary TEQs based on wet weight (A) and lipid weight (B) concentrations.

A.



B.

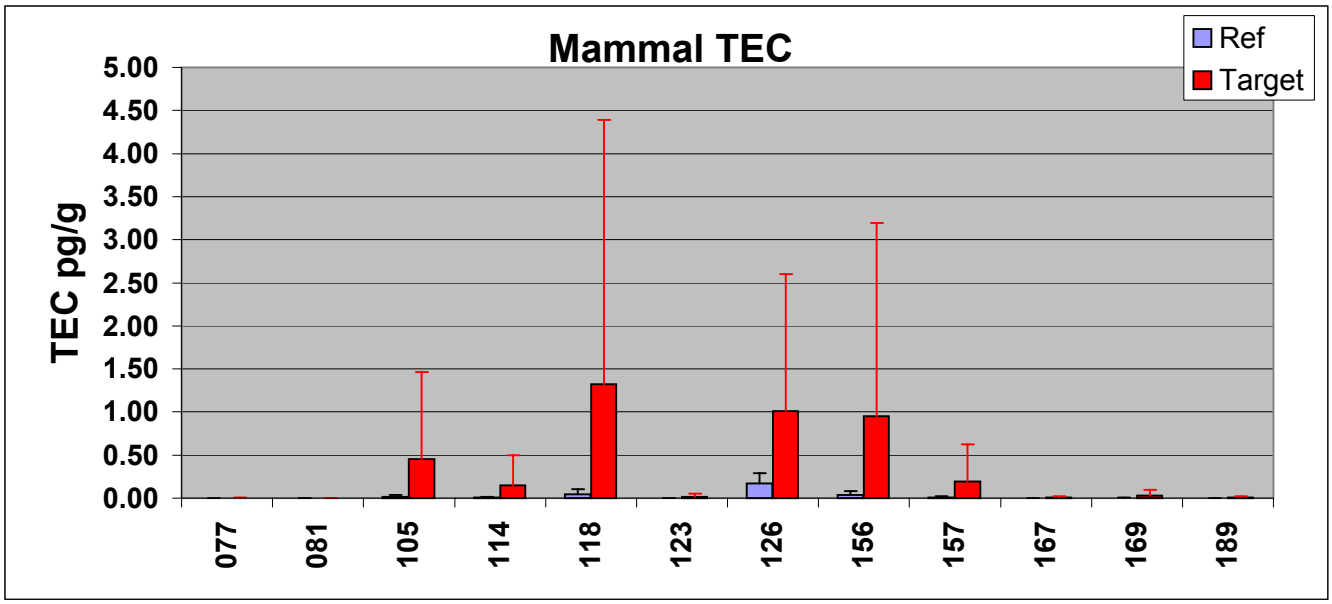


Figure A4F-7. Plots show data from all fish for the average sum of dietary TEC (TEQ) for mammals (A) and the mean and standard deviation of TECs for dioxin-like co-planar PCBs exposure to mammals (B).

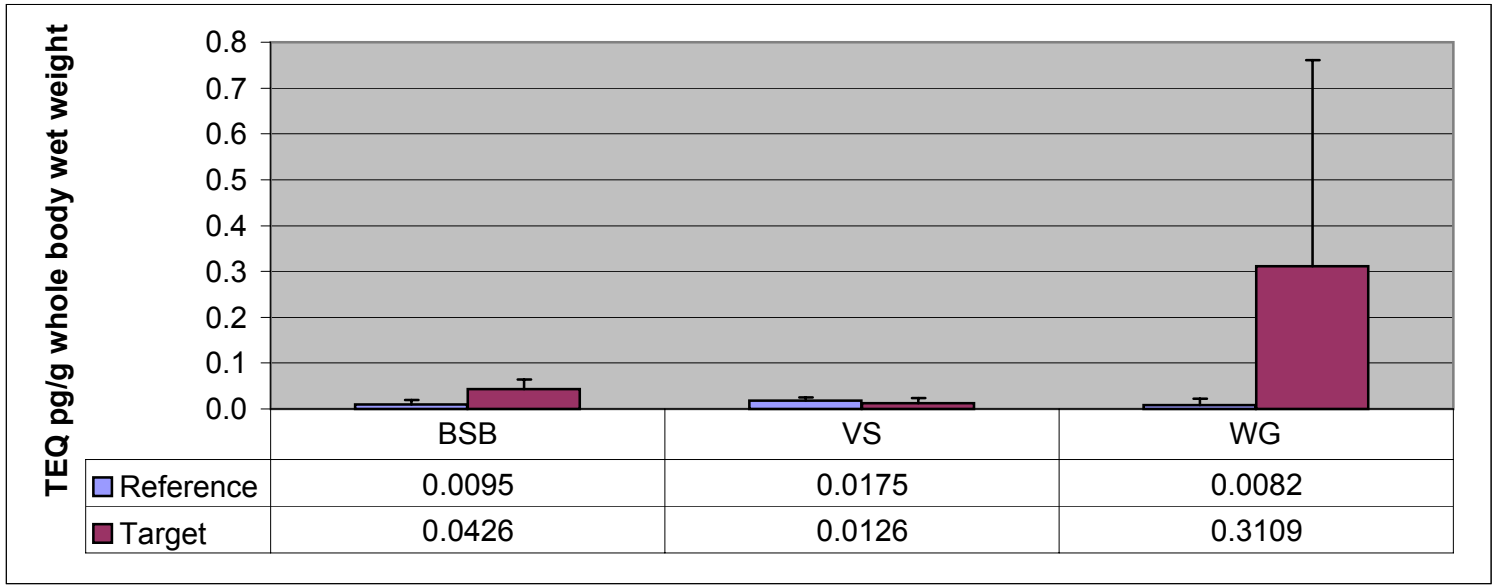
A4F.8-1

Summary of fish data TEQs (assuming ND=0)

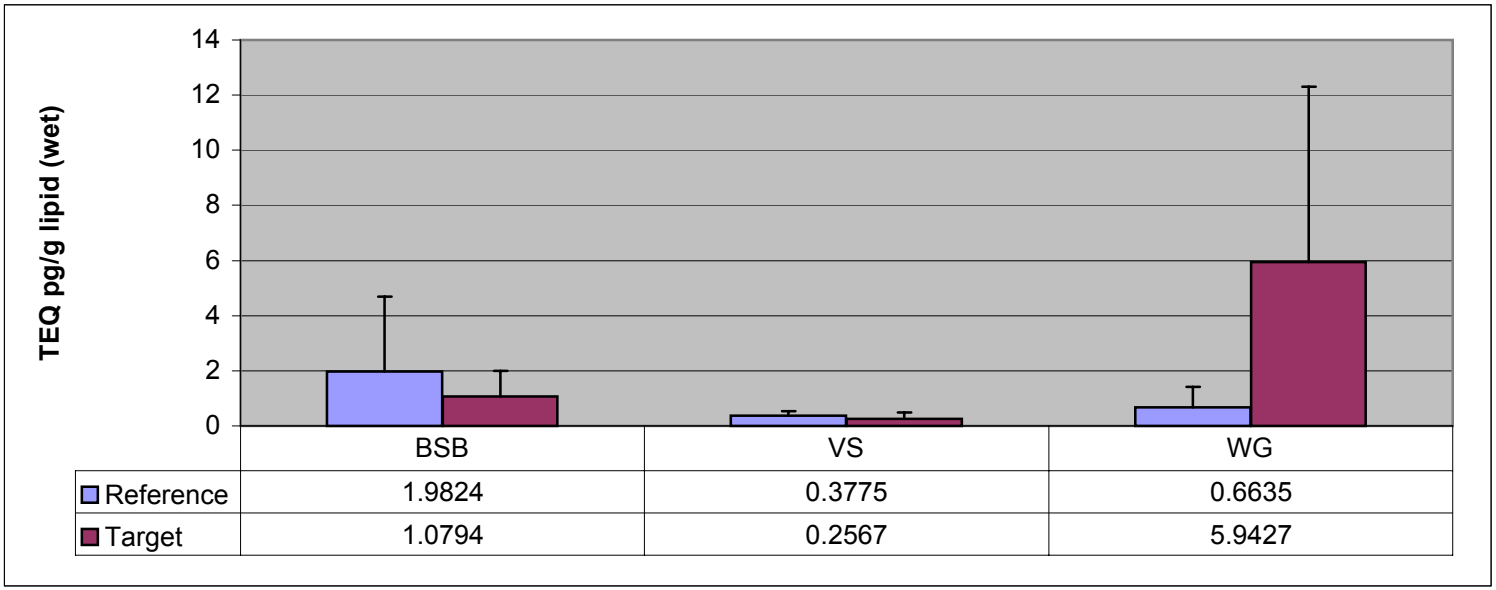
		Fish TEQ pg/g whole body wet weight										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	0.0095	0.0101	0.0024	0.0405	Target	11	0.0426	0.0217	0.0093	0.0798
VS	Reference	22	0.0175	0.0077	0.0038	0.0329	Target	20	0.0126	0.0107	0.0033	0.0456
WG	Reference	20	0.0082	0.0145	0.0007	0.0611	Target	20	0.3109	0.4501	0.0283	1.6613

		fishnd0 TEQ pg/g whole body lipid weight (wet)										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	1.9824	2.7155	0.0901	10.8268	Target	11	1.0794	0.9148	0.2534	2.9626
VS	Reference	22	0.3775	0.1660	0.0640	0.6814	Target	20	0.2567	0.2291	0.0980	0.8226
WG	Reference	20	0.6635	0.7580	0.0900	3.5292	Target	20	5.9427	6.3581	0.7656	23.4318

A4F.8-1 Fish data TEQs (assuming ND=0)



	BSB	VS	WG
Reference	0.0095	0.0175	0.0082
Target	0.0426	0.0126	0.3109



	BSB	VS	WG
Reference	1.9824	0.3775	0.6635
Target	1.0794	0.2567	5.9427

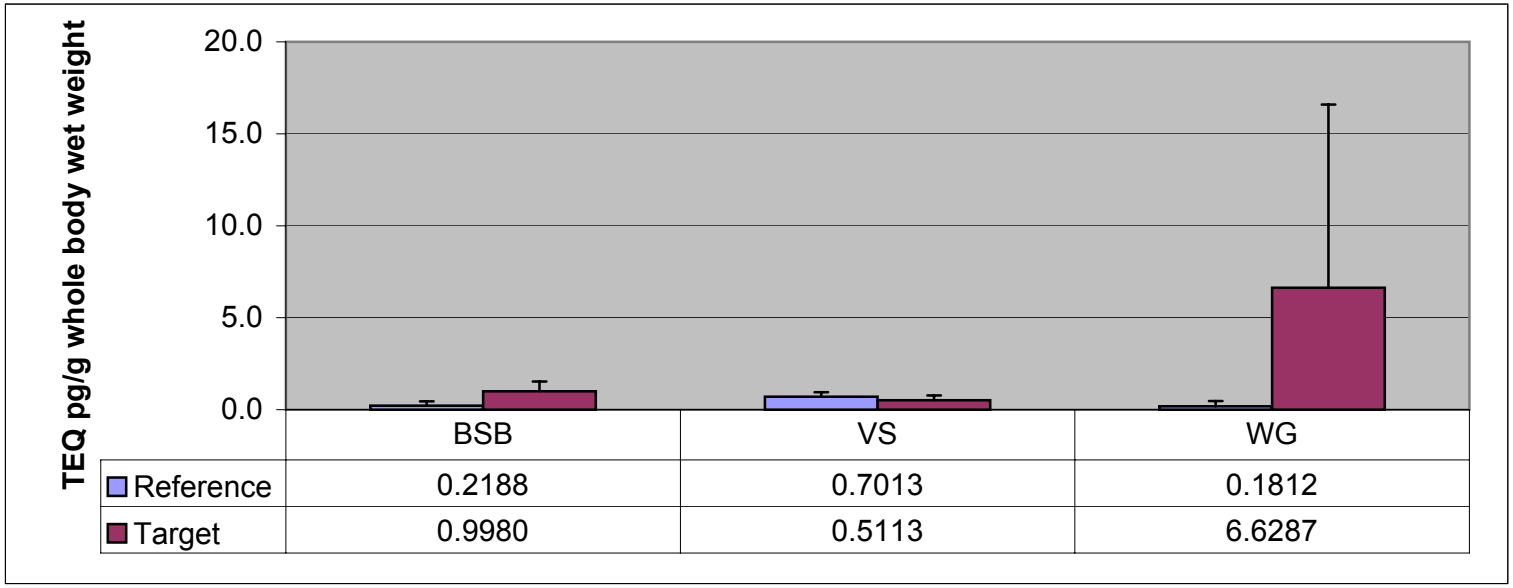
A4F.8 - 2 Bird TEQ (ND=0)

Summary stats for Avian TEQ from the consumption of fish (assuming ND=0)

		Bird TEQ pg/g fish whole body wet weight										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	0.2188	0.2312	0.0227	0.9059	Target	11	0.9980	0.5313	0.1888	1.9479
VS	Reference	22	0.7013	0.2500	0.3228	1.4070	Target	20	0.5113	0.2628	0.0599	1.2505
WG	Reference	20	0.1812	0.2902	0.0060	1.1736	Target	20	6.6287	9.9637	0.4654	41.5826

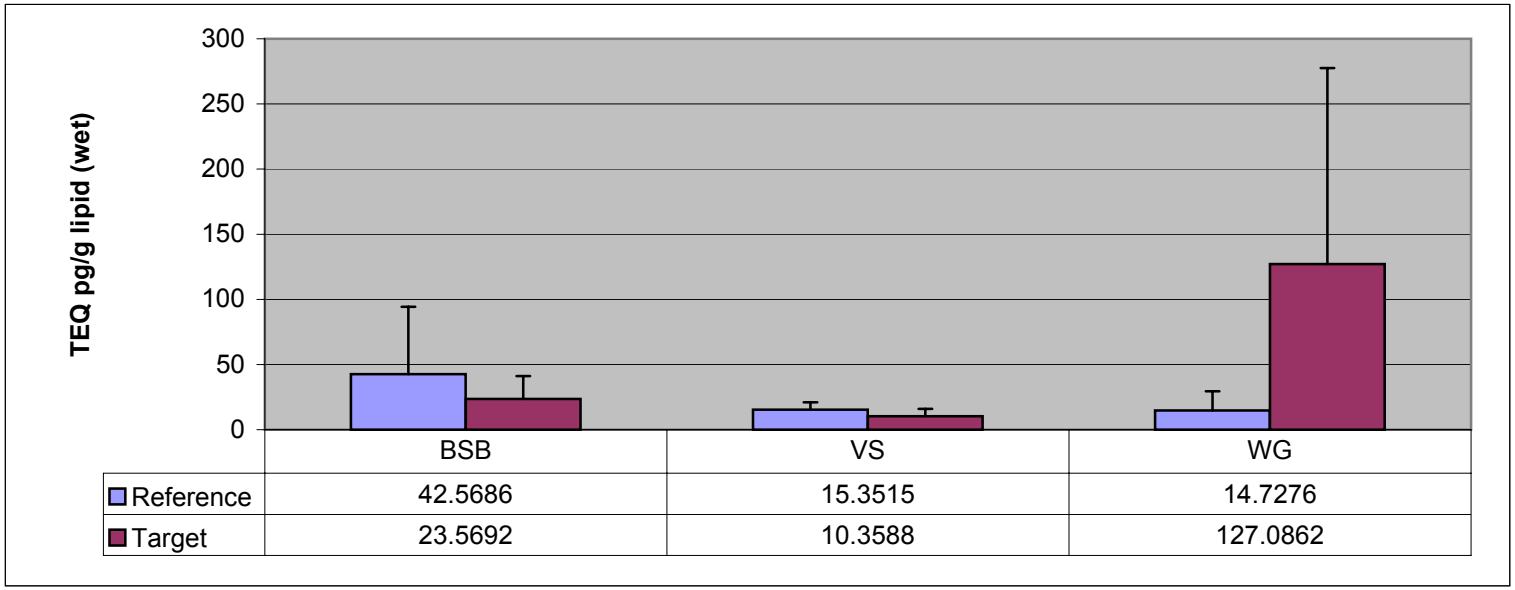
		Bird TEQ pg/g fish whole body lipid weight (wet)										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	42.5686	51.7805	1.6048	205.3295	Target	11	23.5692	17.5548	5.1436	55.5143
VS	Reference	22	15.3515	5.6788	6.6837	29.0662	Target	20	10.3588	5.5777	1.0179	24.8720
WG	Reference	20	14.7276	14.7227	0.9807	67.8382	Target	20	127.0862	150.4194	12.5775	586.4962

A4F.8 - 2 Summary stats for Avian TEQ from the consumption of fish (assuming ND=0)



	BSB	VS	WG
Reference	0.2188	0.7013	0.1812
Target	0.9980	0.5113	6.6287

CCME Birds 2.4 pg/g



	BSB	VS	WG
Reference	42.5686	15.3515	14.7276
Target	23.5692	10.3588	127.0862

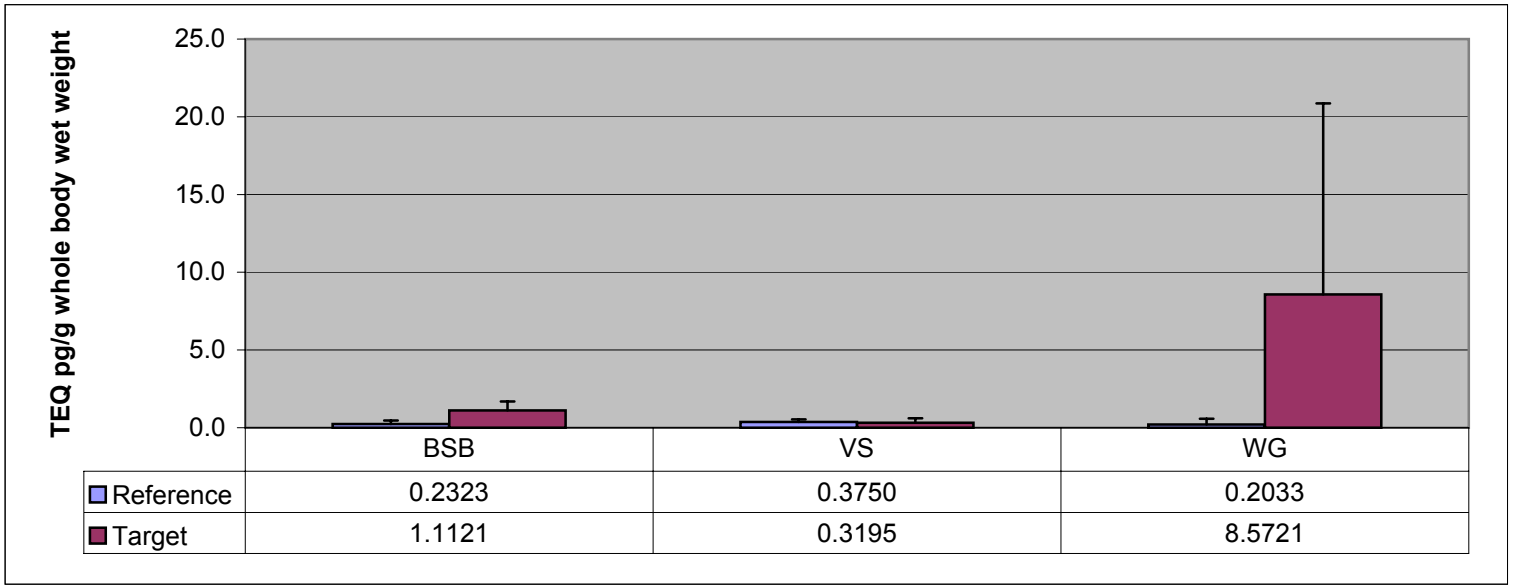
AF4.8-3 Mammal (ND=0)

Summary stats for mammlian TEQs from the consumption of fish (assuming ND=0)

		Mammal TEQ pg/g fish whole body wet weight										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	0.2323	0.2300	0.0707	1.0146	Target	11	1.1121	0.5802	0.2554	2.1591
VS	Reference	22	0.3750	0.1555	0.0881	0.7108	Target	20	0.3195	0.2832	0.0816	1.1785
WG	Reference	20	0.2033	0.3735	0.0179	1.6082	Target	20	8.5721	12.2890	0.7507	42.6658

		Mamnal TEQ pg/g fish whole body lipid weight (wet)										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	47.1797	56.5663	2.8865	228.3635	Target	11	28.5195	25.8205	6.9590	88.4685
VS	Reference	22	8.2468	3.6114	1.4930	14.7154	Target	20	6.5223	6.0366	2.3137	22.7058
WG	Reference	20	16.1335	19.7083	2.5541	92.9569	Target	20	164.2836	175.5306	20.2900	601.7743

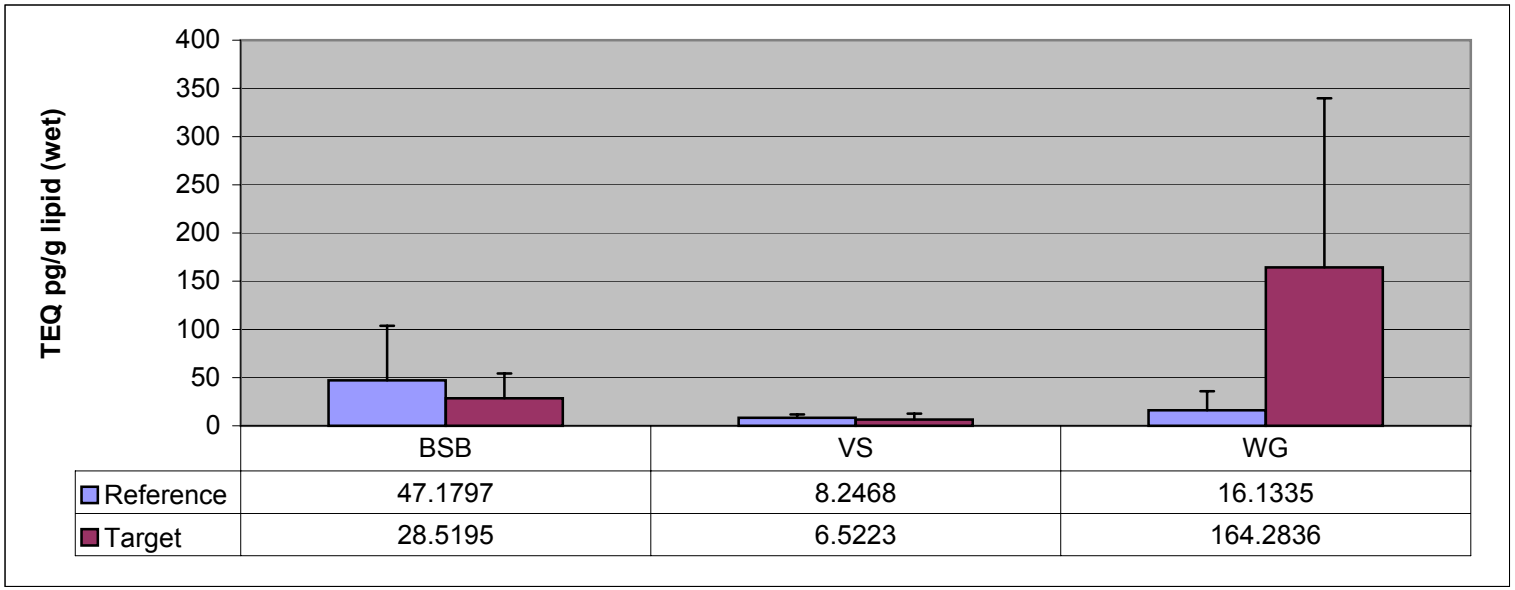
AF4.8-3 Summary stats for mammlian TEQs from the consumption of fish (assuming ND=0)



LOAEL 17.8 pg/g

NOAEL 3.93 pg/g

CCME 0.79 pg/g



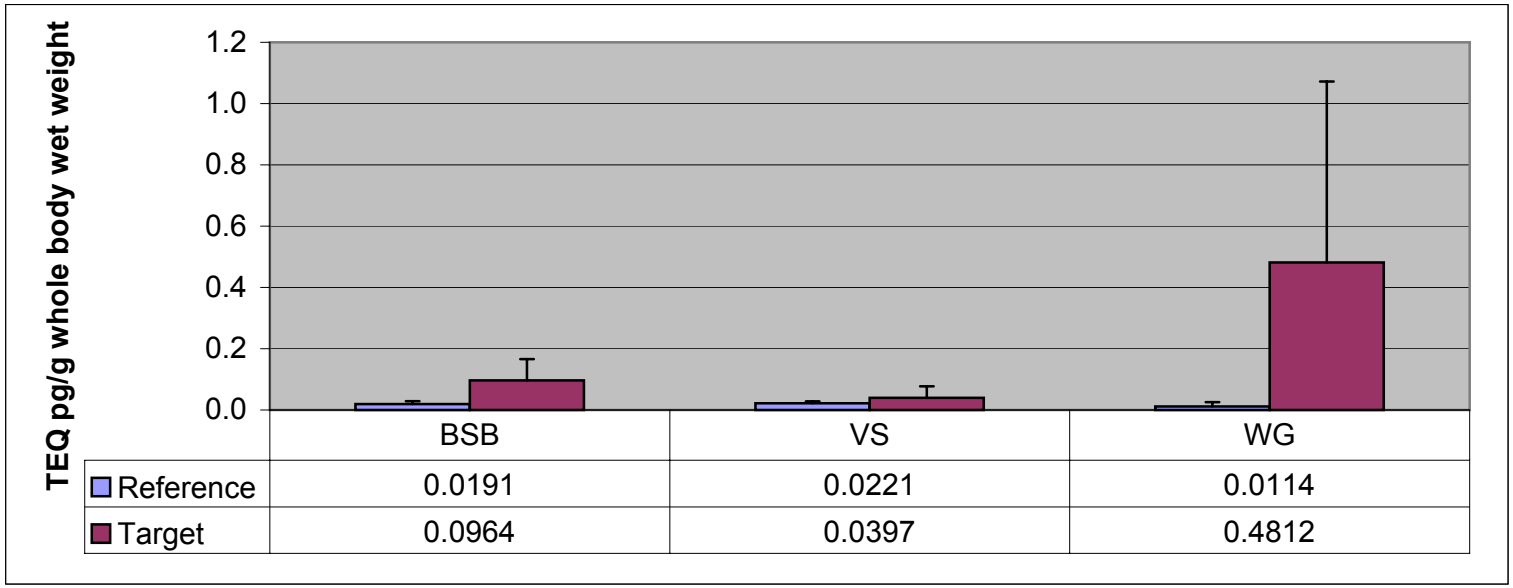
A4F.9-1 Summary of Fish Data TEQ (ND=DL)

This sheet provides summary stats for the fish data TEQs (assuming ND=DL)

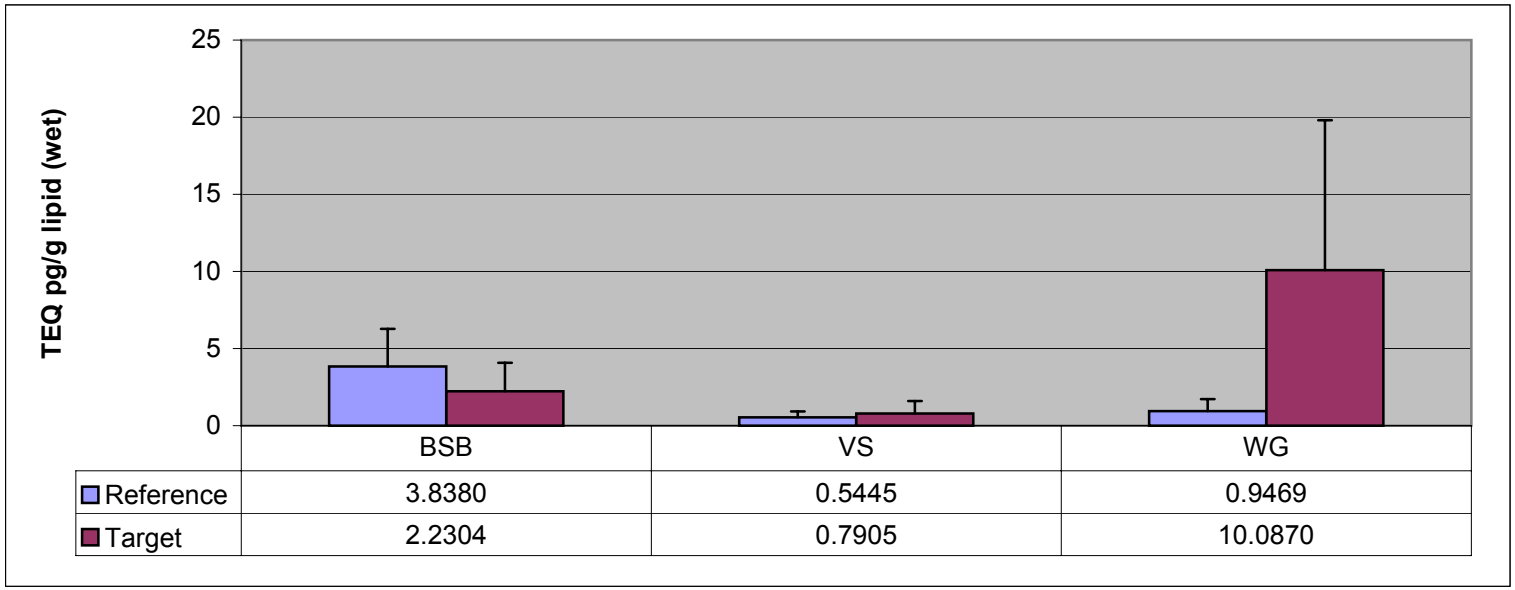
		Fish TEQ pg/g whole body wet weight										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	0.0191	0.0096	0.0089	0.0457	Target	11	0.0964	0.0696	0.0279	0.2564
VS	Reference	22	0.0221	0.0063	0.0128	0.0346	Target	20	0.0397	0.0374	0.0097	0.1641
WG	Reference	20	0.0114	0.0143	0.0024	0.0611	Target	20	0.4812	0.5911	0.0332	2.1136

		fishnd0 TEQ pg/g whole body lipid weight (wet)										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	3.8380	2.4346	0.2360	10.9055	Target	11	2.2304	1.8463	0.7215	6.6571
VS	Reference	22	0.5445	0.3830	0.1995	1.6719	Target	20	0.7905	0.8054	0.2933	3.8465
WG	Reference	20	0.9469	0.7715	0.3007	3.5318	Target	20	10.0870	9.7181	0.9009	28.9142

A4F.9-1 Fish data TEQs (assuming ND=DL)



	BSB	VS	WG
Reference	0.0191	0.0221	0.0114
Target	0.0964	0.0397	0.4812



	BSB	VS	WG
Reference	3.8380	0.5445	0.9469
Target	2.2304	0.7905	10.0870

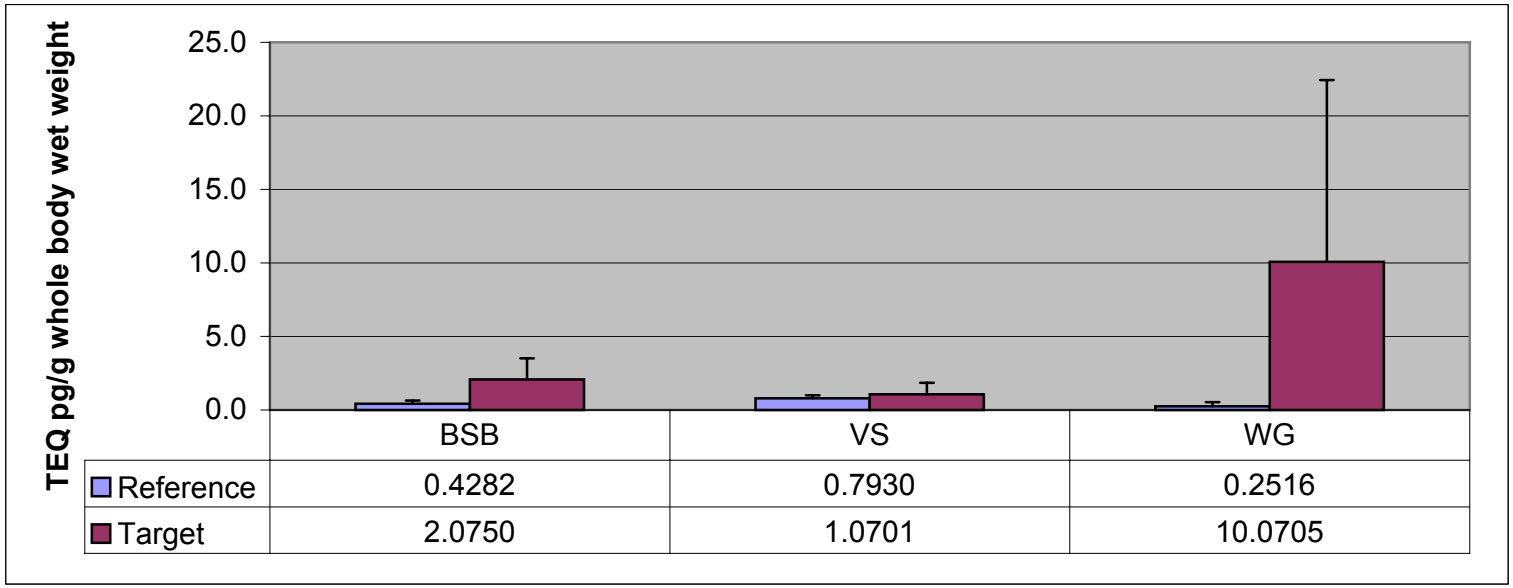
A4F.9-2 Bird (ND=DL)

Summary stats for the avian TEQs from fish consumption (assuming ND=DL)

		Bird TEQ pg/g fish whole body wet weight										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	0.4282	0.2163	0.1733	0.9898	Target	11	2.0750	1.4380	0.6895	5.4792
VS	Reference	22	0.7930	0.2113	0.4816	1.4086	Target	20	1.0701	0.7809	0.3604	3.6416
WG	Reference	20	0.2516	0.2855	0.0562	1.1745	Target	20	10.0705	12.3671	0.8874	41.6223

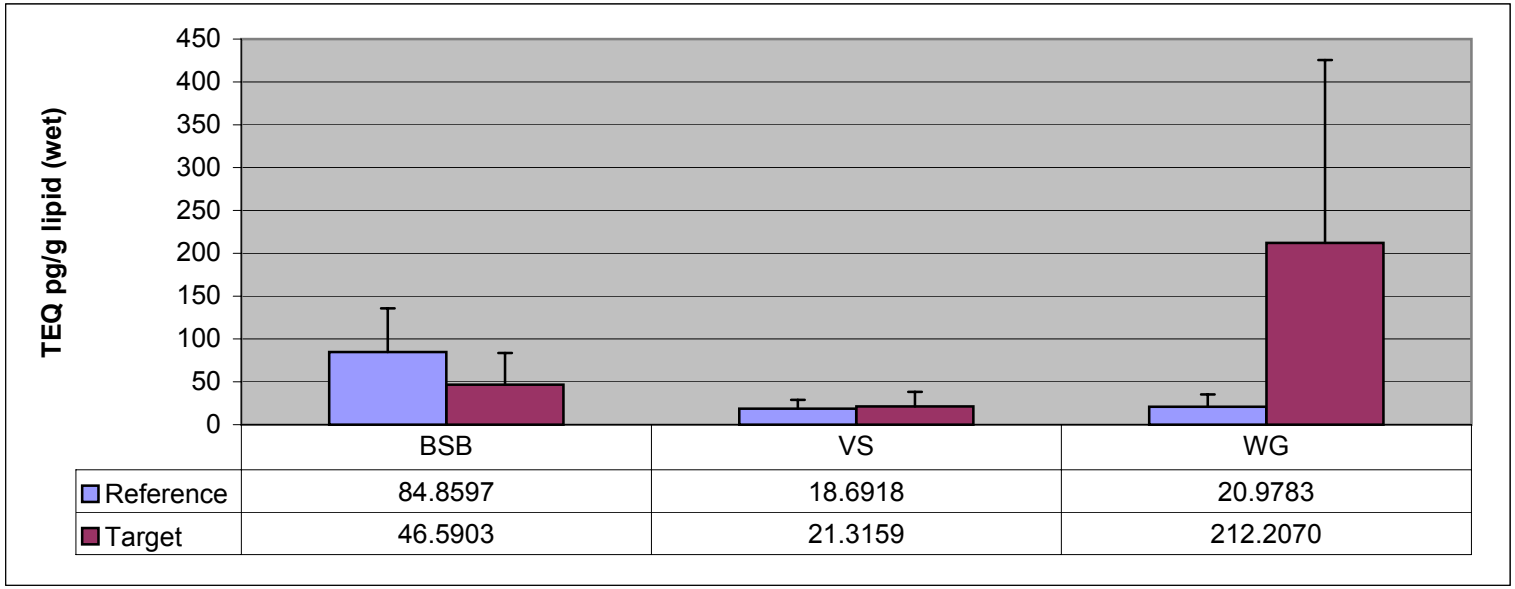
		Bird TEQ pg/g fish whole body lipid weight (wet)										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	84.8597	50.8520	5.5607	226.5120	Target	11	46.5903	36.9810	20.0429	142.2549
VS	Reference	22	18.6918	10.3251	8.2904	49.1252	Target	20	21.3159	16.8787	10.4791	85.3492
WG	Reference	20	20.9783	14.3283	8.2021	67.8906	Target	20	212.2070	213.3612	20.8019	599.7893

A4F.9-2 Avian TEQs from fish consumption (assuming ND=DL)



	BSB	VS	WG
Reference	0.4282	0.7930	0.2516
Target	2.0750	1.0701	10.0705

CCME Birds 2.4 pg/g



	BSB	VS	WG
Reference	84.8597	18.6918	20.9783
Target	46.5903	21.3159	212.2070

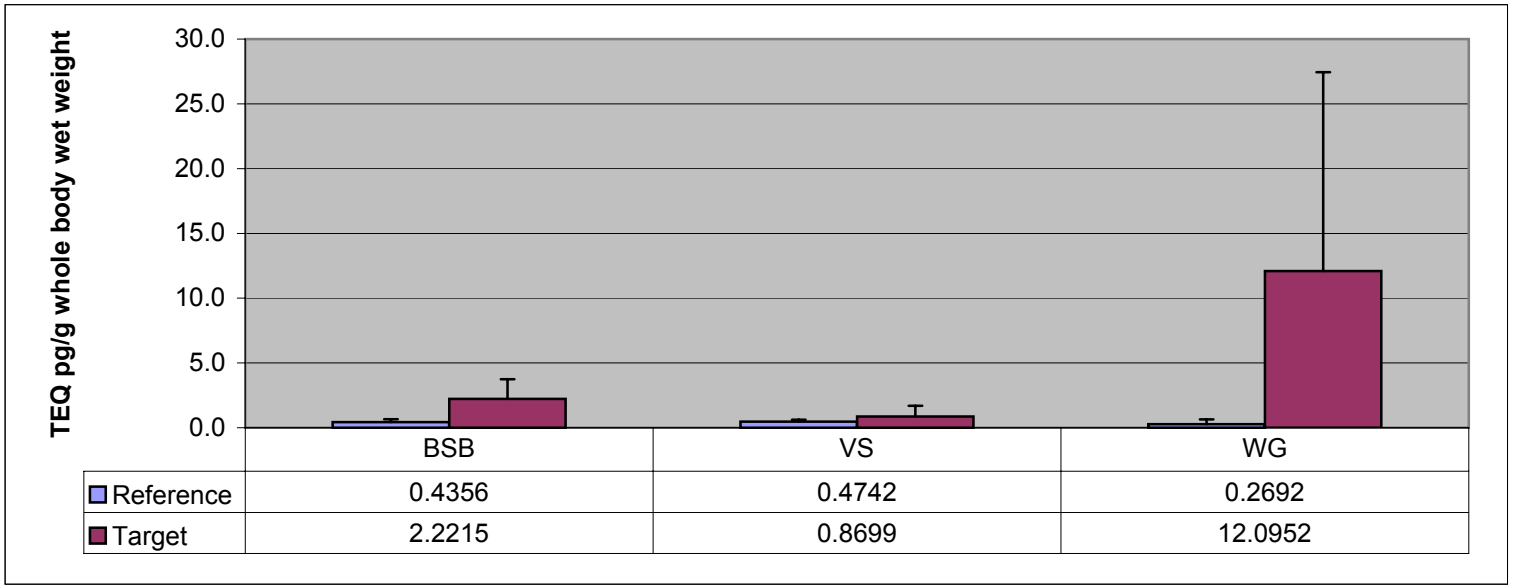
A4F.9-3 Mammal (ND=DL)

These are the mammal TEC concentrations for fish consumption using ND=DL

		Mammal TEQ pg/g fish whole body wet weight										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	0.4356	0.2181	0.2235	1.0207	Target	11	2.2215	1.5167	0.6566	5.7410
VS	Reference	22	0.4742	0.1413	0.2752	0.7736	Target	20	0.8699	0.8245	0.2118	3.5902
WG	Reference	20	0.2692	0.3678	0.0538	1.6172	Target	20	12.0952	15.3420	0.8544	55.7192

		Mammal TEQ pg/g fish whole body lipid weight (wet)										
species	site	n	mean	stdev	min	max	site	n	mean	stdev	min	max
BSB	Reference	20	86.7622	52.4080	5.4878	233.7013	Target	11	52.2263	43.0478	18.4485	149.0533
VS	Reference	22	11.7759	8.4236	4.1319	36.0205	Target	20	17.3720	17.6922	6.3606	84.1444
WG	Reference	20	21.9870	19.9234	6.7303	93.4812	Target	20	249.4152	244.2770	23.2170	762.2325

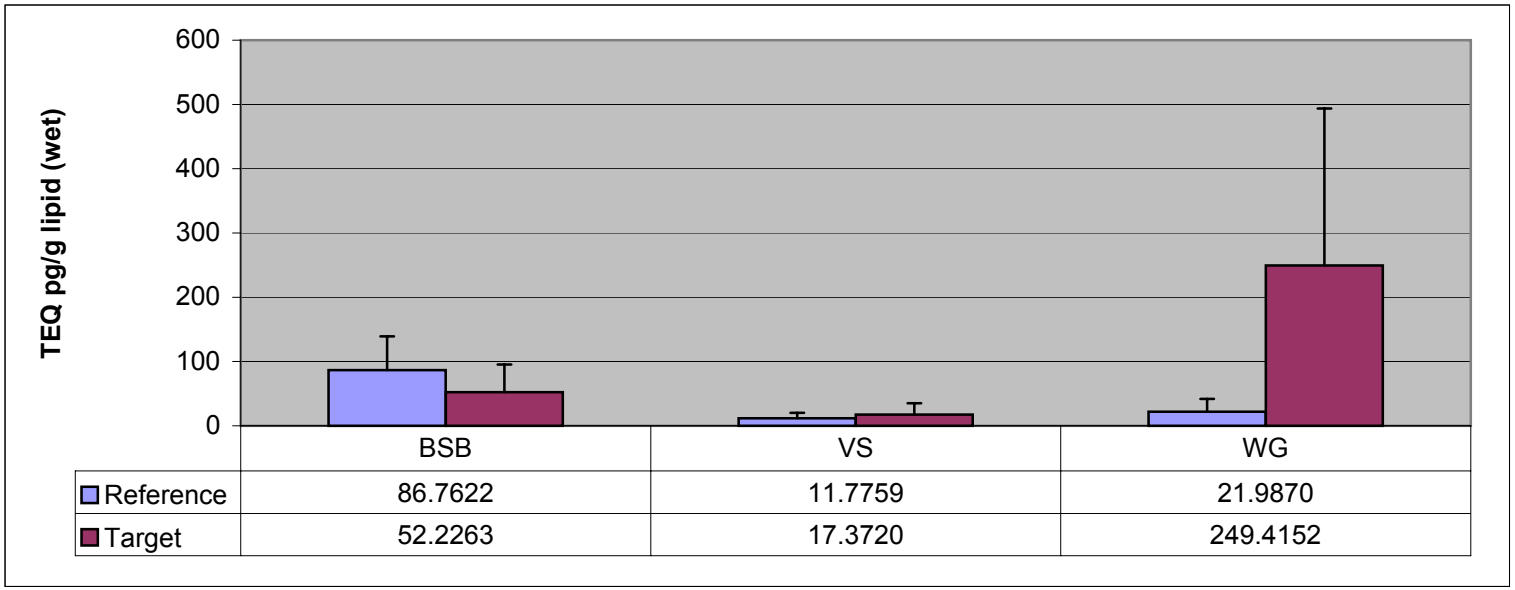
A4F.9-3 Mammal TEC concentrations for fish consumption using ND=DL



LOAEL 17.8 pg/g

NOAEL 3.93 pg/g

CCME 0.79 pg/g



Appendix 5. ERED Search Results for Residue Effects Levels

A5A. PCB

A5B. Cadmium

A5C. Chromium

A5D. Copper

A5E. Nickel

A5F. Lead

A5G. ERED Data used to construct SSD for PCBs

A5G.1. Fish Tissue NOED SSD for PCBs

A5G.2. Fish Tissue LOED SSD for PCBs

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

	Year	Author	Journal	Species	Common Name	Chemical	Conc Wet	Conc Units	Effect	Endpo	Exposure Route	Body Part	Life stage	Comments
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	2.1	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	Pcb With No Acetone Carrier; No Effect On Mortality
Fish LOED 2	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	2.2	MG/KG	Mortality	LOED	Absorption	Whole Body	Immature	5% Mortality In 96 Hours
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	2.3	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Juvenile Mortality In 28 Days
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	2.3	MG/KG	Growth	LOED	Absorption	Whole Body	Immature	Pcb Dosed With Acetone Carrier; Enhanced Growth (weight only; not
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	2.3	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	Pcb Dosed With Acetone Carrier; No Effect On Mortality
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	2.4	MG/KG	Growth	LOED	Absorption	Whole Body	Immature	Pcb Dosed With Acetone Carrier; Enhanced Growth (weight and
	1981	Mac, M.J. and J.G. Seelye	Bull. Environ. Contam. Toxicol. 27:359-367.	Salvelinus namaycush	Trout -Lake	PCBs	2.4	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	Pcb Dosed With Acetone Carrier; No Effect On Mortality
	1972	Sanders, H.O., Chandler, J.H.	Bulletin of Environmental Contamination &	Palaemonetes kadiakensis	Shrimp - Grass	Aroclor 1254	3.2	MG/KG	Mortality	NOED	Combined	Whole Body	Mature	Radiolabeled Compound
	1980	Hawkes, J.W., E.H. Gruger, Jr. and O.P. Olson	Environ. Res. 23:149-161.	Oncorhynchus tshawytscha	Salmon - Chinook	PCBs	3.5	MG/KG	Cellular	LOED	Ingestion	Whole Body	Immature	Structure Changes In Intestine Cells, Increased Exfoliation Of Mucosa, Mucosal Cell Inclusions
	1980	Hawkes, J.W., E.H. Gruger, Jr. and O.P.	Environ. Res. 23:149-161.	Oncorhynchus tshawytscha	Salmon - Chinook	PCBs	3.5	MG/KG	Growth	NOED	Ingestion	Whole Body	Immature	No Effect On Weight Gain
	1979	Broyles, R.H. and M.I. Noveck	Toxicology and Applied Pharmacology 50, 299-	Oncorhynchus tshawytscha	Salmon - Chinook	2,4,6,2`-tetrachl	3.7	MG/KG	Survival	LC28	Combined	Whole Body	Fry	
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Lagodon rhomboides	Pinfish	PCBs	3.8	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Survival In 48 Hours
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Penaeus aztecus	Shrimp - Brown	PCBs	3.8	MG/KG	Mortality	LOED	Absorption	Whole Body	NA	8% Mortality In 96 Hours
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Penaeus duorarum	Shrimp - Pink	PCBs	3.9	MG/KG	Mortality	ED100	Absorption	Whole Body	Immature	100% Mortality After 48 Hours
	1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Crassostrea virginica	Oyster	PCBs	4	MG/KG	Growth	ED10	Absorption	Whole Body	Adult	Reduction In Shell Growth
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	4.2	MG/KG	Developi	NOED	Absorption	Whole Body	Egg-embryo	No Effect On Fertilization Success, Survival Of Embryos To Hatching,
	1983	Westin, D.T., Olney, C.E., Rogers, B.A.	Bull. Environm. Contam. Toxicol. 30: 50-57	Morone saxatilis	Striped Bass	PCBs	4.4	MG/KG	Growth	NOED	Ingestion	Whole Body	Immature	Parental Exposure To Pcbs In Field, Then Post Yolk Absorption
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	4.9	MG/KG	Mortality	NOED	Absorption	Whole Body	Egg-embryo	No Effect On Fry Mortality In 28 Days
	1972	Sanders, H.O., Chandler, J.H.	Bulletin of Environmental Contamination &	Culex tarsalis	Mosquito	Aroclor 1254	5.4	MG/KG	Mortality	NOED	Combined	Whole Body	Immature	Radiolabeled Compound
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	5.4	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	No Effect On Adult Mortality In 28 Days
	1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	5.9	MG/KG	Mortality	NOED	Absorption	Whole Body	Egg-embryo	No Effect On Fry Mortality In 28 Days
	1988	Black, D.E., D.K. Phelps and R.L. Lapan	Mar. Environ. Res. 25:45-62.	Pleuronectes americanus	Winter Flounder	PCBs	7.1	MG/KG	Growth	LOED	Combined	Whole Body	Egg-embryo	Reduced Length And Weight Of Larvae
	1972	Sanders, H.O., Chandler, J.H.	Bulletin of Environmental Contamination &	Gammarus pseudolimnaeu	Amphipod	Aroclor 1254	7.8	MG/KG	Mortality	NOED	Combined	Whole Body	Mature	Radiolabeled Compound
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Crassostrea virginica	Oyster	PCBs	8.1	MG/KG	Growth	NA	Absorption	Whole Body	Immature	19% Reduction In Rate Of Shell Growth
	1970	Duke, T.W., J.I. Lowe and A.J. Wilson, Jr.	Bull. Environ. Contam. Toxicol. 5:171-180.	Crassostrea virginica	Oyster	PCBs	8.1	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Survival In 96 Hours

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

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

Year	Author	Journal	Species	Common Name	Chemical	Conc Wet	Conc Units	Effect	Endpo	Exposure Route	Body Part	Life stage	Comments
1972	Lowe, J.I., P.R. Parrish, J.M. Patrick,	Mar. Biol. 17:209-214.	Crassostrea virginica	Oyster	PCBs	101	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Mortality
1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	106	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	50% Mortality
1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	106	MG/KG	Cellular	LOED	Absorption	Whole Body	Immature	Liver And Pancreatic Cell Alterations
1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	106	MG/KG	Mortality	LOED	Absorption	Whole Body	Immature	Statistically Significant Increase In Mortality
1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	110	MG/KG	Mortality	NOED	Absorption	Whole Body	Adult	No Effect On Adult Mortality In 28 Days
1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	111	MG/KG	Cellular	NOED	Absorption	Whole Body	Immature	No Incidence Of Pathology (liver And Pancreatic Alterations)
1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	111	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Statistically Significant Increase In Mortality
1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	111	MG/KG	Physiolo	NOED	Absorption	Whole Body	Immature	No Reduced Ability To Survive Osmotic Stress After Exposure
1985	Freitag, D., L. Ballhorn, H. Geyer and F. Korte	Chemosphere 14:1589-1616.	Leuciscus idus	Golden Ide	2,4,6,2`,4`-	116	MG/KG	Mortality	NOED	Absorption	Whole Body	NA	No Effect On Survivorship In 3 Days
1985	Freitag, D., L. Ballhorn, H. Geyer and F. Korte	Chemosphere 14:1589-1616.	Leuciscus idus	Golden Ide	2,2` - DBCP	121	MG/KG	Mortality	NOED	Absorption	Whole Body	NA	No Effect On Survivorship In 3 Days
1985	Freitag, D., L. Ballhorn, H. Geyer and F. Korte	Chemosphere 14:1589-1616.	Leuciscus idus	Golden Ide	2,4,6,2`-tetrachl	158	MG/KG	Mortality	NOED	Absorption	Whole Body	NA	No Effect On Survivorship In 3 Days
1995	Van Wezel, A.P., Punte, S.S.,	Environ. Toxicol. Chem. 14: 1579-1585	Pimephales promelas	Fathead minnow	PCB 1	167	MG/KG	Mortality	ED100	Absorption	Whole Body	Adult	Lethal Body Burden Measured In Fish Immediately After Death;
1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	170	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Statistically Significant Increase In Mortality
1980	Bengtsson, B.E.	Water Res. 14:681-687.	Phoxinus phoxinus	Minnow	PCBs	170	MG/KG	Growth	LOED	Ingestion	Whole Body	Adult	Increased Growth
1980	Bengtsson, B.E.	Water Res. 14:681-687.	Phoxinus phoxinus	Minnow	PCBs	170	MG/KG	Mortality	LOED	Ingestion	Whole Body	Adult	Doubling Of Mortality Rate Compared To Controls After 300
1980	Bengtsson, B.E.	Water Res. 14:681-687.	Phoxinus phoxinus	Minnow	PCBs	170	MG/KG	Reprodu	NA	Ingestion	Whole Body	Adult	85% Reduction In Hatchability Of Eggs
1985	Freitag, D., L. Ballhorn, H. Geyer and F. Korte	Chemosphere 14:1589-1616.	Leuciscus idus	Golden Ide	2,4`-dichloro	178	MG/KG	Mortality	NOED	Absorption	Whole Body	NA	No Effect On Survivorship In 3 Days
1985	Freitag, D., L. Ballhorn, H. Geyer and F. Korte	Chemosphere 14:1589-1616.	Leuciscus idus	Golden Ide	PCB 31	193	MG/KG	Mortality	NOED	Absorption	Whole Body	NA	No Effect On Survivorship In 3 Days
1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	200	MG/KG	Mortality	LOED	Absorption	Whole Body	Egg-embryo	Lethal To 86% Of Fry In 28 Days
1990	Hermens, J.L., S.P. Bradbury and S.J.	Ecotoxicol. Environ. Saf. 20:156-166.	Oncorhynchus mykiss	Trout - Rainbow	PCBs	200	MG/KG	Physiolo	NA	NA	Whole Body	Immature	Mixed Function Oxidase Induction, Including Benzo(a)pyrene
1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	205	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	50% Mortality
1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	205	MG/KG	Morphole	LOED	Absorption	Whole Body	Immature	Darkened Coloration
1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	220	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Juvenile Mortality In 28 Days
1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	230	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Juvenile Mortality In 28 Days

Year	Author	Journal	Species	Common Name	Chemical	Conc Wet	Conc Units	Effect	Endpo	Exposure Route	Body Part	Life stage	Comments
1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	250	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	Lethal Body Burden
1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	250	MG/KG	Morphole	LOED	Absorption	Whole Body	Immature	Color Changes
1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	253	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	Lethal Body Burden
1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	256	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	Lethal Body Burden
1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	271	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	Lethal Body Burden
1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	293	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	Lethal Body Burden
1972	Hattula, M.I. and O. Karlog	Acta Pharmacol. Toxicol. 31:238-240.	Carassius auratus	Goldfish	PCBs	324	MG/KG	Mortality	ED50	Absorption	Whole Body	Immature	Lethal Body Burden
1972	Lowe, J.I., P.R. Parrish, J.M. Patrick, Jr. and J. Forester	Mar. Biol. 17:209-214.	Crassostrea virginica	Oyster	PCBs	425	MG/KG	Cellular	LOED	Absorption	Whole Body	Immature	Atrophy Of Digestive Diverticulata
1972	Lowe, J.I., P.R. Parrish, J.M. Patrick,	Mar. Biol. 17:209-214.	Crassostrea virginica	Oyster	PCBs	425	MG/KG	Growth	LOED	Absorption	Whole Body	Immature	Reduced Growth
1972	Lowe, J.I., P.R. Parrish, J.M. Patrick,	Mar. Biol. 17:209-214.	Crassostrea virginica	Oyster	PCBs	425	MG/KG	Mortality	NOED	Absorption	Whole Body	Immature	No Effect On Mortality
1974	Hansen, D.J., P.R. Parrish and J. Forester	Environ. Res. 7:363-373.	Lagodon rhomboides	Pinfish	PCBs	620	MG/KG	Mortality	LOED	Absorption	Whole Body	Immature	Statistically Significant Increase In Mortality
1977	Mayer, F.L., P.M. Mehrle, and H.O.	Arch. Environ. Contam. 5:501-511	Oncorhynchus kisutch	Salmon-coho	PCBs	645	MG/KG	Mortality	ED100	Ingestion	Whole Body	Immature	Radiolabeled - Contam. Food Fed.
1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	1100	MG/KG	Morphole	LOED	Absorption	Whole Body	Immature	Darkened Body Coloration, Body Lesions
1975	Hansen, D.J., S.C. Schimmel and J.	Trans. Amer. Fish. Soc. 104:584-588.	Cyprinodon variegatus	Sheepshead minnow	PCBs	1100	MG/KG	Mortality	LOED	Absorption	Whole Body	Immature	88% Juvenile Mortality In 28 Days

Appendix 5.2 Cadmium

Ref_ID	Year	Author	Journal	Species	Common Name	Chem	Conc Wet	Conc Uni	Reps	Effect	Endpoin	Exposure
URS133	1988	Jenkins, K.D. and A.Z. Mason	Aquat. Toxicol. 12:229-244.	Nereis arenaceodentata	Polychaete	Cadmium	0.0028	MG/KG	1	Mortality	NOED	Absorption
URS133	1988	Jenkins, K.D. and A.Z. Mason	Aquat. Toxicol. 12:229-244.	Nereis arenaceodentata	Polychaete	Cadmium	0.0028	MG/KG	1	Reproduction	NOED	Absorption
URS133	1988	Jenkins, K.D. and A.Z. Mason	Aquat. Toxicol. 12:229-244.	Nereis arenaceodentata	Polychaete	Cadmium	0.028	MG/KG	1	Mortality	NOED	Absorption
URS133	1988	Jenkins, K.D. and A.Z. Mason	Aquat. Toxicol. 12:229-244.	Nereis arenaceodentata	Polychaete	Cadmium	0.028	MG/KG	1	Reproduction	NOED	Absorption
URS99	1992	Handy, R.D.	Arch. Environ. Contam. Toxicol. 22:74-81.	Oncorhynchus mykiss	Trout - Rainbow	Cadmium	0.0599	MG/KG	7	Mortality	NOED	Absorption
SEQ97-34	1978	Spehar, R.L., Leonard, E.N., Defoe, D.L.	Tans. Am. Fish. Soc., 107(2): 354-360 (1978)	Jordanella floridae	American flagfish	Cadmium	0.09	MG/KG	1	Mortality	NOED	Combined
URS73	1982	Dressing, S.A., R.P. Maas and C.M. Weiss	Bull. Environ. Contam. Toxicol. 28:172-180.	Hydropsyche sp.	Caddisfly	Cadmium	0.0934	MG/KG	1	Mortality	LOED	Absorption
URS73	1982	Dressing, S.A., R.P. Maas and C.M. Weiss	Bull. Environ. Contam. Toxicol. 28:172-180.	Hydropsyche sp.	Caddisfly	Cadmium	0.118	MG/KG	1	Mortality	LOED	Absorption
JB17	1992	Janssens De Bisthoven, L.G., Timmermans, K.R. and F. Ollevier	Hydrobiologia 239: 141-149	Chironomus gr. thummi	Midge	Cadmium	0.156	MG/KG	9	Morphology	NOED	Combined
URS73	1982	Dressing, S.A., R.P. Maas and C.M. Weiss	Bull. Environ. Contam. Toxicol. 28:172-180.	Hydropsyche sp.	Caddisfly	Cadmium	0.202	MG/KG	1	Mortality	NOED	Absorption
URS13	1978	Beattie, J.H. and D. Pascoe	J. Fish. Biol. 13:631-637.	Oncorhynchus mykiss	Trout - Rainbow	Cadmium	0.21	MG/KG	3	Morphology	LOED	Absorption
URS13	1978	Beattie, J.H. and D. Pascoe	J. Fish. Biol. 13:631-637.	Oncorhynchus mykiss	Trout - Rainbow	Cadmium	0.21	MG/KG	3	Mortality	LOED	Absorption
URS133	1988	Jenkins, K.D. and A.Z. Mason	Aquat. Toxicol. 12:229-244.	Nereis arenaceodentata	Polychaete	Cadmium	0.22	MG/KG	1	Mortality	NOED	Absorption
URS133	1988	Jenkins, K.D. and A.Z. Mason	Aquat. Toxicol. 12:229-244.	Nereis arenaceodentata	Polychaete	Cadmium	0.22	MG/KG	1	Reproduction	NOED	Absorption
URS73	1982	Dressing, S.A., R.P. Maas and C.M. Weiss	Bull. Environ. Contam. Toxicol. 28:172-180.	Hydropsyche sp.	Caddisfly	Cadmium	0.284	MG/KG	1	Mortality	NOED	Absorption
SEQ97-34	1978	Spehar, R.L., Leonard, E.N., Defoe, D.L.	Tans. Am. Fish. Soc., 107(2): 354-360 (1978)	Jordanella floridae	American flagfish	Cadmium	0.4	MG/KG	1	Mortality	LOED	Combined
SEQ97-34	1978	Spehar, R.L., Leonard, E.N., Defoe, D.L.	Tans. Am. Fish. Soc., 107(2): 354-360 (1978)	Jordanella floridae	American flagfish	Cadmium	0.4	MG/KG	1	Mortality	LOED	Combined

Appendix 5.2 Cadmium

Ref_ID	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS133	Whole Body	NA	Cape Cod to Cape Hatteras; burrows in soft substrata	Predator on small invertebrates	No Effect On Survival
URS133	Whole Body	NA	Cape Cod to Cape Hatteras; burrows in soft substrata	Predator on small invertebrates	No Effect On Reproduction
URS133	Whole Body	NA	Cape Cod to Cape Hatteras; burrows in soft substrata	Predator on small invertebrates	No Effect On Survival
URS133	Whole Body	NA	Cape Cod to Cape Hatteras; burrows in soft substrata	Predator on small invertebrates	No Effect On Reproduction
URS99	Whole Body	Adult	Cool streams	Carnivore-juv fish, inverts	No Effect On Mortality
SEQ97-34	Whole Body	Immature	Peninsular Florida north to St. Johns and Ochlockonee River drainages; in vegetated sloughs, lakes, sluggish streams	Feeds on detritus, small invertebrates	Body Burden Est. From Graph, Fish Initially Exposed As Embryos
URS73	Whole Body	Larval	Burrow in streams, rivers, sometimes along shores of lakes with moderate current, considerable wave action	Larvae construct drift nets near burrow, filter flowing water for small animals, detritus	Mortality In Two Days
URS73	Whole Body	Larval	Burrow in streams, rivers, sometimes along shores of lakes with moderate current, considerable wave action	Larvae construct drift nets near burrow, filter flowing water for small animals, detritus	Mortality In One Day
JB17	Whole Body	Egg-embryo	Not Specified	Not Specified	4th Instar Larvae
URS73	Whole Body	Larval	Burrow in streams, rivers, sometimes along shores of lakes with moderate current, considerable wave action	Larvae construct drift nets near burrow, filter flowing water for small animals, detritus	No Effect On Mortality In One Day
URS13	Whole Body	Egg-embryo	Cool streams	Carnivore-juv fish, inverts	Deformed Vertebrae, Blood Clots In Fins
URS13	Whole Body	Egg-embryo	Cool streams	Carnivore-juv fish, inverts	Hatching Alevins Unable To Break Free From Egg Membrane, Died
URS133	Whole Body	NA	Cape Cod to Cape Hatteras; burrows in soft substrata	Predator on small invertebrates	No Effect On Survival
URS133	Whole Body	NA	Cape Cod to Cape Hatteras; burrows in soft substrata	Predator on small invertebrates	No Effect On Reproduction
URS73	Whole Body	Larval	Burrow in streams, rivers, sometimes along shores of lakes with moderate current, considerable wave action	Larvae construct drift nets near burrow, filter flowing water for small animals, detritus	No Effect On Mortality In One Day
SEQ97-34	Whole Body	Immature	Peninsular Florida north to St. Johns and Ochlockonee River drainages; in vegetated sloughs, lakes, sluggish streams	Feeds on detritus, small invertebrates	Body Burden Est. From Graph, Fish Initially Exposed As Embryos
SEQ97-34	Whole Body	Immature	Peninsular Florida north to St. Johns and Ochlockonee River drainages; in vegetated sloughs, lakes, sluggish streams	Feeds on detritus, small invertebrates	Body Burden Est. From Graph, Fish Not Exposed As Embryos

Appendix 5.2 Cadmium

Ref_ID	Year	Author	Journal	Species	Common Name	Chem	Conc Wet	Conc Uni	Reps	Effect	Endpoin	Exposure
SEQ97-34	1978	Spehar, R.L., Leonard, E.N., Defoe, D.L.	Tans. Am. Fish. Soc., 107(2): 354-360 (1978)	Jordanella floridae	American flagfish	Cadmium	0.4	MG/KG	1	Mortality	NOED	Combined
URS107	1982	Hatakeyama, S. and M. Yasuno	Bull. Environ. Contam. Toxicol. 29:159-166.	Poecilia reticulata	Guppy	Cadmium	0.5	MG/KG	2	Growth	LOED	Ingestion
URS107	1982	Hatakeyama, S. and M. Yasuno	Bull. Environ. Contam. Toxicol. 29:159-166.	Poecilia reticulata	Guppy	Cadmium	0.8	MG/KG	2	Growth	NA	Ingestion
URS13	1978	Beattie, J.H. and D. Pascoe	J. Fish. Biol. 13:631-637.	Oncorhynchus mykiss	Trout - Rainbow	Cadmium	0.84	MG/KG	3	Mortality	ED100	Absorption
URS198	1988	Meteyer, M.J., D.A. Wright and F.D. Martin	Environ. Toxicol. Chem. 7:321-328.	Cyprinodon variegatus	Sheepshead minnow	Cadmium	0.9	MG/KG	3	Development	LOED	Absorption
SEQ98-19	1996	Rule, J.H., and R.W. Alden III	Environmental Toxicology and Chemistry, Vol. 15, No. 4, pp. 466-471. 1996	Palaemonetes pugio	Shrimp - Grass	Cadmium	0.9	MG/KG	6	Mortality	NOED	Combined
URS107	1982	Hatakeyama, S. and M. Yasuno	Bull. Environ. Contam. Toxicol. 29:159-166.	Poecilia reticulata	Guppy	Cadmium	1.2	MG/KG	2	Mortality	LOED	Ingestion
URS57	1985	Carr, R.S., J.W. Williams, F.I. Saksa, R.L. Buhl and J.M. Neff	Environ. Toxicol. Chem. 4:181-188.	Mysidopsis bahia	Mysid	Cadmium	1.29	MG/KG	1	Growth	LOED	Absorption
URS57	1985	Carr, R.S., J.W. Williams, F.I. Saksa, R.L. Buhl and J.M. Neff	Environ. Toxicol. Chem. 4:181-188.	Mysidopsis bahia	Mysid	Cadmium	1.29	MG/KG	1	Physiological	LOED	Absorption
THD1	1995	Nebeker, AV, et.al.	Arch. Environ. Contam Toxicol 29: 492-503	Ambystoma gracile	Salamander	Cadmium	1.62	MG/KG	1	Growth	NOED	Absorption
URS17	1991	Enserink, E.L., J.L. Maas-Diepeveen and C.J. Van Leeuwen	Water Res. 25:679-687.	Daphnia magna	Water flea	Cadmium	1.7	MG/KG	4	Reproduction	ED10	Absorption
SEQ97-39	1984	Sundelin, B.	Ecotoxicological Testing for the Marine Environment, Vol. 2, 588 P, 1984	Monoporeia affinis	Amphipod	Cadmium	2	MG/KG	3	Mortality	NOED	Combined
SEQ97-6	1986	Pascoe, D., S.A. Evans, and J. Woodworth	Arch. Environ. Contam. Toxicol. 15, 481-487 (1986)	Oncorhynchus mykiss	Trout - Rainbow	Cadmium	2.2	MG/KG	1	Mortality	ED50	Combined

Appendix 5.2 Cadmium

Ref_ID	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
SEQ97-34	Whole Body	Immature	Peninsular Florida north to St. Johns and Ochlockonee River drainages; in vegetated sloughs, lakes, sluggish streams	Feeds on detritus, small invertebrates	Body Burden Est. From Graph, Fish Not Exposed As Embryos
URS107	Whole Body	Immature	Native to West Indies, n. South America; est. in AB, AZ, ID, NV, TX, WY, possibly CA; generally uncommon	Feeds on detritus, small invertebrates	Reduction In Body Length Within 10 Days
URS107	Whole Body	Immature	Native to West Indies, n. South America; est. in AB, AZ, ID, NV, TX, WY, possibly CA; generally uncommon	Feeds on detritus, small invertebrates	Reduction In Body Length Within 10 Days
URS13	Whole Body	Larval	Cool streams	Carnivore-juv fish, inverts	Complete Mortality Of Alevins Within 320 Hours
URS198	Whole Body	Egg-embryo	Shallow brackish waters, Cape Cod to Mexico	Wide variety of small aquatic animals and plants	Decreased Time To Hatch
SEQ98-19	Whole Body	Adult	Nova Scotia south to Corpus Christi, TX; estuaries on beds of submerged vegetation	Detritus with associated bacteria, diatoms	Estimated Wet Weight
URS107	Whole Body	Immature	Native to West Indies, n. South America; est. in AB, AZ, ID, NV, TX, WY, possibly CA; generally uncommon	Feeds on detritus, small invertebrates	14% Reduction In Survival
URS57	Whole Body	Juvenile	Brackish sub-tropical waters	Phytoplankton, small zooplanters	Reduction In Growth, Mean Dry Weight Of Animals
URS57	Whole Body	Juvenile	Brackish sub-tropical waters	Phytoplankton, small zooplanters	Altered O:n Ratio, Shift Towards Lipid Utilization With Increasing Cadmium Concentration
THD1	Whole Body	Larval	Ponds, marshes of northwestern US	Principal food is tadpoles; also eats other small aquatic invertebrates	No Significant Reduction In Length Or Weight
URS17	Whole Body	Immature	Southwestern to south-central Canada, Northwestern to north-central US; ponds, small lakes, clear and weedy waters	Feeds on algae and similar organisms	10% Reduction In Number Of Offspring
SEQ97-39	Whole Body	Immature	Holarctic, coastal marine, mainly brackish lakes and estuaries, marine-glacial relict lakes	Detritivore	Body Burden Est. From Graph
SEQ97-6	Whole Body	Adult	Cool streams	Carnivore-juv fish, inverts	Hardness: 70 Mg/l Caco3

Appendix 5.2 Cadmium

Ref_ID	Year	Author	Journal	Species	Common Name	Chem	Conc Wet	Conc Uni	Reps	Effect	Endpoin	Exposure
URS57	1985	Carr, R.S., J.W. Williams, F.I. Saksa, R.L. Buhl and J.M. Neff	Environ. Toxicol. Chem. 4:181-188.	Mysidopsis bahia	Mysid	Cadmium	2.38	MG/KG	1	Growth	NA	Absorption
URS57	1985	Carr, R.S., J.W. Williams, F.I. Saksa, R.L. Buhl and J.M. Neff	Environ. Toxicol. Chem. 4:181-188.	Mysidopsis bahia	Mysid	Cadmium	2.38	MG/KG	1	Physiological	NA	Absorption
URS224	1977	Vernberg, W.B., Decoursey, P.J., Kelly, M., Johns, D.M.	Bull. Environ. Contam. Toxicol. 17: 16-24	Palaemonetes pugio	Shrimp - Grass	Cadmium	2.6	MG/KG	1	Mortality	NA	Absorption
SEQ97-44	1983	Sundelin, B.	Marine Biology 74, 203-212 (1983)	Monoporeia affinis	Amphipod	Cadmium	3	MG/KG	1	Reproduction	NOED	Combined
URS181	1978	Marshall, J.S.	J. Fish. Res. Bd. Can. 35:461-469.	Daphnia galeata mendotae	Cladoceran	Cadmium	3.5	MG/KG	4	Mortality	LOED	Absorption
URS181	1978	Marshall, J.S.	J. Fish. Res. Bd. Can. 35:461-469.	Daphnia galeata mendotae	Cladoceran	Cadmium	3.5	MG/KG	4	Growth	NOED	Absorption
SEQ97-6	1986	Pascoe, D., S.A. Evans, and J. Woodworth	Arch. Environ. Contam. Toxicol. 15, 481-487 (1986)	Oncorhynchus mykiss	Trout - Rainbow	Cadmium	3.74	MG/KG	1	Mortality	ED50	Combined
URS223	1991	Velduizen-Tsoerkan, M.B., Holwerda, D.A., Zandee, D.I.	Arch. Environ. Contam. Toxicol. 20: 259-265	Mytilus edulis	Mussel	Cadmium	3.74	MG/KG	20	Mortality	NA	Absorption
THD1	1995	Nebeker, AV, et.al.	Arch. Environ. Contam Toxicol 29: 492-503	Ambystoma gracile	Salamander	Cadmium	3.75	MG/KG	1	Growth	NOED	Absorption
SEQ97-6	1986	Pascoe, D., S.A. Evans, and J. Woodworth	Arch. Environ. Contam. Toxicol. 15, 481-487 (1986)	Oncorhynchus mykiss	Trout - Rainbow	Cadmium	4	MG/KG	1	Mortality	ED50	Combined
THD1	1995	Nebeker, AV, et.al.	Arch. Environ. Contam Toxicol 29: 492-503	Ambystoma gracile	Salamander	Cadmium	4.13	MG/KG	1	Mortality	NOED	Absorption
URS223	1991	Velduizen-Tsoerkan, M.B., Holwerda, D.A., Zandee, D.I.	Arch. Environ. Contam. Toxicol. 20: 259-265	Mytilus edulis	Mussel	Cadmium	4.22	MG/KG	20	Mortality	NA	Absorption
URS57	1985	Carr, R.S., J.W. Williams, F.I. Saksa, R.L. Buhl and J.M. Neff	Environ. Toxicol. Chem. 4:181-188.	Mysidopsis bahia	Mysid	Cadmium	4.36	MG/KG	1	Growth	NA	Absorption
URS57	1985	Carr, R.S., J.W. Williams, F.I. Saksa, R.L. Buhl and J.M. Neff	Environ. Toxicol. Chem. 4:181-188.	Mysidopsis bahia	Mysid	Cadmium	4.36	MG/KG	1	Physiological	NA	Absorption
URS133	1988	Jenkins, K.D. and A.Z. Mason	Aquat. Toxicol. 12:229-244.	Nereis arenaceodentata	Polychaete	Cadmium	4.5	MG/KG	1	Mortality	NOED	Absorption

Appendix 5.2 Cadmium

Ref_ID	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS57	Whole Body	Juvenile	Brackish sub-tropical waters	Phytoplankton, small zooplanters	Reduction In Growth, Mean Dry Weight Of Animals
URS57	Whole Body	Juvenile	Brackish sub-tropical waters	Phytoplankton, small zooplanters	Altered O:n Ratio, Shift Towards Lipid Utilization With Increasing Cadmium Concentration
URS224	Whole Body	NA	Nova Scotia south to Corpus Christi, TX; estuaries on beds of submerged vegetation	Detritus with associated bacteria, diatoms	20% Increased Mortality Over Control In 5 Ppt Water; No Statistical Analysis
SEQ97-44	Whole Body	Adult	Holarctic, coastal marine, mainly brackish lakes and estuaries, marine-glacial relict lakes	Detritivore	Percent Malformed Eggs
URS181	Whole Body	Population	In lakes of northern part of continent, especially glaciated regions	Feeds on algae and similar organisms	Reduced Longevity, Increased Prenatal Mortality
URS181	Whole Body	Population	In lakes of northern part of continent, especially glaciated regions	Feeds on algae and similar organisms	No Effect On Individual Weight
SEQ97-6	Whole Body	Adult	Cool streams	Carnivore-juv fish, inverts	Hardness: 279 Mg/l Caco3
URS223	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Decreased Anoxic Survival Time (control 13 Days)
THD1	Whole Body	Larval	Ponds, marshes of northwestern US	Principal food is tadpoles; also eats other small aquatic invertebrates	No Significant Reduction In Length Or Weight
SEQ97-6	Whole Body	Adult	Cool streams	Carnivore-juv fish, inverts	Hardness: 70 Mg/l Caco3
THD1	Whole Body	Larval	Ponds, marshes of northwestern US	Principal food is tadpoles; also eats other small aquatic invertebrates	No Significant Increase In Mortality At Highest Test Concentration
URS223	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Decreased Anoxic Survival Time (control 10.7 Days)
URS57	Whole Body	Juvenile	Brackish sub-tropical waters	Phytoplankton, small zooplanters	Reduction In Growth, Mean Dry Weight Of Animals
URS57	Whole Body	Juvenile	Brackish sub-tropical waters	Phytoplankton, small zooplanters	Altered O:n Ratio, Shift Towards Lipid Utilization With Increasing Cadmium Concentration
URS133	Whole Body	NA	Cape Cod to Cape Hatteras; burrows in soft substrata	Predator on small invertebrates	No Effect On Survival

Appendix 5.2 Cadmium

Ref_ID	Year	Author	Journal	Species	Common Name	Chem	Conc Wet	Conc Uni	Reps	Effect	Endpoin	Exposure
URS133	1988	Jenkins, K.D. and A.Z. Mason	Aquat. Toxicol. 12:229-244.	Nereis arenaceodentata	Polychaete	Cadmium	4.5	MG/KG	1	Reproduction	NOED	Absorption
THD1	1995	Nebeker, AV, et.al.	Arch. Environ. Contam Toxicol 29: 492-503	Ambystoma gracile	Salamander	Cadmium	4.7	MG/KG	1	Growth	LOED	Absorption
URS181	1978	Marshall, J.S.	J. Fish. Res. Bd. Can. 35:461-469.	Daphnia galeata mendotae	Cladoceran	Cadmium	5.7	MG/KG	4	Mortality	NA	Absorption
URS181	1978	Marshall, J.S.	J. Fish. Res. Bd. Can. 35:461-469.	Daphnia galeata mendotae	Cladoceran	Cadmium	5.7	MG/KG	4	Growth	NOED	Absorption
URS224	1977	Vernberg, W.B., Decoursey, P.J., Kelly, M., Johns, D.M.	Bull. Environ. Contam. Toxicol. 17: 16-24	Palaemonetes pugio	Shrimp - Grass	Cadmium	5.8	MG/KG	1	Mortality	NA	Absorption
SEQ97-34	1978	Spehar, R.L., Leonard, E.N., Defoe, D.L.	Tans. Am. Fish. Soc., 107(2): 354-360 (1978)	Jordanella floridae	American flagfish	Cadmium	6	MG/KG	1	Growth	NOED	Combined
SEQ97-34	1978	Spehar, R.L., Leonard, E.N., Defoe, D.L.	Tans. Am. Fish. Soc., 107(2): 354-360 (1978)	Jordanella floridae	American flagfish	Cadmium	6	MG/KG	1	Reproduction	NOED	Combined
SEQ97-44	1983	Sundelin, B.	Marine Biology 74, 203-212 (1983)	Monoporeia affinis	Amphipod	Cadmium	6	MG/KG	1	Reproduction	LOED	Combined
SEQ97-44	1983	Sundelin, B.	Marine Biology 74, 203-212 (1983)	Monoporeia affinis	Amphipod	Cadmium	6	MG/KG	1	Mortality	NOED	Combined
THD1	1995	Nebeker, AV, et.al.	Arch. Environ. Contam Toxicol 29: 492-503	Ambystoma gracile	Salamander	Cadmium	6.28	MG/KG	1	Growth	LOED	Absorption
SEQ97-6	1986	Pascoe, D., S.A. Evans, and J. Woodworth	Arch. Environ. Contam. Toxicol. 15, 481-487 (1986)	Oncorhynchus mykiss	Trout - Rainbow	Cadmium	6.4	MG/KG	1	Mortality	ED50	Combined
SEQ98-19	1996	Rule, J.H., and R.W. Alden III	Environmental Toxicology and Chemistry, Vol. 15, No. 4, pp. 466-471. 1996	Mytilus edulis	Mussel	Cadmium	6.45	MG/KG	6	Mortality	NOED	Combined
URS224	1977	Vernberg, W.B., Decoursey, P.J., Kelly, M., Johns, D.M.	Bull. Environ. Contam. Toxicol. 17: 16-24	Palaemonetes pugio	Shrimp - Grass	Cadmium	7	MG/KG	1	Mortality	NA	Absorption
URS108	1981	Hatakeyama, S. and M. Yasuno	Ecotoxicol. Environ. Saftey 5:341-350.	Moina macrocopa	Cladoceran	Cadmium	8	MG/KG	4	Reproduction	NOED	Ingestion
URS107	1982	Hatakeyama, S. and M. Yasuno	Bull. Environ. Contam. Toxicol. 29:159-166.	Poecilia reticulata	Guppy	Cadmium	8	MG/KG	2	Mortality	ED50	Absorption
URS223	1991	Velduizen-Tsoerkan, M.B., Holwerda, D.A., Zandee, D.I.	Arch. Environ. Contam. Toxicol. 20: 259-265	Mytilus edulis	Mussel	Cadmium	8.06	MG/KG	20	Mortality	NA	Absorption

Appendix 5.2 Cadmium

Ref_ID	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS133	Whole Body	NA	Cape Cod to Cape Hatteras; burrows in soft substrata	Predator on small invertebrates	No Effect On Reproduction
THD1	Whole Body	Larval	Ponds, marshes of northwestern US	Principal food is tadpoles; also eats other small aquatic invertebrates	Significant Reduction In Both Length And Weight
URS181	Whole Body	Population	In lakes of northern part of continent, especially glaciated regions	Feeds on algae and similar organisms	Reduced Longevity, Increased Prenatal Mortality
URS181	Whole Body	Population	In lakes of northern part of continent, especially glaciated regions	Feeds on algae and similar organisms	No Effect On Individual Weight
URS224	Whole Body	NA	Nova Scotia south to Corpus Christi, TX; estuaries on beds of submerged vegetation	Detritus with associated bacteria, diatoms	22% Increased Mortality Over Control In 5 Ppt Water; No Statistical Analysis
SEQ97-34	Whole Body	Immature	Peninsular Florida north to St. Johns and Ochlockonee River drainages; in vegetated sloughs, lakes, sluggish streams	Feeds on detritus, small invertebrates	Body Burden Est. From Graph
SEQ97-34	Whole Body	Immature	Peninsular Florida north to St. Johns and Ochlockonee River drainages; in vegetated sloughs, lakes, sluggish streams	Feeds on detritus, small invertebrates	Body Burden Est. From Graph
SEQ97-44	Whole Body	Adult	Holarctic, coastal marine, mainly brackish lakes and estuaries, marine-glacial relict lakes	Detritivore	Percent Malformed Eggs
SEQ97-44	Whole Body	Adult	Holarctic, coastal marine, mainly brackish lakes and estuaries, marine-glacial relict lakes	Detritivore	
THD1	Whole Body	Larval	Ponds, marshes of northwestern US	Principal food is tadpoles; also eats other small aquatic invertebrates	Significant Reduction In Both Length And Weight
SEQ97-6	Whole Body	Adult	Cool streams	Carnivore-juv fish, inverts	Hardness: 279 Mg/l Caco3
SEQ98-19	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Estimated Wet Weight
URS224	Whole Body	NA	Nova Scotia south to Corpus Christi, TX; estuaries on beds of submerged vegetation	Detritus with associated bacteria, diatoms	25% Increased Mortality Over Control In 5 Ppt Water; No Statistical Analysis
URS108	Whole Body	Larval	Not Specified	Not Specified	No Effect On Brood Size
URS107	Whole Body	Immature	Native to West Indies, n. South America; est. in AB, AZ, ID, NV, TX, WY, possibly CA; generally uncommon	Feeds on detritus, small invertebrates	50% Reduction In Survival
URS223	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Decreased Anoxic Survival Time (control 10.7 Days)

Appendix 5.2 Cadmium

Ref_ID	Year	Author	Journal	Species	Common Name	Chem	Conc Wet	Conc Uni	Reps	Effect	Endpoin	Exposure
URS223	1991	Velduizen-Tsoerkan, M.B., Holwerda, D.A., Zandee, D.I.	Arch. Environ. Contam. Toxicol. 20: 259-265	Mytilus edulis	Mussel	Cadmium	8.06	MG/KG	20	Mortality	NA	Absorption
URS223	1991	Velduizen-Tsoerkan, M.B., Holwerda, D.A., Zandee, D.I.	Arch. Environ. Contam. Toxicol. 20: 259-265	Mytilus edulis	Mussel	Cadmium	8.06	MG/KG	20	Physiological	NOED	Absorption
URS181	1978	Marshall, J.S.	J. Fish. Res. Bd. Can. 35:461-469.	Daphnia galeata mendotae	Cladoceran	Cadmium	8.6	MG/KG	4	Mortality	NA	Absorption
URS181	1978	Marshall, J.S.	J. Fish. Res. Bd. Can. 35:461-469.	Daphnia galeata mendotae	Cladoceran	Cadmium	8.6	MG/KG	4	Growth	NOED	Absorption
URS73	1982	Dressing, S.A., R.P. Maas and C.M. Weiss	Bull. Environ. Contam. Toxicol. 28:172-180.	Hydropsyche sp.	Caddisfly	Cadmium	9.8	MG/KG	1	Mortality	LOED	Absorption
SEQ97-33	1976	Spehar, R.L.	J. Fish. Res. Board Can., Vol. 33 (1976)	Jordanella floridae	American flagfish	Cadmium	10	MG/KG	1	Growth	NOED	Combined
SEQ97-39	1984	Sundelin, B.	Ecotoxicological Testing for the Marine Environment, Vol. 2, 588 P, 1984	Monoporeia affinis	Amphipod	Cadmium	10	MG/KG	3	Mortality	NOED	Combined
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	10	MG/KG	1	Growth	NOED	Absorption
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	10	MG/KG	1	Mortality	NOED	Absorption
URS241	1973	Cearley, J.E. and R.L. Coleman	Bull. Environ. Contam. Toxicol. 9:100-101.	Najas quadulepensis	Southern Naiad	Cadmium	10.3	MG/KG	2	Development	LOED	Absorption
URS181	1978	Marshall, J.S.	J. Fish. Res. Bd. Can. 35:461-469.	Daphnia galeata mendotae	Cladoceran	Cadmium	10.3	MG/KG	4	Growth	LOED	Absorption
URS181	1978	Marshall, J.S.	J. Fish. Res. Bd. Can. 35:461-469.	Daphnia galeata mendotae	Cladoceran	Cadmium	10.3	MG/KG	4	Mortality	NA	Absorption
URS108	1981	Hatakeyama, S. and M. Yasuno	Ecotoxicol. Environ. Saftey 5:341-350.	Moina macrocopa	Cladoceran	Cadmium	10.6	MG/KG	4	Reproduction	LOED	Ingestion
URS108	1981	Hatakeyama, S. and M. Yasuno	Ecotoxicol. Environ. Saftey 5:341-350.	Moina macrocopa	Cladoceran	Cadmium	10.6	MG/KG	4	Mortality	NOED	Ingestion
SEQ97-44	1983	Sundelin, B.	Marine Biology 74, 203-212 (1983)	Monoporeia affinis	Amphipod	Cadmium	11	MG/KG	1	Mortality	LOED	Combined
URS209	1979	Thorp, J.H., Giesy, J.P., Wineriter, S.A.	Arch. Environm. Contam. Toxicol. 8: 449-456	Cambarus latimanus	Crayfish	Cadmium	14.9	MG/KG	46	Growth	NOED	Combined
URS209	1979	Thorp, J.H., Giesy, J.P., Wineriter, S.A.	Arch. Environm. Contam. Toxicol. 8: 449-456	Cambarus latimanus	Crayfish	Cadmium	14.9	MG/KG	46	Mortality	NOED	Combined
URS209	1979	Thorp, J.H., Giesy, J.P., Wineriter, S.A.	Arch. Environm. Contam. Toxicol. 8: 449-456	Cambarus latimanus	Crayfish	Cadmium	14.9	MG/KG	46	Physiological	NOED	Combined

Appendix 5.2 Cadmium

Ref_ID	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS223	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Decreased Anoxic Survival Time (control 10.7 Days)
URS223	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	No Significant Changes In Adenylate Energy Charge Or Glycogen Content
URS181	Whole Body	Population	In lakes of northern part of continent, especially glaciated regions	Feeds on algae and similar organisms	Reduced Longevity, Increased Prenatal Mortality
URS181	Whole Body	Population	In lakes of northern part of continent, especially glaciated regions	Feeds on algae and similar organisms	No Effect On Individual Weight
URS73	Whole Body	Larval	Burrow in streams, rivers, sometimes along shores of lakes with moderate current, considerable wave action	Larvae construct drift nets near burrow, filter flowing water for small animals, detritus	Mortality In One Day
SEQ97-33	Whole Body	Immature	Peninsular Florida north to St. Johns and Ochlockonee River drainages; in vegetated sloughs, lakes, sluggish streams	Feeds on detritus, small invertebrates	Total Length Of Females
SEQ97-39	Whole Body	Adult	Holarctic, coastal marine, mainly brackish lakes and estuaries, marine-glacial relict lakes	Detritivore	Body Burden Est. From Graph
URS114	Whole Body	Larval	Not Specified	Not Specified	No Effect On Biomass
URS114	Whole Body	Larval	Not Specified	Not Specified	No Effect On Mortality In 96 Hours
URS241	Whole Body	Adult	Not Specified	Not Specified	Reductions In Chlorophyll And Stolon Development
URS181	Whole Body	Population	In lakes of northern part of continent, especially glaciated regions	Feeds on algae and similar organisms	Increased Weight Of Individual Animals
URS181	Whole Body	Population	In lakes of northern part of continent, especially glaciated regions	Feeds on algae and similar organisms	Reduced Longevity, Increased Prenatal Mortality
URS108	Whole Body	Larval	Not Specified	Not Specified	Reduced Brood Size
URS108	Whole Body	Larval	Not Specified	Not Specified	No Effect On Survival
SEQ97-44	Whole Body	Adult	Holarctic, coastal marine, mainly brackish lakes and estuaries, marine-glacial relict lakes	Detritivore	
URS209	Whole Body	Adult	Streams, lakes, swamps, North Carolina to Florida	Feeds on both plant and animal material	No Significant Difference From Control Growth At Lowest Test Concentration
URS209	Whole Body	Adult	Streams, lakes, swamps, North Carolina to Florida	Feeds on both plant and animal material	No Significant Difference From Control Mortality
URS209	Whole Body	Adult	Streams, lakes, swamps, North Carolina to Florida	Feeds on both plant and animal material	No Significant Difference From Control Temperature Sensitivity At Lowest Test Concentration

Appendix 5.2 Cadmium

Ref_ID	Year	Author	Journal	Species	Common Name	Chem	Conc Wet	Conc Uni	Reps	Effect	Endpoin	Exposure
URS73	1982	Dressing, S.A., R.P. Maas and C.M. Weiss	Bull. Environ. Contam. Toxicol. 28:172-180.	Hydropsyche sp.	Caddisfly	Cadmium	16	MG/KG	1	Mortality	NOED	Absorption
URS13	1978	Beattie, J.H. and D. Pascoe	J. Fish. Biol. 13:631-637.	Oncorhynchus mykiss	Trout - Rainbow	Cadmium	16.4	MG/KG	3	Mortality	ED100	Absorption
URS108	1981	Hatakeyama, S. and M. Yasuno	Ecotoxicol. Environ. Saftey 5:341-350.	Moina macrocopa	Cladoceran	Cadmium	16.4	MG/KG	4	Reproduction	ED100	Ingestion
URS108	1981	Hatakeyama, S. and M. Yasuno	Ecotoxicol. Environ. Saftey 5:341-350.	Moina macrocopa	Cladoceran	Cadmium	16.4	MG/KG	4	Growth	LOED	Ingestion
URS108	1981	Hatakeyama, S. and M. Yasuno	Ecotoxicol. Environ. Saftey 5:341-350.	Moina macrocopa	Cladoceran	Cadmium	16.4	MG/KG	4	Mortality	LOED	Ingestion
URS73	1982	Dressing, S.A., R.P. Maas and C.M. Weiss	Bull. Environ. Contam. Toxicol. 28:172-180.	Hydropsyche sp.	Caddisfly	Cadmium	17.4	MG/KG	1	Mortality	LOED	Absorption
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	18	MG/KG	1	Growth	NOED	Absorption
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	18	MG/KG	1	Mortality	NOED	Absorption
URS240	1981	Zaroogian, G.E., Morrison, G.	Bull. Environm. Contam. Toxicol. 27: 344-348	Crassostrea virginica	Oyster	Cadmium	18.2	MG/KG	1	Reproduction	NOED	Absorption
SEQ97-33	1976	Spehar, R.L.	J. Fish. Res. Board Can., Vol. 33 (1976)	Jordanella floridae	American flagfish	Cadmium	20	MG/KG	1	Growth	LOED	Combined
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	20	MG/KG	1	Growth	LOED	Absorption
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	20	MG/KG	1	Mortality	NOED	Absorption
URS209	1979	Thorp, J.H., Giesy, J.P., Wineriter, S.A.	Arch. Environm. Contam. Toxicol. 8: 449-456	Cambarus latimanus	Crayfish	Cadmium	22	MG/KG	39	Mortality	LOED	Combined
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	23	MG/KG	7	NA	NOED	Ingestion
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	23	MG/KG	10	NA	NOED	Ingestion
URS73	1982	Dressing, S.A., R.P. Maas and C.M. Weiss	Bull. Environ. Contam. Toxicol. 28:172-180.	Hydropsyche sp.	Caddisfly	Cadmium	24.8	MG/KG	1	Mortality	NOED	Absorption
URS73	1982	Dressing, S.A., R.P. Maas and C.M. Weiss	Bull. Environ. Contam. Toxicol. 28:172-180.	Hydropsyche sp.	Caddisfly	Cadmium	29.8	MG/KG	1	Mortality	LOED	Absorption

Appendix 5.2 Cadmium

Ref_ID	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS73	Whole Body	Larval	Burrow in streams, rivers, sometimes along shores of lakes with moderate current, considerable wave action	Larvae construct drift nets near burrow, filter flowing water for small animals, detritus	No Effect On Mortality In One Day
URS13	Whole Body	Larval	Cool streams	Carnivore-juv fish, inverts	Complete Mortality Of Alevins Within 10 Hours
URS108	Whole Body	Larval	Not Specified	Not Specified	No Reproduction After 12 Days
URS108	Whole Body	Larval	Not Specified	Not Specified	Reduced Growth
URS108	Whole Body	Larval	Not Specified	Not Specified	Reduced Survival
URS73	Whole Body	Larval	Burrow in streams, rivers, sometimes along shores of lakes with moderate current, considerable wave action	Larvae construct drift nets near burrow, filter flowing water for small animals, detritus	Mortality In Two Days
URS114	Whole Body	Larval	Not Specified	Not Specified	No Effect On Biomass
URS114	Whole Body	Larval	Not Specified	Not Specified	No Effect On Mortality In 96 Hours
URS240	Whole Body	Adult	Intertidal flats to depth of 40 ft.	Filter phytoplankton, zooplankton, detritus	No Reduced Viability Of Gametes After Exposure Of Adults In 21 Ppt Seawater
SEQ97-33	Whole Body	Immature	Peninsular Florida north to St. Johns and Ochlockonee River drainages; in vegetated sloughs, lakes, sluggish streams	Feeds on detritus, small invertebrates	Total Length Of Females
URS114	Whole Body	Larval	Not Specified	Not Specified	Reduced Biomass
URS114	Whole Body	Larval	Not Specified	Not Specified	No Effect On Mortality In 96 Hours
URS209	Whole Body	Adult	Streams, lakes, swamps, North Carolina to Florida	Feeds on both plant and animal material	Significantly Greater Mortality Than In Control
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Tap Water
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Tap Water With 0.5 um EDTA
URS73	Whole Body	Larval	Burrow in streams, rivers, sometimes along shores of lakes with moderate current, considerable wave action	Larvae construct drift nets near burrow, filter flowing water for small animals, detritus	No Effect On Mortality In One Day
URS73	Whole Body	Larval	Burrow in streams, rivers, sometimes along shores of lakes with moderate current, considerable wave action	Larvae construct drift nets near burrow, filter flowing water for small animals, detritus	Mortality In Four Days

Appendix 5.2 Cadmium

Ref_ID	Year	Author	Journal	Species	Common Name	Chem	Conc Wet	Conc Uni	Reps	Effect	Endpoin	Exposure
SEQ97-13	1982	Poulsen, E., H.U. Riisgard, and F. Mohlenberg	Marine Biology 68, 25-29 (1982)	Mytilus edulis	Mussel	Cadmium	30	MG/KG	20	Growth	NOED	Combined
SEQ97-13	1982	Poulsen, E., H.U. Riisgard, and F. Mohlenberg	Marine Biology 68, 25-29 (1982)	Mytilus edulis	Mussel	Cadmium	30	MG/KG	20	Mortality	NOED	Combined
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	30	MG/KG	1	Growth	NA	Absorption
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	30	MG/KG	1	Mortality	NOED	Absorption
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	30	MG/KG	7	NA	LOED	Ingestion
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	32	MG/KG	10	NA	NOED	Ingestion
SEQ97-33	1976	Spehar, R.L.	J. Fish. Res. Board Can., Vol. 33 (1976)	Jordanella floridae	American flagfish	Cadmium	35	MG/KG	1	Mortality	NOED	Combined
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	38	MG/KG	4	Mortality	ED50	Ingestion
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	39	MG/KG	10	NA	LOED	Ingestion
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	39	MG/KG	10	NA	LOED	Ingestion
URS73	1982	Dressing, S.A., R.P. Maas and C.M. Weiss	Bull. Environ. Contam. Toxicol. 28:172-180.	Hydropsyche sp.	Caddisfly	Cadmium	41.8	MG/KG	1	Mortality	NOED	Absorption
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	42	MG/KG	10	NA	NOED	Ingestion
THD1	1995	Nebeker, AV, et.al.	Arch. Environ. Contam Toxicol 29: 492-503	Ambystoma gracile	Salamander	Cadmium	43.5	MG/KG	1	Growth	NOED	Ingestion
THD1	1995	Nebeker, AV, et.al.	Arch. Environ. Contam Toxicol 29: 492-503	Ambystoma gracile	Salamander	Cadmium	43.5	MG/KG	1	Mortality	NOED	Ingestion
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	44	MG/KG	4	Mortality	ED50	Ingestion

Ref_ID	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
SEQ97-13	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	
SEQ97-13	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Highest Body Burden Reported
URS114	Whole Body	Larval	Not Specified	Not Specified	Reduced Biomass
URS114	Whole Body	Larval	Not Specified	Not Specified	No Effect On Mortality In 96 Hours
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Tap Water
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Tap Water With 20mg/l Humic Acid
SEQ97-33	Whole Body	Immature	Peninsular Florida north to St. Johns and Ochlockonee River drainages; in vegetated sloughs, lakes, sluggish streams	Feeds on detritus, small invertebrates	
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Tap Water
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Tap Water With 20mg/l Humic Acid
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Tap Water With 0.5 um EDTA
URS73	Whole Body	Larval	Burrow in streams, rivers, sometimes along shores of lakes with moderate current, considerable wave action	Larvae construct drift nets near burrow, filter flowing water for small animals, detritus	No Effect On Mortality In One Day
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Med:90% Distilled Water
THD1	Whole Body	Larval	Ponds, marshes of northwestern US	Principal food is tadpoles; also eats other small aquatic invertebrates	No Significant Reduction In Length Or Weight At Highest Test Concentration
THD1	Whole Body	Larval	Ponds, marshes of northwestern US	Principal food is tadpoles; also eats other small aquatic invertebrates	No Significant Increase In Mortality At Highest Test Concentration
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Tap Water With 20mg/l Humic Acid

Appendix 5.2 Cadmium

Ref_ID	Year	Author	Journal	Species	Common Name	Chem	Conc Wet	Conc Uni	Reps	Effect	Endpoin	Exposure
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	44	MG/KG	4	Mortality	ED50	Ingestion
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	47	MG/KG	4	NA	NOED	Ingestion
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	50	MG/KG	1	Growth	NA	Absorption
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	50	MG/KG	1	Mortality	NOED	Absorption
URS240	1981	Zaroogian, G.E., Morrison, G.	Bull. Environm. Contam. Toxicol. 27: 344-348	Crassostrea virginica	Oyster	Cadmium	54	MG/KG	1	Reproduction	NOED	Absorption
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	62	MG/KG	4	NA	NOED	Ingestion
URS133	1988	Jenkins, K.D. and A.Z. Mason	Aquat. Toxicol. 12:229-244.	Nereis arenaceodentata	Polychaete	Cadmium	67	MG/KG	1	Reproduction	ED100	Absorption
URS133	1988	Jenkins, K.D. and A.Z. Mason	Aquat. Toxicol. 12:229-244.	Nereis arenaceodentata	Polychaete	Cadmium	67	MG/KG	1	Mortality	NOED	Absorption
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	72	MG/KG	1	Growth	NA	Absorption
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	72	MG/KG	1	Mortality	NOED	Absorption
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	76	MG/KG	10	NA	LOED	Ingestion
URS242	1982	Carr, R.S. and J.M. Neff	Aquat. Toxicol. 2:319-333.	Nereis virens	Polychaete - Sandworm	Cadmium	78	MG/KG	1	Physiological	LOED	Absorption
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	79	MG/KG	4	Mortality	ED50	Ingestion
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	86	MG/KG	4	Mortality	ED50	Ingestion
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	87	MG/KG	4	NA	LOED	Ingestion
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	98	MG/KG	4	Mortality	ED50	Ingestion

Appendix 5.2 Cadmium

Ref_ID	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Tap Water With 0.5 um EDTA
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Sediment A
URS114	Whole Body	Larval	Not Specified	Not Specified	Reduced Biomass
URS114	Whole Body	Larval	Not Specified	Not Specified	No Effect On Mortality In 96 Hours
URS240	Whole Body	Adult	Intertidal flats to depth of 40 ft.	Filter phytoplankton, zooplankton, detritus	24% Reduction In Viability Of Gametes After Exposure Of Adults In 21 Ppt Seawater
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Sediment B
URS133	Whole Body	NA	Cape Cod to Cape Hatteras; burrows in soft substrata	Predator on small invertebrates	Reproductive Failure
URS133	Whole Body	NA	Cape Cod to Cape Hatteras; burrows in soft substrata	Predator on small invertebrates	No Effect On Survival
URS114	Whole Body	Larval	Not Specified	Not Specified	Reduced Biomass
URS114	Whole Body	Larval	Not Specified	Not Specified	No Effect On Mortality In 96 Hours
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Med:90% Distilled Water
URS242	Whole Body	Adult	Labrador to southern New England; northern coasts of Europe and Great Britain; intertidal to subtidal; under rocks, in burrows	Feeds on worms and other small invertebrates	Total Glycogen Reduced, Increase In Ascorbic Acid
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Med:90% Distilled Water
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Sediment A
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Sediment A
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Sediment B

Appendix 5.2 Cadmium

Ref_ID	Year	Author	Journal	Species	Common Name	Chem	Conc Wet	Conc Uni	Reps	Effect	Endpoin	Exposure
URS13	1978	Beattie, J.H. and D. Pascoe	J. Fish. Biol. 13:631-637.	Oncorhynchus mykiss	Trout - Rainbow	Cadmium	101	MG/KG	3	Mortality	ED100	Absorption
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	138	MG/KG	1	Growth	NA	Absorption
URS114	1990	Heinis, F., Timmermans, K.R., and W.R. Swain	Aquat. Toxicol. 16:73-86.	Glyptotendipes pallens	Midge	Cadmium	138	MG/KG	1	Mortality	NOED	Absorption
JB9	1987	Hamilton, S.J., Mehrle, P.M., and J.R. Jones	Trans. Am. Fish. Soc. 116: 551-560	Salvelinus fontinalis	Trout - Brook	Cadmium	144	MG/KG	2	Mortality	LOED	Absorption
JB9	1987	Hamilton, S.J., Mehrle, P.M., and J.R. Jones	Trans. Am. Fish. Soc. 116: 551-560	Salvelinus fontinalis	Trout - Brook	Cadmium	144	MG/KG	2	Physiological	LOED	Absorption
THD1	1995	Nebeker, AV, et.al.	Arch. Environ. Contam Toxicol 29: 492-503	Ambystoma gracile	Salamander	Cadmium	145	MG/KG	3	Growth	NOED	Ingestion
THD1	1995	Nebeker, AV, et.al.	Arch. Environ. Contam Toxicol 29: 492-503	Ambystoma gracile	Salamander	Cadmium	145	MG/KG	3	Mortality	NOED	Ingestion
JB15	1991	Borgmann, U., Norwood, W.P., and I.M. Babirad	Can. J. Fish. Aquat. Sci. 48:1055-1060	Hyalella azteca	Amphipod - Freshwater	Cadmium	148	MG/KG	4	NA	LOED	Ingestion
URS17	1991	Enserink, E.L., J.L. Maas-Diepeveen and C.J. Van Leeuwen	Water Res. 25:679-687.	Daphnia magna	Water flea	Cadmium	221	MG/KG	4	Mortality	ED50	Absorption
URS242	1982	Carr, R.S. and J.M. Neff	Aquat. Toxicol. 2:319-333.	Nereis virens	Polychaete - Sandworm	Cadmium	290	MG/KG	1	Physiological	LOED	Absorption
URS53	1991	Carlson, A.R., G.L. Phipps, V.R. Mattson, P.A. Kosian and A.M. Cotter	Environ. Toxicol. Chem. 10:1309-1319.	Helisoma sp.	Snail	Cadmium	300	MG/KG	2	Mortality	NOED	Absorption
URS53	1991	Carlson, A.R., G.L. Phipps, V.R. Mattson, P.A. Kosian and A.M. Cotter	Environ. Toxicol. Chem. 10:1309-1319.	Lumbriculus variegatus	Oligochaete	Cadmium	310	MG/KG	2	Mortality	NOED	Absorption
URS53	1991	Carlson, A.R., G.L. Phipps, V.R. Mattson, P.A. Kosian and A.M. Cotter	Environ. Toxicol. Chem. 10:1309-1319.	Helisoma sp.	Snail	Cadmium	460	MG/KG	2	Mortality	NOED	Absorption
URS89	1977	Gillespie, R., T. Reisine and E.J. Massaro	Environ. Res. 13:364-368.	Orconectes propinquus	Crayfish	Cadmium	534	MG/KG	5	Mortality	NOED	Absorption

Ref_ID	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS13	Whole Body	Egg-embryo	Cool streams	Carnivore-juv fish, inverts	Complete Mortality Of Eggs Within 32 Hours
URS114	Whole Body	Larval	Not Specified	Not Specified	Reduced Biomass
URS114	Whole Body	Larval	Not Specified	Not Specified	No Effect On Mortality In 96 Hours
JB9	Whole Body	Immature	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	Significantly Reduced Survival At Lowest Test Concentration, Exp_conc = <3.6
JB9	Whole Body	Immature	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	Significantly Increased Metallothionein In Whloe Body Tissues At Lowest Test Concentration; No Correlation Between Metallothionein Concentration And Mortality Or Whole Body Tissue Residuesexp_conc<3.6
THD1	Whole Body	Immature	Ponds, marshes of northwestern US	Principal food is tadpoles; also eats other small aquatic invertebrates	No Significant Reduction In Length Or Weight At Highest Test Concentration
THD1	Whole Body	Immature	Ponds, marshes of northwestern US	Principal food is tadpoles; also eats other small aquatic invertebrates	No Significant Increase In Mortality At Highest Test Concentration
JB15	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Sediment B
URS17	Whole Body	Immature	Southwestern to south-central Canada, Northwestern to north-central US; ponds, small lakes, clear and weedy waters	Feeds on algae and similar organisms	Lethal Body Burden After 21 Day Exposure
URS242	Whole Body	Adult	Labrador to southern New England; northern coasts of Europe and Great Britain; intertidal to subtidal; under rocks, in burrows	Feeds on worms and other small invertebrates	Increase In Ascorbic Acid Content
URS53	Whole Body	Adult	Not Specified	Not Specified	No Effect On Mortality
URS53	Whole Body	Adult	Most of North America, Europe; Ponds, lakes, on top of mud	Feeds on small animals in substrata	No Effect On Mortality
URS53	Whole Body	Adult	Not Specified	Not Specified	No Effect On Mortality
URS89	Whole Body	NA	Not Specified	Not Specified	7% Mortality After 190.5 Hours, Probably Not Significant

Appendix 5.2 Cadmium

Ref_ID	Year	Author	Journal	Species	Common Name	Chem	Conc Wet	Conc Uni	Reps	Effect	Endpoin	Exposure
URS53	1991	Carlson, A.R., G.L. Phipps, V.R. Mattson, P.A. Kosian and A.M. Cotter	Environ. Toxicol. Chem. 10:1309-1319.	Helisoma sp.	Snail	Cadmium	625	MG/KG	2	Mortality	ED50	Absorption
URS47	1980	Cain, J.R., D.C. Paschal and C.M. Hayden	Arch. Environ. Contam. Toxicol. 9:9-16.	Scenedesmus obliquus	Algae - Freshwater Colonial Green	Cadmium	658	MG/KG	2	Growth	LOED	Absorption
URS53	1991	Carlson, A.R., G.L. Phipps, V.R. Mattson, P.A. Kosian and A.M. Cotter	Environ. Toxicol. Chem. 10:1309-1319.	Lumbriculus variegatus	Oligochaete	Cadmium	670	MG/KG	2	Mortality	LOED	Absorption
URS47	1980	Cain, J.R., D.C. Paschal and C.M. Hayden	Arch. Environ. Contam. Toxicol. 9:9-16.	Scenedesmus obliquus	Algae - Freshwater Colonial Green	Cadmium	2340	MG/KG	2	Growth	LOED	Absorption
URS47	1980	Cain, J.R., D.C. Paschal and C.M. Hayden	Arch. Environ. Contam. Toxicol. 9:9-16.	Scenedesmus obliquus	Algae - Freshwater Colonial Green	Cadmium	3030	MG/KG	2	Growth	NOED	Absorption

Appendix 5.2 Cadmium

Ref_ID	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS53	Whole Body	Adult	Not Specified	Not Specified	50% Mortality
URS47	Whole Body	Cell	Not Specified	Not Specified	39% Reduction In Population Growth From Controls
URS53	Whole Body	Adult	Most of North America, Europe; Ponds, lakes, on top of mud	Feeds on small animals in substrata	40% Mortality
URS47	Whole Body	Cell	Not Specified	Not Specified	Significant Inhibition Of Growth (27% Reduction From Control)
URS47	Whole Body	Cell	Not Specified	Not Specified	No Significant Inhibition Of Growth

Ref_ID	Year	Author	Journal	Species	Species Name	Chem	Conc_V	Conc_U
URS42	1977	Buhler, D.R., R.M. Stokes and R.S. Caldwell	J. Fish. Res. Bd. Can. 34:9-18.	Oncorhynchus mykiss	Trout - Rainbow	Chromium	0.18	MG/KG
URS42	1977	Buhler, D.R., R.M. Stokes and R.S. Caldwell	J. Fish. Res. Bd. Can. 34:9-18.	Oncorhynchus mykiss	Trout - Rainbow	Chromium	0.87	MG/KG
SEQ97-14	1989	Poulton, B.C., T.L. Beitinger, and K.W. Stewart	Arch. Environ. Contam. Toxicol. 18, 594-600 (1989)	Clioperla clio	Stonefly	Chromium	1.44	MG/KG
SEQ97-14	1989	Poulton, B.C., T.L. Beitinger, and K.W. Stewart	Arch. Environ. Contam. Toxicol. 18, 594-600 (1989)	Clioperla clio	Stonefly	Chromium	1.67	MG/KG
SEQ97-14	1989	Poulton, B.C., T.L. Beitinger, and K.W. Stewart	Arch. Environ. Contam. Toxicol. 18, 594-600 (1989)	Clioperla clio	Stonefly	Chromium	1.84	MG/KG
URS215	1981	Van De Putte, L., Lubbers, J., Kolar, Z.	Aquatic Toxicol. 1: 3-18	Oncorhynchus mykiss	Trout - Rainbow	Chromium VI	2.3	MG/KG
URS215	1981	Van De Putte, L., Lubbers, J., Kolar, Z.	Aquatic Toxicol. 1: 3-18	Oncorhynchus mykiss	Trout - Rainbow	Chromium VI	5.5	MG/KG
URS215	1981	Van De Putte, L., Lubbers, J., Kolar, Z.	Aquatic Toxicol. 1: 3-18	Oncorhynchus mykiss	Trout - Rainbow	Chromium VI	8.7	MG/KG
URS215	1981	Van De Putte, L., Lubbers, J., Kolar, Z.	Aquatic Toxicol. 1: 3-18	Oncorhynchus mykiss	Trout - Rainbow	Chromium VI	8.9	MG/KG
URS215	1981	Van De Putte, L., Lubbers, J., Kolar, Z.	Aquatic Toxicol. 1: 3-18	Oncorhynchus mykiss	Trout - Rainbow	Chromium VI	10.5	MG/KG
URS17	1991	Enserink, E.L., J.L. Maas-Diepeveen and C.J. Van Leeuwen	Water Res. 25:679-687.	Daphnia magna	Water flea	Chromium	55	MG/KG

Ref_ID	Reps	Effect	Endpoint	Exposure	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS42	6	Physiological	NOED	Absorption	Whole Body	Adult	Cool streams	Carnivore-juv fish, inverts	No Reduction In Enzyme Activity
URS42	6	Physiological	ED50	Absorption	Whole Body	Adult	Cool streams	Carnivore-juv fish, inverts	Reduced Kidney Nadh-cytochrome C Reductase Activity
SEQ97-14	3	Mortality	ED10	Combined	Whole Body	Immature	Not Specified	Not Specified	
SEQ97-14	3	Mortality	ED30	Combined	Whole Body	Immature	Not Specified	Not Specified	
SEQ97-14	3	Mortality	ED50	Combined	Whole Body	Immature	Not Specified	Not Specified	
URS215	1	Mortality	NOED	Absorption	Whole Body	Immature	Cool streams	Carnivore-juv fish, inverts	Ph 7.8; No Increased Mortality Relative To Control
URS215	1	Mortality	NOED	Absorption	Whole Body	Immature	Cool streams	Carnivore-juv fish, inverts	Ph 6.5; No Increased Mortality Relative To Control
URS215	1	Mortality	ED75	Absorption	Whole Body	Immature	Cool streams	Carnivore-juv fish, inverts	Ph 6.5; Increased Mortality Relative To Control
URS215	1	Mortality	NA	Absorption	Whole Body	Immature	Cool streams	Carnivore-juv fish, inverts	Ph 7.8; Increased Mortality Relative To Control
URS215	1	Mortality	ED50	Absorption	Whole Body	Immature	Cool streams	Carnivore-juv fish, inverts	Ph 7.8; Increased Mortality Relative To Control
URS17	4	Mortality	ED50	Absorption	Whole Body	Immature	Southwestern to south-central Canada, Northwestern to north-central US; ponds, small lakes, clear and weedy waters	Feeds on algae and similar organisms	Lethal Body Burden After 21 Day Exposure

Ref_ID	Year	Author	Journal	Species	Species Name	ChemCon	Conc_Wet	Conc_Ur	Reps	Effect
URS23	1981	Dixon, D.G. and J.B. Sprague	Aquat. Toxicol. 1:69-81.	Oncorhynchus mykiss	Trout - Rainbow	Copper	1.6	MG/KG	10	Mortality
URS79	1980	Evans, M.L.	Bull. Environ. Contam. Toxicol. 24:916-920.	Orconectes rusticus	Crayfish	Copper	2	MG/KG	3	Mortality
URS99	1992	Handy, R.D.	Arch. Environ. Contam. Toxicol. 22:74-81.	Oncorhynchus mykiss	Trout - Rainbow	Copper	2.22	MG/KG	7	Mortality
URS149	1987	Kosalwat, P. and A.W. Knight	Arch. Environ. Contam. Toxicol. 16:283-290.	Chironomus decorus	Midge	Copper	2.28	MG/KG	3	Development
URS150	1993	Kraak, M.H.S., M. Toussaint, E.A.J. Bleeker and D. Lavy	p. 175 - 186 in Dallinger, R. et.al. Ecotoxicology of Metals in Invertebrates	Dreissena polymorpha	Mussel - Zebra	Copper	2.7	MG/KG	2	Physiological
URS77	1979	Engel, D.W. and W.G. Sunda	Mar. Biol. 50:121-126.	Leiostomus xanthurus	Spot	Copper	3	MG/KG	4	Reproduction
ABB2	1994	Mount, D.R., A.K. Barth, T.D.Garrison, K.A. Barten, and J.R. Hockett	Environmental Toxicology and Chemistry 13(12):2031-2041	Oncorhynchus mykiss	Trout - Rainbow	Copper	3.92	MG/KG	3	NA
ABB2	1994	Mount, D.R., A.K. Barth, T.D.Garrison, K.A. Barten, and J.R. Hockett	Environmental Toxicology and Chemistry 13(12):2031-2041	Oncorhynchus mykiss	Trout - Rainbow	Copper	4.48	MG/KG	3	Survival
URS17	1991	Enserink, E.L., J.L. Maas-Diepeveen and C.J. Van Leeuwen	Water Res. 25:679-687.	Daphnia magna	Water flea	Copper	5.8	MG/KG	4	Reproduction
URS23	1981	Dixon, D.G. and J.B. Sprague	Aquat. Toxicol. 1:69-81.	Oncorhynchus mykiss	Trout - Rainbow	Copper	6.8	MG/KG	10	Physiological
JB17	1992	Timmermans, K.R. and F. Ollevier	Hydrobiologia 239: 141-149	Chironomus gr. thummi	Midge	Copper	7.14	MG/KG	9	Morphology
URS149	1987	Kosalwat, P. and A.W. Knight	Arch. Environ. Contam. Toxicol. 16:283-290.	Chironomus decorus	Midge	Copper	7.2	MG/KG	3	Development
SEQ97-38	1996	Stouthart, J.H.X., Haans, J.L.M., Lock, R.A.C., Bonga, S.E.W.	Environmental Toxicology and Chemistry, Vol. 15, No. 3, pp. 376-383 (1996)	Cyprinus carpio	Common carp	Copper	7.62	MG/KG	1	Morphology
SEQ97-38	1996	Stouthart, J.H.X., Haans, J.L.M., Lock, R.A.C., Bonga, S.E.W.	Environmental Toxicology and Chemistry, Vol. 15, No. 3, pp. 376-383 (1996)	Cyprinus carpio	Common carp	Copper	7.62	MG/KG	1	Mortality

Ref_ID	Endpoir	Exposure	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS23	ED100	Absorption	Whole Body	Immature	Cool streams	Carnivore-juv fish, inverts	100% Mortality In Non-metallothionein Induced Fish
URS79	NOED	Absorption	Whole Body	Adult	Alberta to Arizona eastward to eastern seaboard, except South Carolina to Florida; introduced Cal., Ore.; streams	Scavengers; dead and decaying matter, some live food like snails, worms, insect larvae, some plants	No Effect On Survivorship
URS99	LOED	Absorption	Whole Body	Adult	Cool streams	Carnivore-juv fish, inverts	50% Mortality In 7 Hours
URS149	NOED	Ingestion	Whole Body	Egg-embryo	Bottom dwelling in tubes in shallow ponds or lakes	Adults non-feeding; larvae utilize microorganisms small bits of detritus	No Effect On Time To Adult Emergence
URS150	NOED	Absorption	Whole Body	Adult	Introduced; spread to all Great Lakes, some rivers in Atlantic, Mississippi drainage basins; attaches to rocks, other hard surface	Filter feeder; phytoplankton, bacteria, fine detrital particles	No Effect On Internal Cu Regulatory Process
URS77	LOED	Absorption	Whole Body	Egg-embryo	Inshore waters Texas to southern New England	Small invertebrates, fish, detritus	Hatching Inhibited
ABB2	NOED	Combined	Whole Body	Immature	Cool streams	Carnivore-juv fish, inverts	
ABB2	LOED	Combined	Whole Body	Immature	Cool streams	Carnivore-juv fish, inverts	
URS17	ED10	Absorption	Whole Body	Immature	Southwestern to south-central Canada, Northwestern to north-central US; ponds, small lakes, clear and weedy waters	Feeds on algae and similar organisms	10% Reduction In Number Of Offspring
URS23	LOED	Absorption	Whole Body	Immature	Cool streams	Carnivore-juv fish, inverts	Induction Of Metallothionein
JB17	NOED	Combined	Whole Body	Egg-embryo	Not Specified	Not Specified	4th Instar Larvae
URS149	NOED	Ingestion	Whole Body	Egg-embryo	Bottom dwelling in tubes in shallow ponds or lakes	Adults non-feeding; larvae utilize microorganisms small bits of detritus	No Effect On Time To Adult Emergence
SEQ97-38	NOED	Combined	Whole Body	Egg	Warm lakes, ponds, streams	Omnivore-plants, detritus	Larval Deformation, Ph 7.6, Body Burd From Graph
SEQ97-38	NOED	Combined	Whole Body	Egg	Warm lakes, ponds, streams	Omnivore-plants, detritus	Larval Mort, Ph 7.6, Body Burd From Graph

Ref_ID	Year	Author	Journal	Species	Species Name	ChemCon	Conc_Wet	Conc_Ur	Reps	Effect
URS150	1993	Kraak, M.H.S., M. Toussaint, E.A.J. Bleeker and D. Lavy	p. 175 - 186 in Dallinger, R. et.al. Ecotoxicology of Metals in Invertebrates	Dreissena polymorpha	Mussel - Zebra	Copper	8.1	MG/KG	2	Physiological
URS79	1980	Evans, M.L.	Bull. Environ. Contam. Toxicol. 24:916-920.	Orconectes rusticus	Crayfish	Copper	9	MG/KG	3	Mortality
URS79	1980	Evans, M.L.	Bull. Environ. Contam. Toxicol. 24:916-920.	Orconectes rusticus	Crayfish	Copper	11.2	MG/KG	3	Mortality
URS182	1979	Martin, J.L.M.	Bull. Environ. Contam. Toxicol. 21:808-814.	Mytilus edulis	Mussel	Copper	12	MG/KG	1	Mortality
URS182	1979	Martin, J.L.M.	Bull. Environ. Contam. Toxicol. 21:808-814.	Mytilus edulis	Mussel	Copper	12	MG/KG	1	Mortality
URS182	1979	Martin, J.L.M.	Bull. Environ. Contam. Toxicol. 21:808-814.	Mytilus edulis	Mussel	Copper	12	MG/KG	1	Mortality
SEQ97-38	1996	Stouthart, J.H.X., Haans, J.L.M., Lock, R.A.C., Bonga, S.E.W.	Environmental Toxicology and Chemistry, Vol. 15, No. 3, pp. 376-383 (1996)	Cyprinus carpio	Common carp	Copper	12.1	MG/KG	1	Morphology
SEQ97-38	1996	Stouthart, J.H.X., Haans, J.L.M., Lock, R.A.C., Bonga, S.E.W.	Environmental Toxicology and Chemistry, Vol. 15, No. 3, pp. 376-383 (1996)	Cyprinus carpio	Common carp	Copper	12.1	MG/KG	1	Morphology
SEQ97-38	1996	Stouthart, J.H.X., Haans, J.L.M., Lock, R.A.C., Bonga, S.E.W.	Environmental Toxicology and Chemistry, Vol. 15, No. 3, pp. 376-383 (1996)	Cyprinus carpio	Common carp	Copper	12.1	MG/KG	1	Mortality
SEQ97-38	1996	Stouthart, J.H.X., Haans, J.L.M., Lock, R.A.C., Bonga, S.E.W.	Environmental Toxicology and Chemistry, Vol. 15, No. 3, pp. 376-383 (1996)	Cyprinus carpio	Common carp	Copper	12.1	MG/KG	1	Mortality
SEQ97-38	1996	Stouthart, J.H.X., Haans, J.L.M., Lock, R.A.C., Bonga, S.E.W.	Environmental Toxicology and Chemistry, Vol. 15, No. 3, pp. 376-383 (1996)	Cyprinus carpio	Common carp	Copper	12.1	MG/KG	1	Reproduction
SEQ97-38	1996	Stouthart, J.H.X., Haans, J.L.M., Lock, R.A.C., Bonga, S.E.W.	Environmental Toxicology and Chemistry, Vol. 15, No. 3, pp. 376-383 (1996)	Cyprinus carpio	Common carp	Copper	12.1	MG/KG	1	Reproduction
URS149	1987	Kosalwat, P. and A.W. Knight	Arch. Environ. Contam. Toxicol. 16:283-290.	Chironomus decorus	Midge	Copper	13	MG/KG	3	Development

Ref_ID	Endpoir	Exposure	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS150	LOED	Absorption	Whole Body	Adult	Introduced; spread to all Great Lakes, some rivers in Atlantic, Mississippi drainage basins; attaches to rocks, other hard surface	Filter feeder; phytoplankton, bacteria, fine detrital particles	Indicative Of Breakdown Of Internal Cu Regulatory Process
URS79	NOED	Absorption	Whole Body	Adult	Alberta to Arizona eastward to eastern seaboard, except South Carolina to Florida; introduced Cal., Ore.; streams	Scavengers; dead and decaying matter, some live food like snails, worms, insect larvae, some plants	No Effect On Survivorship
URS79	NOED	Absorption	Whole Body	Adult	Alberta to Arizona eastward to eastern seaboard, except South Carolina to Florida; introduced Cal., Ore.; streams	Scavengers; dead and decaying matter, some live food like snails, worms, insect larvae, some plants	No Effect On Survivorship
URS182	ED100	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Lethal Body Burden
URS182	ED100	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Lethal Body Burden
URS182	ED100	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Lethal Body Burden
SEQ97-38	LOED	Combined	Whole Body	Egg	Warm lakes, ponds, streams	Omnivore-plants, detritus	Larval Deformation, Ph 6.3, Body Burd From Graph
SEQ97-38	LOED	Combined	Whole Body	Egg	Warm lakes, ponds, streams	Omnivore-plants, detritus	Larval Deformation, Ph 7.6, Body Burd From Graph
SEQ97-38	LOED	Combined	Whole Body	Egg	Warm lakes, ponds, streams	Omnivore-plants, detritus	Larval Mort, Ph 6.3, Body Burd From Graph
SEQ97-38	LOED	Combined	Whole Body	Egg	Warm lakes, ponds, streams	Omnivore-plants, detritus	Larval Mort, Ph 7.6, Body Burd From Graph
SEQ97-38	NOED	Combined	Whole Body	Egg	Warm lakes, ponds, streams	Omnivore-plants, detritus	Egg Mortality, Ph 7.6, Body Burd From Graph
SEQ97-38	NOED	Combined	Whole Body	Egg	Warm lakes, ponds, streams	Omnivore-plants, detritus	Egg Mortality, Ph 6.3, Body Burd From Graph
URS149	NOED	Ingestion	Whole Body	Egg-embryo	Bottom dwelling in tubes in shallow ponds or lakes	Adults non-feeding; larvae utilize microorganisms small bits of detritus	No Effect On Time To Adult Emergence

Ref_ID	Year	Author	Journal	Species	Species Name	ChemCon	Conc_Wet	Conc_Ur	Reps	Effect
URS182	1979	Martin, J.L.M.	Bull. Environ. Contam. Toxicol. 21:808-814.	Mytilus edulis	Mussel	Copper	15	MG/KG	1	Mortality
JAW1	1994	Ericksson, S.P., and J.M. Weeks	Aquatic Toxicology 29:73-81	Corophium volutator	Amphipod	Copper	16.9	MG/KG	3	NA
URS149	1987	Kosalwat, P. and A.W. Knight	Arch. Environ. Contam. Toxicol. 16:283-290.	Chironomus decorus	Midge	Copper	18	MG/KG	3	Development
SEQ99_10	1996	Cacela, J. A. Hansen, H. L. Bergman, J.S. Meyer, and C. Hogstrand	Aquatic Toxicology	Oncorhynchus mykiss	Trout - Rainbow	Copper	18.1	MG/KG	6	Growth
SEQ99_10	1996	Cacela, J. A. Hansen, H. L. Bergman, J.S. Meyer, and C. Hogstrand	Aquatic Toxicology	Oncorhynchus mykiss	Trout - Rainbow	Copper	18.1	MG/KG	6	Growth
URS79	1980	Evans, M.L.	Bull. Environ. Contam. Toxicol. 24:916-920.	Orconectes rusticus	Crayfish	Copper	19.2	MG/KG	3	Mortality
SEQ99_10	1996	Cacela, J. A. Hansen, H. L. Bergman, J.S. Meyer, and C. Hogstrand	Aquatic Toxicology	Oncorhynchus mykiss	Trout - Rainbow	Copper	20.5	MG/KG	6	Growth
SEQ99_10	1996	Cacela, J. A. Hansen, H. L. Bergman, J.S. Meyer, and C. Hogstrand	Aquatic Toxicology	Oncorhynchus mykiss	Trout - Rainbow	Copper	20.6	MG/KG	6	Growth
SEQ99_10	1996	Cacela, J. A. Hansen, H. L. Bergman, J.S. Meyer, and C. Hogstrand	Aquatic Toxicology	Oncorhynchus mykiss	Trout - Rainbow	Copper	20.9	MG/KG	6	Growth
URS182	1979	Martin, J.L.M.	Bull. Environ. Contam. Toxicol. 21:808-814.	Mytilus edulis	Mussel	Copper	23	MG/KG	1	Mortality
SEQ97-38	1996	Stouthart, J.H.X., Haans, J.L.M., Lock, R.A.C., Bonga, S.E.W.	Environmental Toxicology and Chemistry, Vol. 15, No. 3, pp. 376-383 (1996)	Cyprinus carpio	Common carp	Copper	24.1	MG/KG	1	Reproduction
URS77	1979	Engel, D.W. and W.G. Sunda	Mar. Biol. 50:121-126.	Menidia menidia	Silverside - Atlantic	Copper	25	MG/KG	5	Reproduction
SEQ99_10	1996	Cacela, J. A. Hansen, H. L. Bergman, J.S. Meyer, and C. Hogstrand	Aquatic Toxicology	Oncorhynchus mykiss	Trout - Rainbow	Copper	25.9	MG/KG	6	Growth
URS79	1980	Evans, M.L.	Bull. Environ. Contam. Toxicol. 24:916-920.	Orconectes rusticus	Crayfish	Copper	26	MG/KG	3	Mortality

Ref_ID	Endpoir	Exposure	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS182	ED100	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Lethal Body Burden
JAW1	LOED	Absorption	Whole Body	Adult	Cape Cod to Bay of Fundy; in tubes in fine sediments	Food consists of living and dead animals of all kinds; decaying vegetable matter	100% DO Saturation During Test
URS149	LOED	Ingestion	Whole Body	Egg-embryo	Bottom dwelling in tubes in shallow ponds or lakes	Adults non-feeding; larvae utilize microorganisms small bits of detritus	Increased Time To Adult Emergence By 10 Days
SEQ99_10	ED25	Water	Whole Body	Fry	Cool streams	Carnivore-juv fish, inverts	
SEQ99_10	ED45	Water	Whole Body	Fry	Cool streams	Carnivore-juv fish, inverts	
URS79	NOED	Absorption	Whole Body	Adult	Alberta to Arizona eastward to eastern seaboard, except South Carolina to Florida; introduced Cal., Ore.; streams	Scavengers; dead and decaying matter, some live food like snails, worms, insect larvae, some plants	No Effect On Survivorship
SEQ99_10	ED25	Water	Whole Body	Fry	Cool streams	Carnivore-juv fish, inverts	
SEQ99_10	ED10	Water	Whole Body	Fry	Cool streams	Carnivore-juv fish, inverts	
SEQ99_10	ED25	Water	Whole Body	Fry	Cool streams	Carnivore-juv fish, inverts	
URS182	ED100	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Lethal Body Burden
SEQ97-38	LOED	Combined	Whole Body	Egg	Warm lakes, ponds, streams	Omnivore-plants, detritus	Egg Mortality, Ph 6.3, Body Burd From Graph
URS77	LOED	Absorption	Whole Body	Egg-embryo	Protected bays, coves, river mouths on sand or gravel	Feed on small worms, crustaceans mollusks, plants	Inhibition Of Hatching
SEQ99_10	ED50	Water	Whole Body	Fry	Cool streams	Carnivore-juv fish, inverts	
URS79	NOED	Absorption	Whole Body	Adult	Alberta to Arizona eastward to eastern seaboard, except South Carolina to Florida; introduced Cal., Ore.; streams	Scavengers; dead and decaying matter, some live food like snails, worms, insect larvae, some plants	No Effect On Survivorship

Ref_ID	Year	Author	Journal	Species	Species Name	ChemCon	Conc_Wet	Conc_Ur	Reps	Effect
URS182	1979	Martin, J.L.M.	Bull. Environ. Contam. Toxicol. 21:808-814.	Mytilus edulis	Mussel	Copper	36	MG/KG	1	Mortality
URS182	1979	Martin, J.L.M.	Bull. Environ. Contam. Toxicol. 21:808-814.	Mytilus edulis	Mussel	Copper	56	MG/KG	1	Mortality
URS128	1983	Hvilsom, M.M.	Mar. Biol. 76:291-295.	Mytilus edulis	Mussel	Copper	67.4	MG/KG	10	Mortality
URS128	1983	Hvilsom, M.M.	Mar. Biol. 76:291-295.	Mytilus edulis	Mussel	Copper	67.4	MG/KG	10	Behavior
URS17	1991	Enserink, E.L., J.L. Maas-Diepeveen and C.J. Van Leeuwen	Water Res. 25:679-687.	Daphnia magna	Water flea	Copper	68	MG/KG	4	Mortality
URS182	1979	Martin, J.L.M.	Bull. Environ. Contam. Toxicol. 21:808-814.	Mytilus edulis	Mussel	Copper	80	MG/KG	1	Mortality
SEQ97-41	1990	Powell, M.I., White, K.N.	Marine Environmental Research 30 (1990) 91-118	Balanus crenatus	Barnacle	Copper	80	MG/KG	1	Behavior
URS148	1987	Kosalwat, P. and A.W. Knight	Arch. Environ. Contam. Toxicol. 16:275-282.	Chironomus decorus	Midge	Copper	86.2	MG/KG	1	Mortality
URS148	1987	Kosalwat, P. and A.W. Knight	Arch. Environ. Contam. Toxicol. 16:275-282.	Chironomus decorus	Midge	Copper	107	MG/KG	1	Mortality
URS148	1987	Kosalwat, P. and A.W. Knight	Arch. Environ. Contam. Toxicol. 16:275-282.	Chironomus decorus	Midge	Copper	126	MG/KG	1	Mortality
URS148	1987	Kosalwat, P. and A.W. Knight	Arch. Environ. Contam. Toxicol. 16:275-282.	Chironomus decorus	Midge	Copper	142	MG/KG	1	Mortality
URS154	1980	Kumaraguru, A.K., D. Selvi and V.K. Venugopalan	Bull. Environ. Contam. Toxicol. 24:853-857.	Meretrix casta	Clam - marine	Copper	201	MG/KG	1	Mortality
SEQ99_06	1997	Ritterhoff, J., and G-P. Zauke	Aquatic Toxicology	Themisto abyssorum	Mesoplankton amphipod	Copper	374	MG/KG	3	Mortality
SEQ99_06	1997	Ritterhoff, J., and G-P. Zauke	Aquatic Toxicology	Themisto libellula	Mesoplankton amphipod	Copper	374	MG/KG	3	Mortality

Ref_ID	Endpoir	Exposure	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS182	ED100	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Lethal Body Burden
URS182	ED100	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Lethal Body Burden
URS128	ED50	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Lethal Body Burden After 7 - 8 Days
URS128	LOED	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Total Valve Closure, Increased Mucus Production, Reduced Byssus Production
URS17	ED50	Absorption	Whole Body	Immature	Southwestern to south-central Canada, Northwestern to north-central US; ponds, small lakes, clear and weedy waters	Feeds on algae and similar organisms	Lethal Body Burden After 21 Day Exposure
URS182	ED100	Absorption	Whole Body	Adult	Intertidal zone on rocks, pilings and flats; may extend to depths over 40 ft.	Filter plankton, diatoms, bottom vegetation	Lethal Body Burden
SEQ97-41	NOED	Combined	Whole Body	Adult	Boreal; Littoral zone to 91 m; on stones, piers, piles, buoys ships	Filter feeder; zooplankton, phytoplankton	Regulation Of Metals Endpoint - Summer Experiment
URS148	NOED	Absorption	Whole Body	Larval	Bottom dwelling in tubes in shallow ponds or lakes	Adults non-feeding; larvae utilize microorganisms small bits of detritus	No Effect On Mortality
URS148	LOED	Absorption	Whole Body	Larval	Bottom dwelling in tubes in shallow ponds or lakes	Adults non-feeding; larvae utilize microorganisms small bits of detritus	Significant Mortality
URS148	LOED	Ingestion	Whole Body	Larval	Bottom dwelling in tubes in shallow ponds or lakes	Adults non-feeding; larvae utilize microorganisms small bits of detritus	Significant Mortality
URS148	ED50	Absorption	Whole Body	Larval	Bottom dwelling in tubes in shallow ponds or lakes	Adults non-feeding; larvae utilize microorganisms small bits of detritus	ED50
URS154	ED50	Absorption	Whole Body	NA	Not Specified	Not Specified	Lethal Body Burden
SEQ99_06	LC50	Water	Whole Body	Adult	Open boreal ocean	Omnivore-diatoms, small crustacean	
SEQ99_06	LC50	Water	Whole Body	Adult	Open boreal ocean	Omnivore-diatoms, small crustacean	

Ref_ID	Year	Author	Journal	Species	Species Name	ChemCon	Conc_Wet	Conc_Ur	Reps	Effect
URS148	1987	Kosalwat, P. and A.W. Knight	Arch. Environ. Contam. Toxicol. 16:275-282.	Chironomus decorus	Midge	Copper	1000	MG/KG	1	Mortality
SEQ99_06	1997	Ritterhoff, J., and G-P. Zauke	Aquatic Toxicology	Calanus hyperboreus	Calanoid copepod	Copper	1320	MG/KG	3	Mortality
SEQ99_06	1997	Ritterhoff, J., and G-P. Zauke	Aquatic Toxicology	Calanus hyperboreus	Calanoid copepod	Copper	2440	MG/KG	3	Mortality

Ref_ID	Endpoir	Exposure	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS148	ED100	Absorption	Whole Body	Larval	Bottom dwelling in tubes in shallow ponds or lakes	Adults non-feeding; larvae utilize microorganisms small bits of detritus	100% Mortality
SEQ99_06	LC50	Water	Whole Body	Adult	Open boreal ocean	Omnivore-diatoms, small crustacean	low concentration exposure
SEQ99_06	LC50	Water	Whole Body	Adult	Open boreal ocean	Omnivore-diatoms, small crustacean	High concentration exposure

Ref_ID	Year	Author	Journal	Species	SpeciesComm	Chem	Conc	Conc_U	Reps	Effect	End point	Exposure	Body Part
URS236	1983	Wilson, J.G.	Mar. Environ. Res. 8: 129-148	Cerastoderma edule	Clam	Nickel	56.6	MG/KG	2	Mortality	ED50	Absorption	Whole Body
URS236	1983	Wilson, J.G.	Mar. Environ. Res. 8: 129-148	Cerastoderma edule	Clam	Nickel	167	MG/KG	2	Physiological	NOED	Absorption	Whole Body
URS17	1991	Enserink, E.L., J.L. Maas-Diepeveen and C.J. Van Leeuwen	Water Res. 25:679-687.	Daphnia magna	Water flea	Nickel	223	MG/KG	4	Mortality	ED50	Absorption	Whole Body

Ref_ID	Life Stage	Habitat	FeedingBehavior	Comments
URS236	Adult	Western Barents Sea and Baltic, south along west coast of Africa; mid-tide to low water, in sand	Deposit feeder, detritus, small plankters	Estimated Body Residue By Regression From Other Data Values, Number Of Reps Is 2 To 5
URS236	Adult	Western Barents Sea and Baltic, south along west coast of Africa; mid-tide to low water, in sand	Deposit feeder, detritus, small plankters	No Significant Effect On Respiration Rate At 100 Ug/l (highest Test Concentration At Which Body Residues Were Measured), Number Of Reps Is 2 To 5
URS17	Immature	Southwestern to south-central Canada, Northwestern to north-central US; ponds, small lakes, clear and weedy waters	Feeds on algae and similar organisms	Lethal Body Burden After 21 Day Exposure

Ref_ID	Year	Author	Journal	Species	Species Name	ChemComNa	Conc	Conc Units	Reps	Effect	Endpoint
URS124	1976	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim	J. Fish. Res. Bd. Can. 33:1731-1741.	Salvelinus fontinalis	Trout - Brook	Lead	1.6	MG/KG	2	Development	NOED
URS124	1976	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim	J. Fish. Res. Bd. Can. 33:1731-1741.	Salvelinus fontinalis	Trout - Brook	Lead	1.6	MG/KG	2	Growth	NOED
URS124	1976	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim	J. Fish. Res. Bd. Can. 33:1731-1741.	Salvelinus fontinalis	Trout - Brook	Lead	1.6	MG/KG	2	Morphology	NOED
URS124	1976	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim	J. Fish. Res. Bd. Can. 33:1731-1741.	Salvelinus fontinalis	Trout - Brook	Lead	1.6	MG/KG	2	Mortality	NOED
URS151	1994	Kraak, M.H.S., Y.A. Wink, S.C. Stuijfzand, M.C. Buckert de Jong, C.J. De Groot and W. Admiraal	Aquat. Toxicol. 30:77-89.	Dreissena polymorpha	Mussel - Zebra	Lead	2	MG/KG	1	Mortality	NOED
URS151	1994	Kraak, M.H.S., Y.A. Wink, S.C. Stuijfzand, M.C. Buckert de Jong, C.J. De Groot and W. Admiraal	Aquat. Toxicol. 30:77-89.	Dreissena polymorpha	Mussel - Zebra	Lead	2	MG/KG	1	Physiological	NOED
URS124	1976	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim	J. Fish. Res. Bd. Can. 33:1731-1741.	Salvelinus fontinalis	Trout - Brook	Lead	2.55	MG/KG	2	Development	NOED
URS124	1976	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim	J. Fish. Res. Bd. Can. 33:1731-1741.	Salvelinus fontinalis	Trout - Brook	Lead	2.55	MG/KG	2	Growth	NOED
URS124	1976	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim	J. Fish. Res. Bd. Can. 33:1731-1741.	Salvelinus fontinalis	Trout - Brook	Lead	2.55	MG/KG	2	Morphology	NOED
URS124	1976	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim	J. Fish. Res. Bd. Can. 33:1731-1741.	Salvelinus fontinalis	Trout - Brook	Lead	2.55	MG/KG	2	Mortality	NOED
JB17	1992	Janssens De Bisthoven, L.G., Timmermans, K.R. and F. Ollevier	Hydrobiologia 239: 141-149	Chironomus gr. thummi	Midge	Lead	2.56	MG/KG	9	Morphology	NOED
SEQ97-39	1984	Sundelin, B.	Ecotoxicological Testing for the Marine Environment, Vol. 2, 588 P, 1984	Monoporeia affinis	Amphipod	Lead	4	MG/KG	3	Mortality	NOED
SEQ97-39	1984	Sundelin, B.	Ecotoxicological Testing for the Marine Environment, Vol. 2, 588 P, 1984	Monoporeia affinis	Amphipod	Lead	4	MG/KG	3	Mortality	NOED

Ref_ID	ExposureRou	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS124	Absorption	Whole Body	Egg-embryo	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	No Effect On Embryo Hatchability
URS124	Absorption	Whole Body	Egg-embryo	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	No Effect On Weight Gain
URS124	Absorption	Whole Body	Egg-embryo	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	No Effect On Skeletal Deformities
URS124	Absorption	Whole Body	Egg-embryo	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	No Effect On Mortality
URS151	Absorption	Whole Body	Adult	Introduced; spread to all Great Lakes, some rivers in Atlantic, Mississippi drainage basins; attaches to rocks, other hard surface	Filter feeder; phytoplankton, bacteria, fine detrital particles	No Effect On Mortality
URS151	Absorption	Whole Body	Adult	Introduced; spread to all Great Lakes, some rivers in Atlantic, Mississippi drainage basins; attaches to rocks, other hard surface	Filter feeder; phytoplankton, bacteria, fine detrital particles	No Effect On Filtration Rate
URS124	Absorption	Whole Body	Egg-embryo	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	No Effect On Embryo Hatchability
URS124	Absorption	Whole Body	Egg-embryo	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	No Effect On Weight Gain
URS124	Absorption	Whole Body	Egg-embryo	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	No Effect On Skeletal Deformities
URS124	Absorption	Whole Body	Egg-embryo	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	No Effect On Mortality
JB17	Combined	Whole Body	Egg-embryo	Not Specified	Not Specified	4th Instar Larvae
SEQ97-39	Combined	Whole Body	Immature	Holarctic, coastal marine, mainly brackish lakes and estuaries, marine-glacial relict lakes	Detritivore	Body Burden Est. From Graph
SEQ97-39	Combined	Whole Body	Adult	Holarctic, coastal marine, mainly brackish lakes and estuaries, marine-glacial relict lakes	Detritivore	Body Burden Est. From Graph

Ref_ID	Year	Author	Journal	Species	Species Name	ChemComNa	Conc	Conc Units	Reps	Effect	Endpoint
URS151	1994	Kraak, M.H.S., Y.A. Wink, S.C. Stuijfzand, M.C. Buckert de Jong, C.J. De Groot and W. Admiraal	Aquat. Toxicol. 30:77-89.	Dreissena polymorpha	Mussel - Zebra	Lead	4	MG/KG	1	Mortality	NOED
URS151	1994	Kraak, M.H.S., Y.A. Wink, S.C. Stuijfzand, M.C. Buckert de Jong, C.J. De Groot and W. Admiraal	Aquat. Toxicol. 30:77-89.	Dreissena polymorpha	Mussel - Zebra	Lead	4	MG/KG	1	Physiological	NOED
URS124	1976	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim	J. Fish. Res. Bd. Can. 33:1731-1741.	Salvelinus fontinalis	Trout - Brook	Lead	4.02	MG/KG	2	Development	LOED
URS124	1976	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim	J. Fish. Res. Bd. Can. 33:1731-1741.	Salvelinus fontinalis	Trout - Brook	Lead	4.02	MG/KG	2	Growth	LOED
URS124	1976	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim	J. Fish. Res. Bd. Can. 33:1731-1741.	Salvelinus fontinalis	Trout - Brook	Lead	4.02	MG/KG	2	Morphology	LOED
URS124	1976	Holcombe, G.W., D.A. Benoit, E.N. Leonard and J.M. Mckim	J. Fish. Res. Bd. Can. 33:1731-1741.	Salvelinus fontinalis	Trout - Brook	Lead	4.02	MG/KG	2	Mortality	NOED
URS151	1994	Kraak, M.H.S., Y.A. Wink, S.C. Stuijfzand, M.C. Buckert de Jong, C.J. De Groot and W. Admiraal	Aquat. Toxicol. 30:77-89.	Dreissena polymorpha	Mussel - Zebra	Lead	6	MG/KG	1	Mortality	NOED
URS151	1994	Kraak, M.H.S., Y.A. Wink, S.C. Stuijfzand, M.C. Buckert de Jong, C.J. De Groot and W. Admiraal	Aquat. Toxicol. 30:77-89.	Dreissena polymorpha	Mussel - Zebra	Lead	6	MG/KG	1	Physiological	NOED
URS230	1991	Weber, D.N., Russo, A., Seale, D.B., Spieler, R.E.	Aquatic Toxicol. 21: 71-80	Pimephales promelas	Fathead minnow	Lead	26.2	MG/KG	1	Behavior	LOED
URS230	1991	Weber, D.N., Russo, A., Seale, D.B., Spieler, R.E.	Aquatic Toxicol. 21: 71-80	Pimephales promelas	Fathead minnow	Lead	26.2	MG/KG	1	Behavior	LOED
URS230	1991	Weber, D.N., Russo, A., Seale, D.B., Spieler, R.E.	Aquatic Toxicol. 21: 71-80	Pimephales promelas	Fathead minnow	Lead	26.2	MG/KG	1	Behavior	NOED

Ref_ID	ExposureRou	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS151	Absorption	Whole Body	Adult	Introduced; spread to all Great Lakes, some rivers in Atlantic, Mississippi drainage basins; attaches to rocks, other hard surface	Filter feeder; phytoplankton, bacteria, fine detrital particles	No Effect On Mortality
URS151	Absorption	Whole Body	Adult	Introduced; spread to all Great Lakes, some rivers in Atlantic, Mississippi drainage basins; attaches to rocks, other hard surface	Filter feeder; phytoplankton, bacteria, fine detrital particles	No Effect On Filtration Rate
URS124	Absorption	Whole Body	Egg-embryo	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	Reduced Embryo Hatchability
URS124	Absorption	Whole Body	Egg-embryo	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	Reduced Weight Gain
URS124	Absorption	Whole Body	Egg-embryo	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	Deformed Vertebral Column
URS124	Absorption	Whole Body	Egg-embryo	Cool streams, gravel bottoms	Carnivore-aquatic insects, fish	No Effect On Mortality
URS151	Absorption	Whole Body	Adult	Introduced; spread to all Great Lakes, some rivers in Atlantic, Mississippi drainage basins; attaches to rocks, other hard surface	Filter feeder; phytoplankton, bacteria, fine detrital particles	No Effect On Mortality
URS151	Absorption	Whole Body	Adult	Introduced; spread to all Great Lakes, some rivers in Atlantic, Mississippi drainage basins; attaches to rocks, other hard surface	Filter feeder; phytoplankton, bacteria, fine detrital particles	No Effect On Filtration Rate
URS230	Absorption	Whole Body	Immature	Lakes, ponds, streams	Not Specified	Significant Reduction In Number Of Ineffective Feeding Behaviors In Lowest Test Concentration With 2-day-old Daphnia
URS230	Absorption	Whole Body	Immature	Lakes, ponds, streams	Not Specified	Significant Reduction In Feeding Rate And Number Of Ineffective Feeding Behaviors In Lowest Test Concentration With 7-day-old Daphnia
URS230	Absorption	Whole Body	Immature	Lakes, ponds, streams	Not Specified	No Significant Reduction In Feeding Rate And Number Of Ineffective Feeding Behaviors With 1-day-old Daphnia

Ref_ID	Year	Author	Journal	Species	Species Name	ChemComNa	Conc	Conc Units	Reps	Effect	Endpoint
URS230	1991	Weber, D.N., Russo, A., Seale, D.B., Spieler, R.E.	Aquatic Toxicol. 21: 71-80	Pimephales promelas	Fathead minnow	Lead	26.2	MG/KG	1	Physiological	NOED
URS151	1994	Kraak, M.H.S., Y.A. Wink, S.C. Stuijfzand, M.C. Buckert de Jong, C.J. De Groot and W. Admiraal	Aquat. Toxicol. 30:77-89.	Dreissena polymorpha	Mussel - Zebra	Lead	30	MG/KG	1	Physiological	LOED
URS151	1994	Kraak, M.H.S., Y.A. Wink, S.C. Stuijfzand, M.C. Buckert de Jong, C.J. De Groot and W. Admiraal	Aquat. Toxicol. 30:77-89.	Dreissena polymorpha	Mussel - Zebra	Lead	30	MG/KG	1	Mortality	NOED
SEQ99_06	1997	Ritterhoff, J., and G-P. Zauke	Aquatic Toxicology	Calanus hyperboreus	Calanoid copepod	Lead	40.7	MG/KG	3	Mortality	LC50
URS230	1991	Weber, D.N., Russo, A., Seale, D.B., Spieler, R.E.	Aquatic Toxicol. 21: 71-80	Pimephales promelas	Fathead minnow	Lead	44.2	MG/KG	1	Behavior	LOED
URS230	1991	Weber, D.N., Russo, A., Seale, D.B., Spieler, R.E.	Aquatic Toxicol. 21: 71-80	Pimephales promelas	Fathead minnow	Lead	44.2	MG/KG	1	Physiological	LOED
URS230	1991	Weber, D.N., Russo, A., Seale, D.B., Spieler, R.E.	Aquatic Toxicol. 21: 71-80	Pimephales promelas	Fathead minnow	Lead	44.2	MG/KG	1	Behavior	NOED
SEQ99_06	1997	Ritterhoff, J., and G-P. Zauke	Aquatic Toxicology	Themisto abyssorum	Mesoplankto n amphipod	Lead	63.3	MG/KG	3	Mortality	LC50
SEQ99_06	1997	Ritterhoff, J., and G-P. Zauke	Aquatic Toxicology	Themisto libellula	Mesoplankto n amphipod	Lead	63.3	MG/KG	3	Mortality	LC50
URS175	1993	Maclean, R.S., U. Borgmann and D.G. Dixon	Poster P418, 14th Annual Meeting, SETAC Houston	Hyalella azteca	Amphipod - Freshwater	Lead	70	MG/KG	1	Mortality	ED50
SEQ97-41	1990	Powell, M.I., White, K.N.	Marine Environmental Research 30 (1990) 91-118	Balanus crenatus	Barnacle	Lead	90	MG/KG	1	Behavior	NOED
URS175	1993	Maclean, R.S., U. Borgmann and D.G. Dixon	Poster P418, 14th Annual Meeting, SETAC Houston	Hyalella azteca	Amphipod - Freshwater	Lead	90	MG/KG	1	Mortality	ED50
URS175	1993	Maclean, R.S., U. Borgmann and D.G. Dixon	Poster P418, 14th Annual Meeting, SETAC Houston	Hyalella azteca	Amphipod - Freshwater	Lead	115	MG/KG	1	Mortality	ED50
URS175	1993	Maclean, R.S., U. Borgmann and D.G. Dixon	Poster P418, 14th Annual Meeting, SETAC Houston	Hyalella azteca	Amphipod - Freshwater	Lead	160	MG/KG	1	Mortality	ED50
URS151	1994	Kraak, M.H.S., Y.A. Wink, S.C. Stuijfzand, M.C. Buckert de Jong, C.J. De Groot and	Aquat. Toxicol. 30:77-89.	Dreissena polymorpha	Mussel - Zebra	Lead	200	MG/KG	1	Physiological	ED100

Ref_ID	ExposureRou	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS230	Absorption	Whole Body	Immature	Lakes, ponds, streams	Not Specified	No Significant Reduction Noepinephrine And Serotin Levels In Brain
URS151	Absorption	Whole Body	Adult	Introduced; spread to all Great Lakes, some rivers in Atlantic, Mississippi drainage basins; attaches to rocks, other hard surface	Filter feeder; phytoplankton, bacteria, fine detrital particles	Reduced Filtration Rate
URS151	Absorption	Whole Body	Adult	Introduced; spread to all Great Lakes, some rivers in Atlantic, Mississippi drainage basins; attaches to rocks, other hard surface	Filter feeder; phytoplankton, bacteria, fine detrital particles	No Effect On Mortality
SEQ99_06	Water	Whole Body	Adult	Open boreal ocean	Omnivore-diatoms, small crustacean	Clearly written paper
URS230	Absorption	Whole Body	Immature	Lakes, ponds, streams	Not Specified	Significant Reduction In Feeding Rate And Number Of Ineffective Feeding Behaviors With 1-day-old Daphnia
URS230	Absorption	Whole Body	Immature	Lakes, ponds, streams	Not Specified	Significant Reduction Noepinephrine And Serotin Levels In Brain
URS230	Absorption	Whole Body	Immature	Lakes, ponds, streams	Not Specified	No Significant Reduction In Number Of Ineffective Feeding Behaviors With 2-day-old Daphnia
SEQ99_06	Water	Whole Body	Adult	Open boreal ocean	Omnivore-diatoms, small crustacean	
SEQ99_06	Water	Whole Body	Adult	Open boreal ocean	Omnivore-diatoms, small crustacean	
URS175	Absorption	Whole Body	Immature	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Lethal Body Burden
SEQ97-41	Combined	Whole Body	Adult	Boreal; Littoral zone to 91 m; on stones, piers, piles, buoys ships	Filter feeder; zooplankton, phytoplankton	Regulation Of Metals Endpoint - Summer Experiment
URS175	Absorption	Whole Body	Adult	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Lethal Body Burden
URS175	Absorption	Whole Body	Adult	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Lethal Body Burden
URS175	Absorption	Whole Body	Adult	Widely distributed in North America in permanent bodies of water with submerged vegetation	Detritivore	Lethal Body Burden
URS151	Absorption	Whole Body	Adult		Filter feeder; phytoplankton, bacteria, fine detrital particles	Mussels Stopped Filtering

Appendix 5.6 Lead

Ref_ID	Year	Author	Journal	Species	Species Name	ChemComNa	Conc	Conc Units	Reps	Effect	Endpoint
URS151	1994	S.C. Stuijfzand, M.C. Buckert de Jong, C.J. De Groot and W. Admiraal	Aquat. Toxicol. 30:77-89.	Dreissena polymorpha	Mussel - Zebra	Lead	200	MG/KG	1	Mortality	LOED
URS17	1991	Enserink, E.L., J.L. Maas-Diepeveen and C.J. Van Leeuwen	Water Res. 25:679-687.	Daphnia magna	Water flea	Lead	1880	MG/KG	4	Reproduction	ED10
URS17	1991	Enserink, E.L., J.L. Maas-Diepeveen and C.J. Van Leeuwen	Water Res. 25:679-687.	Daphnia magna	Water flea	Lead	5040	MG/KG	4	Mortality	ED50

Ref_ID	ExposureRou	Body Part	Life Stage	Habitat	FeedingBehavior	Comments
URS151	Absorption	Whole Body	Adult		Filter feeder; phytoplankton, bacteria, fine detrital particles	Increased Mortality
URS17	Absorption	Whole Body	Immature	Southwestern to south-central Canada, Northwestern to north-central US; ponds, small lakes, clear and weedy waters	Feeds on algae and similar organisms	10% Reduction In Number Of Offspring
URS17	Absorption	Whole Body	Immature	Southwestern to south-central Canada, Northwestern to north-central US; ponds, small lakes, clear and weedy waters	Feeds on algae and similar organisms	Lethal Body Burden After 21 Day Exposure

Data used to calculate species sensitivity distribution for NOED to growth, reproduction, or survival from residues of PCBs in fish tissue.

Ref_ID	Year	Author	Journal	Species	Common Name	Chemical	Conc Wet	Conc Units	Reps	Effect	Endpoint	Exposure Route	Body Part
URS173	1981	and J.G.	Contam.	Salvelinus nai	Trout -Lake	PCBs	0.76	MG/KG	5	Growth	NOED	Absorption	Whole Body
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	0.84	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS74	1970	J.I. Lowe and	Contam.	Lagodon rhon	Pinfish	PCBs	0.98	MG/KG	10	Mortality	NOED	Absorption	Whole Body
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	1.5	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS173	1981	and J.G.	Contam.	Salvelinus nai	Trout -Lake	PCBs	2.1	MG/KG	5	Growth	NOED	Absorption	Whole Body
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	2.3	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS112	1980	J.W., E.H.	23:149-161.	Oncorhynchus	Salmon - Chinook	PCBs	3.5	MG/KG	3	Growth	NOED	Ingestion	Whole Body
URS74	1970	J.I. Lowe and	Contam.	Lagodon rhon	Pinfish	PCBs	3.8	MG/KG	10	Mortality	NOED	Absorption	Whole Body
URS234	1983	Olney, C.E.,	Environm.	Morone saxat	Striped Bass	PCBs	4.4	MG/KG	1	Growth	NOED	Ingestion	Whole Body
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	5.4	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	8.9	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	10	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS104	1976	L.G., W.B.	Bd. Can.	Ictalurus punc	Catfish-Channel	PCBs	10.9	MG/KG	3	Mortality	NOED	Ingestion	Whole Body
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	11	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS104	1976	L.G., W.B.	Bd. Can.	Ictalurus punc	Catfish-Channel	PCBs	11.4	MG/KG	3	Mortality	NOED	Ingestion	Skin
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	12	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS74	1970	J.I. Lowe and	Contam.	Lagodon rhon	Pinfish	PCBs	17	MG/KG	10	Mortality	NOED	Absorption	Whole Body
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	21	MG/KG	2	Mortality	NOED	Absorption	Whole Body
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	23	MG/KG	1	Mortality	NOED	Absorption	Muscle
URS51	1986	G.E., K.	Environ.	Salmo salar	Salmon - Atlantic	PCBs	30	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	46	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	49	MG/KG	1	Mortality	NOED	Absorption	Skin
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	54	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	63	MG/KG	1	Mortality	NOED	Absorption	Muscle
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	72	MG/KG	1	Mortality	ED50	Absorption	Skin
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	76	MG/KG	1	Mortality	NOED	Absorption	Skin
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	79	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	100	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	110	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	111	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS85	1985	Ballhorn, H.	e 14:1589-	Leuciscus idu	Golden Ide	pentachlorobi	116	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS85	1985	Ballhorn, H.	e 14:1589-	Leuciscus idu	Golden Ide	2,2` -DBCP	121	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS85	1985	Ballhorn, H.	e 14:1589-	Leuciscus idu	Golden Ide	tetrachlorobip	158	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	170	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS85	1985	Ballhorn, H.	e 14:1589-	Leuciscus idu	Golden Ide	dichlorobiphe	178	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS85	1985	Ballhorn, H.	e 14:1589-	Leuciscus idu	Golden Ide	PCB 31	193	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	220	MG/KG	1	Mortality	NOED	Absorption	Whole Body
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	230	MG/KG	1	Mortality	NOED	Absorption	Whole Body

Life stage	Habitat	Comments
Immature	of cold	Pcb Dosed With Acetone Carrier; No Effect On Growth (weight or length)
Adult	brackish	No Effect On Adult Mortality In 28 Days
Immature	portions of	No Effect On Survival In 48 Hours
Adult	brackish	No Effect On Adult Mortality In 28 Days
Immature	of cold	Pcb With No Acetone Carrier; No Effect On Growth (weight or length)
Immature	brackish	No Effect On Juvenile Mortality In 28 Days
Immature	of Pacific;	No Effect On Weight Gain
Immature	portions of	No Effect On Survival In 48 Hours
Immature	in various	Parental Exposure To Pcbs In Field, Then Post Yolk Absorption Exposure Of Immature To PCB Contaminated Brine Shrimp; No Significant Change In Growth
Adult	brackish	No Effect On Adult Mortality In 28 Days
Immature	brackish	No Effect On Juvenile Mortality In 28 Days
Immature	brackish	No Effect On Juvenile Mortality In 28 Days
Immature	streams	No Effect On Mortality
Immature	brackish	No Effect On Juvenile Mortality In 28 Days
Immature	streams	No Effect On Mortality
Adult	brackish	No Effect On Adult Mortality In 28 Days
Immature	portions of	No Effect On Survival In 48 Hours
Immature	portions of	No Mortality In 96 Hours
Immature	portions of	No Statistically Significant Increase In Mortality
Immature	of N.Atlantic,	No Effect On Mortality
Adult	brackish	No Effect On Adult Mortality In 28 Days
Immature	portions of	No Statistically Significant Increase In Mortality
Immature	brackish	No Effect On Juvenile Mortality In 28 Days
Immature	portions of	No Statistically Significant Increase In Mortality
Immature	portions of	50% Mortality
Immature	portions of	No Statistically Significant Increase In Mortality
Immature	brackish	No Effect On Juvenile Mortality In 28 Days
Adult	brackish	No Effect On Adult Mortality In 28 Days
Adult	brackish	No Effect On Adult Mortality In 28 Days
Immature	portions of	No Statistically Significant Increase In Mortality
NA	Eurasia; in	No Effect On Survivorship In 3 Days
NA	Eurasia; in	No Effect On Survivorship In 3 Days
NA	Eurasia; in	No Effect On Survivorship In 3 Days
Immature	portions of	No Statistically Significant Increase In Mortality
NA	Eurasia; in	No Effect On Survivorship In 3 Days
NA	Eurasia; in	No Effect On Survivorship In 3 Days
Immature	brackish	No Effect On Juvenile Mortality In 28 Days
Immature	brackish	No Effect On Juvenile Mortality In 28 Days

Data used to calculate species sensitivity distribution for LOED to growth, reproduction, or survival from residues of PCBs in fish tissue.

Ref_ID	Year	Author	Journal	Species	Common Name	Chemical	Conc Wet	Conc Units	Conc. Dry ppb	Reps	Effect	Endpoint	Exposure Route
JAW9	1975	and J.L.	Progressive	Oncorhynchus	Trout - Rainbow	or PCB 1242	1.3	MG/KG	5200	1	Mortality	LOED	NA
URS173	1981	and J.G.	Contam.	Salvelinus nai	Trout -Lake	PCBs	1.8	MG/KG	7200	5	Growth	LOED	Absorption
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	2.2	MG/KG	8800	2	Mortality	LOED	Absorption
URS173	1981	and J.G.	Contam.	Salvelinus nai	Trout -Lake	PCBs	2.3	MG/KG	9200	5	Growth	LOED	Absorption
URS173	1981	and J.G.	Contam.	Salvelinus nai	Trout -Lake	PCBs	2.4	MG/KG	9600	5	Growth	LOED	Absorption
SEQ98-40	1979	and M.I.	and Applied	Oncorhynchus	Salmon - Chinook	tetrachlorobip	3.7	MG/KG	14800	1	Survival	LC28	Combined
URS27	1988	D.K. Phelps	Res. 25:45-	Pleuronectes	Winter Flounder	PCBs	7.1	MG/KG	28400	8	Growth	LOED	Combined
SEQ98-40	1979	and M.I.	and Applied	Salvelinus nai	Trout -Lake	tetrachlorobip	8.4	MG/KG	33600	1	Survival	LC87	Combined
SEQ98-40	1979	and M.I.	and Applied	Salvelinus nai	Trout -Lake	tetrachlorobip	8.6	MG/KG	34400	1	Survival	LC74	Combined
SEQ98-40	1979	and M.I.	and Applied	Salvelinus nai	Trout -Lake	tetrachlorobip	8.8	MG/KG	35200	1	Survival	LC17	Combined
SEQ98-40	1979	and M.I.	and Applied	Salvelinus nai	Trout -Lake	tetrachlorobip	9.2	MG/KG	36800	1	Survival	LC50	Combined
URS104	1976	L.G., W.B.	Bd. Can.	Ictalurus punc	Catfish-Channel	PCBs	11.9	MG/KG	47600	3	Growth	LOED	Ingestion
URS104	1976	L.G., W.B.	Bd. Can.	Ictalurus punc	Catfish-Channel	PCBs	14.3	MG/KG	57200	3	Growth	LOED	Ingestion
URS14	1980	B.E.	14:681-687.	Phoxinus pho	Minnow	PCBs	15	MG/KG	60000	4	Reproduction	LOED	Ingestion
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	30	MG/KG	120000	1	Mortality	ED50	Absorption
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	38	MG/KG	152000	1	Mortality	ED50	Absorption
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	48	MG/KG	192000	1	Mortality	ED50	Absorption
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	65	MG/KG	260000	2	Mortality	NA	Absorption
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	72	MG/KG	288000	1	Mortality	ED50	Absorption
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	106	MG/KG	424000	1	Mortality	ED50	Absorption
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	140	MG/KG	560000	1	Mortality	LOED	Absorption
URS222	1995	A.P., Punte,	Toxicol.	Pimephales p	Fathead minnow	PCB 1	167	MG/KG	668000	10	Mortality	ED100	Absorption
URS14	1980	B.E.	14:681-687.	Phoxinus pho	Minnow	PCBs	170	MG/KG	680000	4	Growth	LOED	Ingestion
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	180	MG/KG	720000	1	Mortality	LOED	Absorption
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	200	MG/KG	800000	1	Mortality	LOED	Absorption
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	205	MG/KG	820000	1	Mortality	ED50	Absorption
URS109	1972	and O. Karlog	Pharmacol.	Carassius aur	Goldfish	PCBs	250	MG/KG	1000000	1	Mortality	ED50	Absorption
URS109	1972	and O. Karlog	Pharmacol.	Carassius aur	Goldfish	PCBs	253	MG/KG	1012000	1	Mortality	ED50	Absorption
URS109	1972	and O. Karlog	Pharmacol.	Carassius aur	Goldfish	PCBs	256	MG/KG	1024000	1	Mortality	ED50	Absorption
URS109	1972	and O. Karlog	Pharmacol.	Carassius aur	Goldfish	PCBs	271	MG/KG	1084000	1	Mortality	ED50	Absorption
URS109	1972	and O. Karlog	Pharmacol.	Carassius aur	Goldfish	PCBs	293	MG/KG	1172000	1	Mortality	ED50	Absorption
URS109	1972	and O. Karlog	Pharmacol.	Carassius aur	Goldfish	PCBs	324	MG/KG	1296000	1	Mortality	ED50	Absorption
URS102	1974	P.R. Parrish	7:363-373.	Lagodon rhon	Pinfish	PCBs	620	MG/KG	2480000	1	Mortality	LOED	Absorption
JAW8	1977	P.M. Mehrle,	Environ.	Oncorhynchus	Salmon-coho	PCBs	645	MG/KG	2580000	1	Mortality	ED100	Ingestion
URS103	1975	S.C.	Fish. Soc.	Cyprinodon va	Sheepshead minnow	PCBs	1100	MG/KG	4400000	1	Morphology	LOED	Absorption

Body Part	Life stage	Habitat	Comments
Whole Body	Egg	Cool streams	10% Mortality
Whole Body	Immature	of cold	Pcb With No Acetone Carrier; Enhanced Growth (weight and length)
Whole Body	Immature	portions of	5% Mortality In 96 Hours
Whole Body	Immature	of cold	Pcb Dosed With Acetone Carrier; Enhanced Growth (weight only; not length)
Whole Body	Immature	of cold	Pcb Dosed With Acetone Carrier; Enhanced Growth (weight and length)
Whole Body	Fry	of Pacific;	
Whole Body	Egg-embryo	muddy sand	Reduced Length And Weight Of Larvae
Whole Body	Fry	of cold	
Whole Body	Fry	of cold	
Whole Body	Fry	of cold	
Whole Body	Fry	of cold	
Skin	Immature	streams	40% Reduction In Mean Weight
Whole Body	Immature	streams	40% Reduction In Mean Weight
Whole Body	Adult	Not Specified	Reduction In Time To Hatch, Fry Death
Muscle	Immature	portions of	50% Mortality
Muscle	Immature	portions of	50% Mortality
Skin	Immature	portions of	50% Mortality
Whole Body	Immature	portions of	18% Mortality In 96 Hours
Skin	Immature	portions of	50% Mortality
Whole Body	Immature	portions of	50% Mortality
Muscle	Immature	portions of	Statistically Significant Increase In Mortality
Whole Body	Adult	ponds,	Lethal Body Burden Measured In Fish Immediately After Death; Maximum Time Duration Used - When All Fish Had Died In Treatment; Ph 6.2
Whole Body	Adult	Not Specified	Increased Growth
Skin	Immature	portions of	Statistically Significant Increase In Mortality
Whole Body	Egg-embryo	brackish	Lethal To 86% Of Fry In 28 Days
Whole Body	Immature	portions of	50% Mortality
Whole Body	Immature	in US	Lethal Body Burden
Whole Body	Immature	in US	Lethal Body Burden
Whole Body	Immature	in US	Lethal Body Burden
Whole Body	Immature	in US	Lethal Body Burden
Whole Body	Immature	in US	Lethal Body Burden
Whole Body	Immature	in US	Lethal Body Burden
Whole Body	Immature	portions of	Statistically Significant Increase In Mortality
Whole Body	Immature	and Asian	Radiolabeled - Contam. Food Fed.
Whole Body	Immature	brackish	Darkened Body Coloration, Body Lesions

Appendix 6. Data from EMAP Carolinian Province

a. PCB Data

b. Metals Data

SAMPLEID	ORGANISM	TotalPCB	PCB101	PCB105	PCB118	PCB128	PCB138	PCB153	PCB170	PCB18	PCB180	PCB187	PCB195	PCB206	PCB209	PCB28	PCB44	PCB52	PCB66	PCB8
CP95165TWL00CAL01	BLUE CRAB	85.17	0	0.24	0	0	1.76	1.31	26.85	0	3.2	0	0.19	1.12	0.36	0	0	0	0	2.86
CP95166TWL00CAL01	BLUE CRAB	37.14	0	0.12	0	0	0.94	1.03	7.24	0	0.59	0.47	0.41	1.36	0.26	0	0	0	0	3.54
CP95SPYTWL00CAL01	BLUE CRAB	386.89	0	23.28	35.3	1.45	14.92	18.78	10.55	0	9.41	3.04	0.43	1.78	0.58	22.61	0	0	30.57	2.96
CP95SPYTWL00CAL02	BLUE CRAB	191.84	0	3.93	14.28	1.86	13.7	19.73	9.63	0	7.32	2.54	0.38	1.06	0.41	2.76	0	0	4.2	4.8
CP97036TWL01CAL01	BLUE CRAB	27.09	0	0	0.5	0	0.69	2.28	1.99	0	0.98	0	0	0	0	0	0	1.76	0	3.17
CP97052TWL12CAL01C	BLUE CRAB	17.48	0.11	0.16	0.68	0.19	0.99	1.98	0.9	0	0.73	0.32	0	0.31	0	0	0.47	0	0.14	0
CP97109TWL12CAL01C	BLUE CRAB	37.60	0.18	0.27	1.37	0.41	2.19	5.05	1.91	0	1.97	1.09	0.28	0.38	0.42	0	0.31	0	0.34	0
CP97114TWL01CAL01	BLUE CRAB	11.45	0.11	0.08	0.31	0.12	0.43	0.84	0.78	0	0.45	0.16	0	0.25	0.06	0	0.45	0.09	0.1	0
CP97120TWL12CAL01C	BLUE CRAB	22.71	0	0.15	0.78	0.31	1.05	1.82	1.88	0	1.84	0.35	0	0	0	0	1.03	0.16	0	0
CP97141TWL12CAL01C	BLUE CRAB	33.62	0	0	0	0	0.16	0	9.81	0	2.37	0.23	0	0	0	0	1.78	0	0	0
CP97156TWL02CAL01	BLUE CRAB	10.77	0	0	0.72	0	0	1.06	0.4	0	1.28	0	0	0	0	0	0.46	0	0	0
CP95114TWL00MIC01	CROAKER	343.41	13.89	2.11	12.08	2.64	20.3	30.2	9.37	0.7	25.55	10.82	1.52	2.07	0.8	1.88	2.64	6.93	7.05	5.26
CP95115TWL00MIC01	CROAKER	74.09	1.57	0.37	2.17	0.87	4.04	7	4.8	0	2.43	2.4	0.55	0.97	0.64	0	0.43	0.74	0.78	3.07
CP95117TWL00MIC01	CROAKER	83.59	2.26	0.39	2.22	0.85	4.32	6.87	4.6	0	2.39	2.65	0.8	1.31	0.81	0.24	1.09	1.43	1.26	3.68
CP95125TWL00MIC01	CROAKER	85.15	2.29	0.38	2.7	0.82	4.41	7.93	5.3	0	2.36	2.84	0.63	1.2	0.65	0.38	0	1.43	0.9	3.66
CP95156TWL00MIC01	CROAKER	81.25	0.94	0.11	0.55	0	1.67	1.76	14.87	0	1.03	0.88	0	0.65	0	0	0	2.26	0.91	10.47
CP95166TWL00MIC01	CROAKER	71.99	1.21	0.28	1.2	0.33	2.02	3.19	6.2	0	1.17	3.05	1.81	4.34	0.77	0.38	0.42	1.57	1.3	2.63
CP95169TWL00MIC01	CROAKER	116.05	0.68	0.1	0.54	0.17	1.67	2.26	6.78	0	1.58	6.64	6.99	15.18	2.88	0	0	0.61	0.55	5.36
CP95172TWL00MIC01	CROAKER	292.67	10.69	1.41	6.76	2.71	19.87	34.38	13.59	0	12.17	11.26	1.39	1.57	0.6	0.22	1.12	4.23	6.14	4.53
CP95SPYTWL00MIC01	CROAKER	135.71	4.91	0.79	4.08	0.92	7.25	10.92	7.42	0	7.06	3.98	0.52	0.94	0.35	0.18	0.9	3.04	2.75	4.96
CP95SPYTWL00MIC02	CROAKER	140.09	5.52	0.74	3.74	0.87	7.47	12.08	7.34	0	6.84	4.54	0.58	0.96	0.33	0.91	1.61	3.67	3.4	2.37
CP97036TWL01MIC01	CROAKER	47.48	1.02	0	1.41	0.24	3.05	7.25	0.71	0	2.5	2.22	0.27	0.37	0.19	0	0	1.45	0	0
CP97052TWL01MIC01	CROAKER	78.58	2.37	0	2.46	1.06	4.86	9.07	3.51	0	3.39	2.68	0.63	1.88	0.45	0	2.29	0.23	0	0
CP97071TWL12MIC01C	CROAKER	19.36	0.12	0	0.64	0	1.09	2.31	0.41	0	0.98	0.74	0	0	0	0	0	0.65	0.9	0
CP97082TWL01MIC01	CROAKER	57.31	1.21	0	2.2	0	2.62	5.27	0.46	0	5.3	2.16	0	0	0	0	4.32	0	1.63	0
CP97109TWL12MIC01C	CROAKER	34.82	1.65	0.21	0.74	1.17	2.38	2.64	1.25	0.2	1.24	0.87	0.2	0.43	0.21	0	1.07	0.33	0.31	0
CP97120TWL02MIC01	CROAKER	26.59	0.75	0.12	0.83	0.31	1.45	2.46	2.43	0	0.96	0.64	0	0.19	0.23	0	0.53	0.24	0	0
CP97149TWL02MIC01	CROAKER	50.74	0.74	0	3.09	0	1.92	2.9	1.21	0	5.58	0	0	0	0	0	0	3.79	2.94	0
CP97156TWL01MIC01	CROAKER	37.25	0.28	0	0.88	0	1.3	2.56	2.48	0	2.08	1.73	0	0	0	0	0.72	0	1.14	2.84
CP95114TWL00LEI01	SPOT	62.63	1.95	0.22	1.42	0.6	2.93	3.58	5.15	0.77	0.94	1.13	0.17	0.44	0.16	0.56	1.02	1.26	0.79	4.51
CP95115TWL00LEI01	SPOT	141.67	4.76	0.78	3.69	1.39	8.74	12.84	6.24	0	5.26	4.9	1.62	3.38	3.26	0.2	1.35	0.92	1.52	2.84
CP95125TWL00LEI01	SPOT	89.51	2.76	0.42	3.14	0.84	5.14	8.71	5.15	0	2.61	2.5	0.68	1.4	0.76	0	0	1.22	1.11	3.43
CP97036TWL02LEI01	SPOT	52.45	0	0	0.9	0	2.61	5.41	2.88	0	3.79	2.83	0	0	0	0	1.04	3.49	0	0
CP97052TWL01LEI01	SPOT	30.64	0.58	0	0.81	0.34	1.52	3.05	3.11	0	1.45	1	0	0.37	0	0	0.76	0	0	0
CP97109TWL02LEI01	SPOT	19.93	0.14	0.12	0.38	0.49	1.49	1.77	0.95	0.05	0.68	0.61	0	0.34	0	0	0.43	0	0	0.65
CP97120TWL12LEI01C	SPOT	27.18	0.54	0.19	0.77	0.31	1.48	2.66	1.46	0	1.16	0.67	0	0.61	0	0	0.42	0	0	1.14
CP97141TWL12LEI01C	SPOT	15.94	0.36	0	0.32	0	0.63	1.53	1.21	0	0.5	0.48	0	0.1	0	0	1.15	0	0	0
CP95152TWL00PEN01	WHITE SHRIM	125.44	3.71	0.49	2.92	0	9.08	11.16	9.4	0	9.16	5.77	0.58	0.74	0.11	0	0	0.63	0.76	1.77
CP95156TWL00PEN01	WHITE SHRIM	27.48	0	0.14	0	0	0.92	0.91	6.51	0	1.25	0	0	0	0	0	0	0	0	1.82
CP95158TWL00PEN01	WHITE SHRIM	28.60	0.68	0.34	1.1	0	1.02	1.12	4.27	0	0.84	0.34	0	0	0	0	0	0	0.85	1.5
CP95162TWL00PEN01	WHITE SHRIM	39.35	0.96	0.25	1.04	0	1.64	1.86	5.46	0	2.64	0.45	0.06	0.46	0.05	0	0	0	0.52	1.58
CP95164TWL00PEN01	WHITE SHRIM	34.12	0.41	0.11	0.34	0	1.07	0.84	6.73	0	1.05	0.22	0.1	0.52	0.13	0	0	0	0	3.06
CP95165TWL00PEN01	WHITE SHRIM	27.46	0.32	0.07	0	0	0.84	0.63	5.31	0	0.71	0.33	0.14	0.63	0.09	0	0	0	0	2.47
CP95166TWL00PEN01	WHITE SHRIM	39.75	0.43	0.1	0.51	0	1.04	0.91	7.63	0	0.71	1.06	0.47	1.47	0.2	0	0	0	0	2.62
CP95169TWL00PEN01	WHITE SHRIM	70.34	0.38	0.18	0	0	0.96	1.18	7.38	0	1.06	3.75	3.18	7.93	1.28	0	0	0	0	3.84
CP95172TWL00PEN01	WHITE SHRIM	55.87	1.56	0.32	1.09	0	3.58	5.92	5.93	0	1.9	1.66	0.02	0	0	0	0	0	0	2.53
CP95SPYTWL00PEN01	WHITE SHRIM	90.99	2.23	0.59	1.98	0	3.57	5.26	15.82	0	4.1	1.94	0	1.15	0	0	0	1.38	1.35	1.18
CP95SPYTWL00PEN02	WHITE SHRIM	75.62	1.98	0.52	2.47	0.21	4.01	5.59	8.28	0	3.52	2.03	0.26	0.64	0.36	0	0	1.64	0.92	1.1
CP97022TWL01PEN01	WHITE SHRIM	17.65	0.29	0	0.46	0	0.22	0.67	1.2	0	0.61	1.11	0.61	0.77	0	0	0.69	0	0.43	0
CP97036TWL02PEN01	WHITE SHRIM	16.27	0	0	0	0	0	0	3.19	0	0	0	0	0	0	0	0	3.24	0	0
CP97082TWL01PEN01	WHITE SHRIM	27.31	0.4	0.19	0.93	0	0.98	1.63	1.36	0	1.57	0.87	0	0	0	0	1.2	1.35	0.99	0
CP97141TWL12PEN01C	WHITE SHRIM	21.97	0.18	0	0.32	0	0.52	0.93	2.61	0	1.25	0.6	0	0	0	0	1.22	0	0	1.4
CP97156TWL12PEN01C	WHITE SHRIM	13.84	0.24	0	0.37	0	0.45	0.93	1.89	0	0.53	0.53	0	0	0	0	0	0	0.38	0
CP97172TWL12PEN01C	WHITE SHRIM	45.14	1.51	0	1.26	0	2.09	3.98	4.38	0	1.9	2.02	0	0	0	0	1.93	0	0.54	0

SAMPLEID	ORGANISM	CD	CR	CU	MN	NI	PB	Cd_ppb	Cr_ppb	Cu_ppb	Mn_ppb	Ni_ppb	Pb_ppb
CP95165TWL00CAL01	BLUE CRAB	0.063	0.34	75	17	0.05	0.16	63	340	75000	17000	50	160
CP95166TWL00CAL01	BLUE CRAB	0.848	0	56	12.8	0.2	0.16	848	250	56000	12800	200	160
CP95SPYTWL00CAL01	BLUE CRAB	0.313	3.7	65	15.4	0.13	0.38	313	3700	65000	15400	130	380
CP95SPYTWL00CAL02	BLUE CRAB	0.212	12.9	89	10	0.16	0.25	212	12900	89000	10000	160	250
CP97036TWL01CAL01	BLUE CRAB	0.06	0	27.7	13.4	0.14	0.13	60	250	27700	13400	140	130
CP97052TWL12CAL01C	BLUE CRAB	0.021	0.51	24.5	4.3	0.1	0.06	21	510	24500	4300	100	60
CP97109TWL12CAL01C	BLUE CRAB	0.4	0.76	86	16.9	0.11	0.16	400	760	86000	16900	110	160
CP97114TWL01CAL01	BLUE CRAB	0.2	0	25.1	4.6	0.16	0.16	200	250	25100	4600	160	160
CP97120TWL12CAL01C	BLUE CRAB	0.34	0.89	21.8	9	0.16	0.14	340	890	21800	9000	160	140
CP97141TWL12CAL01C	BLUE CRAB	0.17	2.2	46	25.7	0.45	0.23	170	2200	46000	25700	450	230
CP97156TWL02CAL01	BLUE CRAB	0.24	0.71	99	14.6	0.13	0.11	240	710	99000	14600	130	110
CP97HOBTWL00CAL01	BLUE CRAB		0						250				
CP97HOBTWL00CAL02	BLUE CRAB		0.6						600				
CP97HOBTWL00CAL03	BLUE CRAB		0						250				
CP97HOBTWL00CAL04	BLUE CRAB		1.1						1100				
CP97HOBTWL00CAL05	BLUE CRAB		0						250				
CP97HOBTWL00CAL06	BLUE CRAB		0						250				
CP97HOBTWL00CAL07	BLUE CRAB		0.8						800				
CP97HOBTWL00CAL08	BLUE CRAB		0.8						800				
CP97HOBTWL00CAL09	BLUE CRAB		0						250				
CP97SPYTWL00CAL01	BLUE CRAB		6.3						6300				
CP97SPYTWL00CAL02	BLUE CRAB		86.5						86500				
CP97SPYTWL00CAL03	BLUE CRAB		7.2						7200				
CP97SPYTWL00CAL04	BLUE CRAB		15.3						15300				
CP97SPYTWL00CAL05	BLUE CRAB		74.5						74500				
CP97SPYTWL00CAL06	BLUE CRAB		21.7						21700				
CP97SPYTWL00CAL07	BLUE CRAB		34.6						34600				
CP97SPYTWL00CAL08	BLUE CRAB		126.3						126300				
CP97SPYTWL00CAL09	BLUE CRAB		10.1						10100				
CP97SPYTWL00CAL10	BLUE CRAB		26.4						26400				
CP97SPYTWL00CAL11	BLUE CRAB		2.8						2800				
CP97SPYTWL00CAL12	BLUE CRAB		11.3						11300				
CP97SPYTWL00CAL13	BLUE CRAB		15.2						15200				
CP97SPYTWL00CAL14	BLUE CRAB		22.8						22800				
CP97SPYTWL00CAL15	BLUE CRAB		114.6						114600				
CP97SPYTWL00CAL16	BLUE CRAB		84						84000				
CP97SPYTWL00CAL17	BLUE CRAB		42.4						42400				
CP97SPYTWL02CAL01	BLUE CRAB		0.8						800				
CP97SPYTWL02CAL02	BLUE CRAB		50.7						50700				
CP97SPYTWL02CAL03	BLUE CRAB		5						5000				
CP97SPYTWL02CAL04	BLUE CRAB		0.6						600				
CP97SPYTWL02CAL05	BLUE CRAB		14.3						14300				
CP97SPYTWL02CAL06	BLUE CRAB		33.5						33500				
CP95114TWL00MIC01	CROAKER	0.503	0.57	0.9	2.8	0.12	0.09	503	570	900	2800	120	90
CP95115TWL00MIC01	CROAKER	0.02	0.31	1	2.9	0.06	0.03	20	310	1000	2900	60	30
CP95117TWL00MIC01	CROAKER	0.128	0	1.1	2.9	0.19	0.2	128	250	1100	2900	190	200
CP95125TWL00MIC01	CROAKER	0.356	0.27	0.93	4.2	0.12	0.09	356	270	930	4200	120	90
CP95156TWL00MIC01	CROAKER	0.1	1	1.7	4.2	0.37	0.36	100	1000	1700	4200	370	360
CP95166TWL00MIC01	CROAKER	0.295	0.35	1.2	0	0.36	0.17	295	350	1200	0	360	170
CP95169TWL00MIC01	CROAKER	0.041	1.1	1.4	0	0.25	0.13	41	1100	1400	0	250	130
CP95172TWL00MIC01	CROAKER	0.029	0.44	1.9	0	0.41	0.21	29	440	1900	0	410	210
CP95SPYTWL00MIC01	CROAKER	0.004	2.6	1.1	0	0.06765	0.04	4	2600	1100	0	67.65	40
CP95SPYTWL00MIC02	CROAKER	0.041	0.53	1.3	0	0.05	0.08	41	530	1300	0	50	80
CP97036TWL01MIC01	CROAKER	0.11	17.5	3.8	4.5	0.33	0.38	110	17500	3800	4500	330	380
CP97052TWL01MIC01	CROAKER	0.036	1.53	1.9	10.4	0.18	0.12	36	1530	1900	10400	180	120
CP97071TWL12MIC01C	CROAKER	0.029	1.1	1.5	3.3	0.7	0.26	29	1100	1500	3300	700	260
CP97082TWL01MIC01	CROAKER	0.01	1.1	1.6	2.5	0.18	0.07	10	1100	1600	2500	180	70
CP97109TWL12MIC01C	CROAKER	0.017	0.58	1.7	1.65	0.1	0.1	17	580	1700	1650	100	100
CP97120TWL02MIC01	CROAKER	0.012	0	4.3	4.3	0.13	0.09	12	250	4300	4300	130	90
CP97149TWL02MIC01	CROAKER	0.017	1.1	2.6	2.4	0.18	0.29	17	1100	2600	2400	180	290
CP97156TWL01MIC01	CROAKER	0.044	0.52	2	2	0.15	0.16	44	520	2000	2000	150	160
CP97SPYTWL01MIC01	CROAKER		1						1000				
CP97SPYTWL02MIC01	CROAKER		1.5						1500				
CP97SPYTWL02MIC02	CROAKER		1.3						1300				
CP97SPYTWL02MIC03	CROAKER		1						1000				
CP97SPYTWL02MIC04	CROAKER		0.7						700				
CP97SPYTWL02MIC05	CROAKER		4.3						4300				
CP97SPYTWL02MIC06C	CROAKER		1.1						1100				
CP97SPYTWL02MIC08	CROAKER		0.8						800				
CP97SPYTWL02MIC09	CROAKER		0.7						700				
CP97JIYTWL00CRA01	OYSTER		1.3						1300				
CP97JIYTWL00CRA02	OYSTER		2.2						2200				
CP97JIYTWL00CRA03	OYSTER		1.3						1300				
CP97JIYTWL00CRA04	OYSTER		2.3						2300				
CP97JIYTWL00CRA05	OYSTER		2.7						2700				
CP97JIYTWL00CRA06	OYSTER		3						3000				
CP97JIYTWL00CRA07	OYSTER		1.2						1200				
CP97JIYTWL00CRA08	OYSTER		3.2						3200				
CP97JIYTWL00CRA09	OYSTER		1.1						1100				
CP97JIYTWL00CRA10C	OYSTER		12.1						12100				
CP97JIYTWL00CRA12	OYSTER		2.2						2200				
CP97JIYTWL00CRA13	OYSTER		2.5						2500				
CP97JIYTWL00CRA14	OYSTER		1.1						1100				

SAMPLEID	ORGANISM	CD	CR	CU	MN	NI	PB	Cd_ppb	Cr_ppb	Cu_ppb	Mn_ppb	Ni_ppb	Pb_ppb
CP97JIYTWL00CRA15	OYSTER		1						1000				
CP97SPYTWL00CRA01C	OYSTER		222.8						222800				
CP97SPYTWL00CRA02	OYSTER		107.4						107400				
CP97SPYTWL00CRA04C	OYSTER		225.8						225800				
CP97SPYTWL00CRA05	OYSTER		78.1						78100				
CP97SPYTWL00CRA06	OYSTER		66.3						66300				
CP97SPYTWL00CRA07	OYSTER		515.9						515900				
CP97SPYTWL00CRA08C	OYSTER		189.1						189100				
CP97SPYTWL00CRA09	OYSTER		88.4						88400				
CP97SPYTWL00CRA10	OYSTER		128.4						128400				
CP97SPYTWL00CRA13C	OYSTER		152.3						152300				
CP97SPYTWL00CRA14	OYSTER		53.9						53900				
CP97SPYTWL00CRA15	OYSTER		65.8						65800				
CP97SPYTWL00CRA17	OYSTER		62.1						62100				
CP97SPYTWL00CRA18	OYSTER		64.3						64300				
CP97SPYTWL00CRA19	OYSTER		122.5						122500				
CP97SPYTWL00CRA20	OYSTER		54.7						54700				
CP97SPYTWL00CRA21	OYSTER		58.7						58700				
CP97SPYTWL00CRA22	OYSTER		113.6						113600				
CP97SPYTWL00CRA23	OYSTER		74.9						74900				
CP97SPYTWL00CRA24	OYSTER		78.6						78600				
CP97SPYTWL00CRA25	OYSTER		108						108000				
CP97SPYTWL00CRA26	OYSTER		82.3						82300				
CP97SPYTWL00CRA27	OYSTER		80.1						80100				
CP97SPYTWL00CRA28	OYSTER		97.2						97200				
CP97SPYTWL00CRA29	OYSTER		63.2						63200				
CP97SPYTWL00CRA30	OYSTER		64.8						64800				
CP97SPYTWL00CRA31	OYSTER		52.8						52800				
CP97SPYTWL00CRA32	OYSTER		61.6						61600				
CP97SPYTWL00CRA33	OYSTER		117.2						117200				
CP97SPYTWL00CRA34	OYSTER		57.4						57400				
CP97SPYTWL00CRA35	OYSTER		58.9						58900				
CP97SPYTWL00CRA36	OYSTER		87.4						87400				
CP97SPYTWL00CRA37	OYSTER		79.2						79200				
CP97SPYTWL00CRA38	OYSTER		138						138000				
CP97SPYTWL00CRA39	OYSTER		54.7						54700				
CP97SPYTWL00CRA40	OYSTER		48.7						48700				
CP97SPYTWL00CRA41	OYSTER		58.1						58100				
CP97SPYTWL00CRA42	OYSTER		41.5						41500				
CP97SPYTWL00CRA43	OYSTER		222.4						222400				
CP97SPYTWL00CRA44	OYSTER		31.6						31600				
CP97SPYTWL00CRA45	OYSTER		404						404000				
CP97SPYTWL00CRA46	OYSTER		70.5						70500				
CP97SPYTWL00CRA47	OYSTER		89.5						89500				
CP97SPYTWL00CRA48	OYSTER		49.8						49800				
CP97SPYTWL00CRA49	OYSTER		125.6						125600				
CP97SPYTWL00CRA50	OYSTER		221.2						221200				
CP97SPYTWL00CRA51	OYSTER		111.3						111300				
CP97SPYTWL00CRA52	OYSTER		190.2						190200				
CP97SPYTWL00CRA53	OYSTER		64.4						64400				
CP97SPYTWL00CRA54	OYSTER		55.4						55400				
CP97SPYTWL00CRA55	OYSTER		44.6						44600				
CP97SPYTWL00CRA56	OYSTER		91.3						91300				
CP97SPYTWL00CRA57	OYSTER		87.1						87100				
CP97SPYTWL00CRA58	OYSTER		66.8						66800				
CP97SPYTWL00CRA59	OYSTER		53.6						53600				
CP97SPYTWL00CRA60	OYSTER		118.8						118800				
CP97SPYTWL00CRA61	OYSTER		60.8						60800				
CP97SPYTWL00CRA62	OYSTER		101.2						101200				
CP97SPYTWL00CRA63	OYSTER		96.9						96900				
CP97WANTWL00CRA01	OYSTER		3.3						3300				
CP97WANTWL00CRA02	OYSTER		1						1000				
CP97WANTWL00CRA03	OYSTER		8.2						8200				
CP97WANTWL00CRA04	OYSTER		0.8						800				
CP97WANTWL00CRA05	OYSTER		1.9						1900				
CP97WANTWL00CRA06	OYSTER		1.1						1100				
CP97WANTWL00CRA07	OYSTER		1.5						1500				
CP97WANTWL00CRA08	OYSTER		0.5						500				
CP97WANTWL00CRA09(	OYSTER		0.7						700				
CP97WANTWL00CRA11	OYSTER		0.6						600				
CP97WANTWL00CRA12	OYSTER		5.6						5600				
CP97WANTWL00CRA13	OYSTER		0						250				
CP97WANTWL00CRA14	OYSTER		2.4						2400				
CP97WANTWL00CRA15	OYSTER		1.5						1500				
CP95114TWL00LEI01	SPOT	0.02	0.43	1.3	0	0.12	0.08	20	430	1300	0	120	80
CP95115TWL00LEI01	SPOT	0.047	0.48	2.3	1.4	0.16	0.24	47	480	2300	1400	160	240
CP95125TWL00LEI01	SPOT	0.262	0	1.4	0	0.6	0.21	262	250	1400	0	600	210
CP97036TWL02LEI01	SPOT	0.033	1.6	2.2	3.6	0.5	0.09	33	1600	2200	3600	500	90
CP97052TWL01LEI01	SPOT	0.074	1.05	2.3	18.4	0.3	0.22	74	1050	2300	18400	300	220
CP97109TWL02LEI01	SPOT	0.029	0.65	2.3	2.1	0.14	0.11	29	650	2300	2100	140	110
CP97120TWL12LEI01C	SPOT	0.024	0.6	3.2	3.4	0.11	0.1	24	600	3200	3400	110	100
CP97141TWL12LEI01C	SPOT	0.03	0.79	1.5	3.9	0.1	0.08	30	790	1500	3900	100	80
CP97SPYTWL02LEI01C	SPOT		1.8						1800				

SAMPLEID	ORGANISM	CD	CR	CU	MN	NI	PB	Cd_ppb	Cr_ppb	Cu_ppb	Mn_ppb	Ni_ppb	Pb_ppb
CP97SPYTWL02LEI02	SPOT		0.7						700				
CP97SPYTWL02LEI03	SPOT		2.7						2700				
CP97SPYTWL02LEI04C	SPOT		2.1						2100				
CP95152TWL00PEN01	WHITE SHRIMP	0.028	1	33	2.9	0.29	0.27	28	1000	33000	2900	290	270
CP95156TWL00PEN01	WHITE SHRIMP	0.096	0.53	28	2.3	0.29	0.14	96	530	28000	2300	290	140
CP95158TWL00PEN01	WHITE SHRIMP	1.096	0.84	26	10	0.31	0.28	1096	840	26000	10000	310	280
CP95162TWL00PEN01	WHITE SHRIMP	0.11	0.45	28	2.9	0.17	0.21	110	450	28000	2900	170	210
CP95164TWL00PEN01	WHITE SHRIMP	0.049	0	26	1.4	0.2	0.12	49	250	26000	1400	200	120
CP95165TWL00PEN01	WHITE SHRIMP	0.041	0.35	31	4.4	0.15	0.29	41	350	31000	4400	150	290
CP95166TWL00PEN01	WHITE SHRIMP	0.109	0	23	2.8	0.34	0.36	109	250	23000	2800	340	360
CP95169TWL00PEN01	WHITE SHRIMP	0.304	0	27	0	0.26	0.35	304	250	27000	0	260	350
CP95172TWL00PEN01	WHITE SHRIMP	0.039	0.41	15.8	0	0.5	0.11	39	410	15800	0	500	110
CP95SPYTWL00PEN01	WHITE SHRIMP	1.454	1.4	30	2.8	0.16	0.16	1454	1400	30000	2800	160	160
CP95SPYTWL00PEN02	WHITE SHRIMP	0.024	0.31	29	2.8	0.08	0.17	24	310	29000	2800	80	170
CP97022TWL01PEN01	WHITE SHRIMP	0.022	0	27.7	4.3	0.13	0.08	22	250	27700	4300	130	80
CP97036TWL02PEN01	WHITE SHRIMP	0.068	0.99	24.2	1.1	0.12	0.08	68	990	24200	1100	120	80
CP97082TWL01PEN01	WHITE SHRIMP	0.036	0	35	2.2	0.24	0.41	36	250	35000	2200	240	410
CP97141TWL12PEN01C	WHITE SHRIMP	0.08	1	20.6	1.49	0.17	0.08	80	1000	20600	1490	170	80
CP97156TWL12PEN01C	WHITE SHRIMP	0.017	0.62	22.4	2.3	0.16	0.09	17	620	22400	2300	160	90
CP97172TWL12PEN01C	WHITE SHRIMP	0.014	0.77	23.3	0.99	0.24	0.08	14	770	23300	990	240	80
CP97SPYTWL00PEN03C	WHITE SHRIMP		135.3						135300				
CP97SPYTWL00PEN06C	WHITE SHRIMP		167.2						167200				
CP97SPYTWL00PEN20C	WHITE SHRIMP		345						345000				
CP97SPYTWL00PEN21	WHITE SHRIMP		135.1						135100				
CP97SPYTWL00PEN23C	WHITE SHRIMP		57.7						57700				
CP97SPYTWL00PEN25	WHITE SHRIMP		69.8						69800				
CP97SPYTWL00PEN26C	WHITE SHRIMP		52.2						52200				
CP97SPYTWL00PEN28C	WHITE SHRIMP		147.5						147500				
CP97SPYTWL00PEN29C	WHITE SHRIMP		181.4						181400				
CP97SPYTWL00PEN31C	WHITE SHRIMP		97.1						97100				
CP97SPYTWL00PEN33C	WHITE SHRIMP		64						64000				
CP97SPYTWL00PEN35C	WHITE SHRIMP		29.7						29700				
CP97SPYTWL00PEN38C	WHITE SHRIMP		109.2						109200				
CP97SPYTWL00PEN40C	WHITE SHRIMP		77.2						77200				
CP97SPYTWL00PEN42C	WHITE SHRIMP		119.7						119700				
CP97SPYTWL00PEN45C	WHITE SHRIMP		50.1						50100				
CP97SPYTWL00PEN48	WHITE SHRIMP		100.6						100600				
CP97SPYTWL00PEN51C	WHITE SHRIMP		123.6						123600				

Appendix 7. HQs and HIs for Tissue Residues

A7A. TSV

A7A.1. Fish Residues

A7A.2. Invertebrate Residues

A7B. Bcv

A7B.1. Fish Residues

A7B.2. Invertebrate Residues

A7C. NOED

A7C.1. Fish Residues

A7C.2. Invertebrate Residues

A7D. LOED

A7D.1. Fish Residues

A7D.2. Invertebrate Residues

A7E. TRV Dolphin

A7E.1. Fish Residues

A7E.2. Invertebrate Residues

A7F. TRV Herring Gull

A7F.1. Fish Residues A7F.2 Invertebrates

A7G. TRV Cormorant

A7H. TRV Shark

A7I. TRV Sea Turtle

A7J. Supplemental Fish HQs

HQ for fish	TSV			ng/g dry (ppb)	1750	170	700	12000	1540	250	
group	Endpoint	name	site	rep	PCB	Cd	Cr	Cu	Ni	Pb	HI
navy	DEMERSAL	Black Sea Bass	Vermilion	1	0.11	0.06	0.03	0.07	0.01	14.45	14.73
navy	DEMERSAL	Gag Grouper	Vermilion	1	0.01	9.15	4.55	0.10	0.01	18.56	32.39
				HQavg	0.06	4.61	2.29	0.08	0.01	16.50	23.56
				HQmax	0.11	9.15	4.55	0.10	0.01	18.56	32.49
other	DEMERSAL	Gray Triggerfish	Y-73 reef	1	0.11						
other	DEMERSAL	Hake	Y-73 Reef	1	0.01	0.06	0.03	0.00	0.01	0.08	
other	DEMERSAL	Hake	Y-73 reef	2	0.01						
other	DEMERSAL	Leopard Toadfish	Y-73 Reef	1	0.11	0.06	0.03	0.00	0.01	0.08	
other	DEMERSAL	Leopard Toadfish	Y-73 reef	2	0.11						
other	DEMERSAL	Leopard Toadfish	Y-73 reef	3	0.11						
other	DEMERSAL	Leopard Toadfish	Y-73 reef	4	0.11						
other	DEMERSAL	Leopard Toadfish	Y-73 reef	5	0.01						
other	DEMERSAL	Leopard Toadfish	Edisto	1	0.41	0.06	5.35	0.16	4.81	10.30	
other	DEMERSAL	Leopard Toadfish	Edisto	2	0.11	0.06	1.13	0.11	0.01	11.90	
other	DEMERSAL	Black Sea Bass	Eagle's Nest	1	0.23	0.06	1.16	0.04	0.01	2.19	
other	DEMERSAL	Gray Triggerfish	Eagle's Nest	1	0.11	0.06	0.76	0.07	0.26	2.50	
other	DEMERSAL	Hake	Eagle's Nest	1		6.26	2.53	0.30		0.08	
other	DEMERSAL	Leopard Toadfish	Eagle's Nest	1	0.01	6.56	5.69	0.08		0.08	
other	DEMERSAL	Sheepshead	Eagle's Nest	1	0.11	0.06	0.79	0.07	0.74	3.26	
other	DEMERSAL	Black Sea Bass	Comanche	1	0.01	0.06	0.03	0.03	0.01	0.08	
				HQavg	0.11	1.33	1.75	0.09	0.73	3.06	7.06
				HQmax	0.41	6.56	5.69	0.30	4.81	11.90	29.67
reference	DEMERSAL	Oyster Toadfish	southern cont	1	0.01						
reference	DEMERSAL	Oyster Toadfish	southern cont	2	0.01						
reference	DEMERSAL	Bank Sea Bass	northern cont	1	0.11	0.06	0.82	0.07	0.34	1.78	
reference	DEMERSAL	Black Sea Bass	northern cont	1	0.11	0.06	0.71	0.08	0.01	1.86	
reference	DEMERSAL	Leopard Toadfish	northern cont	1	0.11	0.06	0.03	0.13	0.01	4.11	
reference	DEMERSAL	Scorpion fish	northern cont	1	0.11	0.06	0.03	0.00	0.30	2.30	
reference	DEMERSAL	Black Sea Bass	central contrc	1	0.01	0.06	0.78	0.04	0.01	1.89	
reference	DEMERSAL	Black Sea Bass	central contrc	2	0.01	0.06	0.03	0.05	0.01	0.08	
reference	DEMERSAL	Black Sea Bass	central contrc	3	0.01	0.06	1.50	0.09	0.31	0.08	
reference	DEMERSAL	Black Sea Bass	central contrc	4	0.01	0.06	1.82	0.04	0.30	0.08	
reference	DEMERSAL	Black Sea Bass	central contrc	5	0.01						
reference	DEMERSAL	Black Sea Bass	central contrc	6	0.01						
reference	DEMERSAL	Black Sea Bass	central contrc	7	0.11						
reference	DEMERSAL	Black Sea Bass	central contrc	8	0.11						
reference	DEMERSAL	Black Sea Bass	central contrc	9	0.77						
reference	DEMERSAL	Gag Grouper	central contrc	1	0.01	0.06	1.12	0.05	0.01	0.08	
reference	DEMERSAL	Gray Triggerfish	central contrc	1	0.01	0.06	8.00	0.04	0.35	0.08	
reference	DEMERSAL	Hake	central contrc	1		8.02	2.63	0.02		0.08	
reference	DEMERSAL	Leopard Toadfish	central contrc	1	0.11	0.06	0.03	0.05	0.01	0.08	
reference	DEMERSAL	Leopard Toadfish	central contrc	2	0.11	2.71	0.51	0.12	0.28	0.08	
reference	DEMERSAL	Leopard Toadfish	central contrc	3	0.11	0.06	1.15	0.03	0.01	0.08	
reference	DEMERSAL	Leopard Toadfish	central contrc	4	0.01						
reference	DEMERSAL	Queen Angelfish	central contrc	1	0.01	0.06	3.15	0.05	0.77	0.08	
reference	DEMERSAL	Red Grouper	central contrc	1	0.11	0.06	0.55	0.08	0.26	0.08	
reference	DEMERSAL	Scamp	central contrc	1	0.01	0.06	0.03	0.06	0.01	0.08	
reference	DEMERSAL	Scamp	central contrc	2	0.27	0.06	0.85	0.06	0.37	0.08	
				HQavg	0.09	0.65	1.32	0.06	0.20	0.72	3.04
				HQmax	0.77	8.02	8.00	0.13	0.77	4.11	21.81

HQ Invertebrates		TSV		ng/g dry (ppb)	2180	210	888	15000	1930	320	
group	Endpoint	name	site	rep	PCB	Cd	Cr	Cu	Ni	Pb	HI
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	1	0.54	16.40	0.03	0.10	0.01	0.08	
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	2	0.01						
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	1	0.11	0.06	0.65	1.46	0.01	2.33	
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	2		0.06	0.61	2.05	0.01	0.08	
navy	INVERTEBRATE	Florida Horse Conch	Vermillion	1	0.28	3.05	0.03	1.94	0.01	0.08	
navy	INVERTEBRATE	Sea Cucumber	Vermillion	1	0.25	0.06	0.68	0.05	0.01	2.61	
navy	INVERTEBRATE	Shovelnose Lobster	Vermillion	1	0.01	25.24	0.03	1.47	0.01	0.08	
navy	INVERTEBRATE	Turkey Wing	Vermillion	1	0.50	18.07	0.03	0.20	0.01	3.45	
navy	INVERTEBRATE	Sponge1	Besty Ross	1	0.01						
navy	INVERTEBRATE	Sponge2		1	0.01						
navy	INVERTEBRATE	Turkey Wing	Besty Ross	1	0.01	23.38	5.03	0.38		12.47	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	2	0.01	16.88	2.80	0.52		12.78	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	3	0.01						
				HQavg	0.15	11.47	1.10	0.91	0.01	3.77	17.41
				HQmax	0.54	25.24	5.03	2.05	0.01	12.78	45.66
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 Reef	1	0.11	87.62	0.03	0.33	0.01	0.08	
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	2	0.11						
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	3	0.01						
other	INVERTEBRATE	Lion's Paw Scallop	Y-73 Reef	1	0.11	64.05	0.03	0.05	0.01	3.05	
other	INVERTEBRATE	Lion's Paw Scallop	Y-73 reef	2	0.01						
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	1	0.36	30.48	0.57	0.25	0.01	0.08	
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	2	0.01	86.67	0.68	0.59	0.26	5.02	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	1	0.48	6.55	0.03	0.10	0.01	0.08	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	2		47.14	9.12	0.68	3.96	28.13	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	1	0.52	11.90	1.85	2.28	0.01	11.11	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	2	0.11	15.02	1.30	1.90	0.01	6.25	
other	INVERTEBRATE	Florida Spiny Jewel Box	Edisto	1		23.10	0.57	0.32	1.06	3.47	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	1	0.25	13.60	0.03	0.42	0.01	3.95	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	2	0.39	86.90	6.25	0.67	2.17	17.66	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	3	0.11	25.71	1.46	0.37		14.72	
other	INVERTEBRATE	Arc Shell	Eagle's Nest Tu	1	0.40	70.00	1.36	0.08	0.01	2.83	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest Tu	1	0.42	5.05	21.23	4.13	0.01	851.56	
other	INVERTEBRATE	Convex Slipper Shell	Eagle's Nest Tu	1		5.19	4.00	3.06		185.94	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	1	0.44	0.06	0.03	0.24	0.01	0.08	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	2		70.00	0.64	0.21	0.01	2.27	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	1	0.53	12.02	6.19	1.37	0.01	13.16	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	2		0.06	0.03	2.57	0.01	5.94	
other	INVERTEBRATE	Crested Oyster	Eagle's Nest LC	1	0.01	0.06	0.03	34.67	0.01	0.08	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	1	0.01	13.12	0.03	0.19	0.01	4.77	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	2	0.01						
other	INVERTEBRATE	Common American Auger	Comanche	1	0.40	0.06	0.03	4.53	0.01	19.22	
other	INVERTEBRATE	Crested Oyster	Comanche	1	0.01						
other	INVERTEBRATE	Purse Shell	Comanche	1	0.01						
				HQavg	0.21	30.65	2.52	2.68	0.38	53.61	90.06
				HQmax	0.53	87.62	21.23	34.67	3.96	851.56	999.57
reference	INVERTEBRATE	Common American Auger	northern contro	1 0		38.81	3.03	3.80	11.66	7.94	
reference	INVERTEBRATE	Florida Spiny Jewel Box	northern contro	1 0		33.33	2.55	0.56	1.74	6.52	
reference	INVERTEBRATE	Crested Oyster	central control s	1 0	0.01						
reference	INVERTEBRATE	Florida Horse Conch	central control s	1 0	0.23	0.06	0.59	15.10	0.01	1.42	
reference	INVERTEBRATE	Shovelnose Lobster	central control s	1 0	0.01	39.76	0.61	0.53	0.01	0.08	
				HQavg	0.08	27.99	1.70	5.00	3.36	3.99	42.11
				HQmax	0.23	39.76	3.03	15.10	11.66	7.94	77.72

HQ for fish	Bcv			ng/g dry (ppb)	24305.05	2380	3200	2480	1540	1590	
group	Endpoint	name	site	rep	PCB	Cd	Cr	Cu	Ni	Pb	HI
navy	DEMERSAL FISH	Black Sea Bass	Vermillion	1	0.01	0.00	0.01	0.34	0.01	2.27	
navy	DEMERSAL FISH	Gag Grouper	Vermillion	1	0.00	0.65	1.00	0.46	0.01	2.92	
				HQavg	0.00	0.33	0.50	0.40	0.01	2.59	3.84
				HQmax	0.01	0.65	1.00	0.46	0.01	2.92	5.05
other	DEMERSAL FISH	Gray Triggerfish	Y-73 reef	1	0.01						
other	DEMERSAL FISH	Hake	Y-73 Reef	1	0.00	0.00	0.01	0.01	0.01	0.01	
other	DEMERSAL FISH	Hake	Y-73 reef	2	0.00						
other	DEMERSAL FISH	Leopard Toadfish	Y-73 Reef	1	0.01	0.00	0.01	0.01	0.01	0.01	
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	2	0.01						
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	3	0.01						
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	4	0.01						
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	5	0.00						
other	DEMERSAL FISH	Leopard Toadfish	Edisto	1	0.03	0.00	1.17	0.76	4.81	1.62	
other	DEMERSAL FISH	Leopard Toadfish	Edisto	2	0.01	0.00	0.25	0.55	0.01	1.87	
other	DEMERSAL FISH	Black Sea Bass	Eagle's Nest Tug	1	0.02	0.00	0.25	0.20	0.01	0.34	
other	DEMERSAL FISH	Gray Triggerfish	Eagle's Nest Tug	1	0.01	0.00	0.17	0.34	0.26	0.39	
other	DEMERSAL FISH	Hake	Eagle's Nest Tug	1		0.45	0.55	1.43		0.01	
other	DEMERSAL FISH	Leopard Toadfish	Eagle's Nest Tug	1	0.00	0.47	1.24	0.37		0.01	
other	DEMERSAL FISH	Sheepshead	Eagle's Nest Tug	1	0.01	0.00	0.17	0.33	0.74	0.51	
other	DEMERSAL FISH	Black Sea Bass	Comanche	1	0.00	0.00	0.01	0.15	0.01	0.01	
				HQavg	0.01	0.09	0.38	0.42			0.90
				HQmax	0.03	0.47	1.24	1.43	4.81	1.87	9.85
reference	DEMERSAL FISH	Oyster Toadfish	southern control s	1	0.00						
reference	DEMERSAL FISH	Oyster Toadfish	southern control s	2	0.00						
reference	DEMERSAL FISH	Bank Sea Bass	northern control s	1	0.01	0.00	0.18	0.31	0.34	0.28	
reference	DEMERSAL FISH	Black Sea Bass	northern control s	1	0.01	0.00	0.16	0.37	0.01	0.29	
reference	DEMERSAL FISH	Leopard Toadfish	northern control s	1	0.01	0.00	0.01	0.63	0.01	0.65	
reference	DEMERSAL FISH	Scorpion fish	northern control s	1	0.01	0.00	0.01	0.01	0.30	0.36	
reference	DEMERSAL FISH	Black Sea Bass	central control sit	1	0.00	0.00	0.17	0.19	0.01	0.30	
reference	DEMERSAL FISH	Black Sea Bass	central control sit	2	0.00	0.00	0.01	0.23	0.01	0.01	
reference	DEMERSAL FISH	Black Sea Bass	central control sit	3	0.00	0.00	0.33	0.41	0.31	0.01	
reference	DEMERSAL FISH	Black Sea Bass	central control sit	4	0.00	0.00	0.40	0.18	0.30	0.01	
reference	DEMERSAL FISH	Black Sea Bass	central control sit	5	0.00						
reference	DEMERSAL FISH	Black Sea Bass	central control sit	6	0.00						
reference	DEMERSAL FISH	Black Sea Bass	central control sit	7	0.01						
reference	DEMERSAL FISH	Black Sea Bass	central control sit	8	0.01						
reference	DEMERSAL FISH	Black Sea Bass	central control sit	9	0.06						
reference	DEMERSAL FISH	Gag Grouper	central control sit	1	0.00	0.00	0.25	0.26	0.01	0.01	
reference	DEMERSAL FISH	Gray Triggerfish	central control sit	1	0.00	0.00	1.75	0.20	0.35	0.01	
reference	DEMERSAL FISH	Hake	central control sit	1		0.57	0.58	0.08		0.01	
reference	DEMERSAL FISH	Leopard Toadfish	central control sit	1	0.01	0.00	0.01	0.26	0.01	0.01	
reference	DEMERSAL FISH	Leopard Toadfish	central control sit	2	0.01	0.19	0.11	0.58	0.28	0.01	
reference	DEMERSAL FISH	Leopard Toadfish	central control sit	3	0.01	0.00	0.25	0.13	0.01	0.01	
reference	DEMERSAL FISH	Leopard Toadfish	central control sit	4	0.00						
reference	DEMERSAL FISH	Queen Angelfish	central control sit	1	0.00	0.00	0.69	0.23	0.77	0.01	
reference	DEMERSAL FISH	Red Grouper	central control sit	1	0.01	0.00	0.12	0.40	0.26	0.01	
reference	DEMERSAL FISH	Scamp	central control sit	1	0.00	0.00	0.01	0.27	0.01	0.01	
reference	DEMERSAL FISH	Scamp	central control sit	2	0.02	0.00	0.19	0.28	0.37	0.01	
				HQavg	0.01	0.05	0.29	0.28	0.20	0.11	0.93
				HQmax	0.06	0.57	1.75	0.63	0.77	0.65	4.43

HQ Invertebrates		Bcv		ng/g dry (ppb)	4680	186000	20000	62000	16400	81000	
group	Endpoint	name	site	rep	PCB	Cd	Cr	Cu	Ni	Pb	HI
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	1	0.25	0.02	0.00	0.03	0.00	0.00	
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	2	0.01						
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	1	0.05	0.00	0.03	0.35	0.00	0.01	
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	2		0.00	0.03	0.50	0.00	0.00	
navy	INVERTEBRATE	Florida Horse Conch	Vermillion	1	0.13	0.00	0.00	0.47	0.00	0.00	
navy	INVERTEBRATE	Sea Cucumber	Vermillion	1	0.12	0.00	0.03	0.01	0.00	0.01	
navy	INVERTEBRATE	Shovelnose Lobster	Vermillion	1	0.01	0.03	0.00	0.36	0.00	0.00	
navy	INVERTEBRATE	Turkey Wing	Vermillion	1	0.24	0.02	0.00	0.05	0.00	0.01	
navy	INVERTEBRATE	Sponge1	Besty Ross	1	0.01						
navy	INVERTEBRATE	Sponge2		1	0.01						
navy	INVERTEBRATE	Turkey Wing	Besty Ross	1	0.01	0.03	0.22	0.09		0.05	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	2	0.01	0.02	0.12	0.13		0.05	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	3	0.01						
				HQavg	0.07	0.01	0.05	0.22	0.00	0.01	0.37
				HQmax	0.25	0.03	0.22	0.50	0.00	0.05	1.05
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 Reef	1	0.05	0.10	0.00	0.08	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	2	0.05						
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	3	0.01						
other	INVERTEBRATE	Lion’s Paw Scallop	Y-73 Reef	1	0.05	0.07	0.00	0.01	0.00	0.01	
other	INVERTEBRATE	Lion’s Paw Scallop	Y-73 reef	2	0.01						
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	1	0.17	0.03	0.03	0.06	0.00	0.00	
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	2	0.01	0.10	0.03	0.14	0.03	0.02	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	1	0.23	0.01	0.00	0.02	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	2		0.05	0.41	0.16	0.47	0.11	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	1	0.24	0.01	0.08	0.55	0.00	0.04	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	2	0.05	0.02	0.06	0.46	0.00	0.02	
other	INVERTEBRATE	Florida Spiny Jewel Box	Edisto	1		0.03	0.03	0.08	0.12	0.01	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	1	0.12	0.02	0.00	0.10	0.00	0.02	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	2	0.18	0.10	0.28	0.16	0.26	0.07	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	3	0.05	0.03	0.07	0.09		0.06	
other	INVERTEBRATE	Arc Shell	Eagle's Nest Tu	1	0.18	0.08	0.06	0.02	0.00	0.01	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest Tu	1	0.20	0.01	0.94	1.00	0.00	3.36	
other	INVERTEBRATE	Convex Slipper Shell	Eagle's Nest Tu	1		0.01	0.18	0.74		0.73	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	1	0.20	0.00	0.00	0.06	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	2		0.08	0.03	0.05	0.00	0.01	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	1	0.25	0.01	0.28	0.33	0.00	0.05	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	2		0.00	0.00	0.62	0.00	0.02	
other	INVERTEBRATE	Crested Oyster	Eagle's Nest LC	1	0.01	0.00	0.00	8.39	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	1	0.01	0.01	0.00	0.05	0.00	0.02	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	2	0.01						
other	INVERTEBRATE	Common American Auger	Comanche	1	0.19	0.00	0.00	1.10	0.00	0.08	
other	INVERTEBRATE	Crested Oyster	Comanche	1	0.01						
other	INVERTEBRATE	Purse Shell	Comanche	1	0.01						
				HQavg	0.10	0.03	0.11	0.65	0.05	0.21	1.15
				HQmax	0.25	0.10	0.94	8.39	0.47	3.36	13.51
reference	INVERTEBRATE	Common American Auger	northern contro	1 0		0.04	0.13	0.92	1.37	0.03	
reference	INVERTEBRATE	Florida Spiny Jewel Box	northern contro	1 0		0.04	0.11	0.14	0.20	0.03	
reference	INVERTEBRATE	Crested Oyster	central control s	1 0	0.01						
reference	INVERTEBRATE	Florida Horse Conch	central control s	1 0	0.11	0.00	0.03	3.65	0.00	0.01	
reference	INVERTEBRATE	Shovelnose Lobster	central control s	1 0	0.01	0.04	0.03	0.13	0.00	0.00	
				HQavg	0.04	0.03	0.08	1.21	0.39	0.02	1.77
				HQmax	0.11	0.04	0.13	3.65	1.37	0.03	5.34

HQ for fish	NOED			ng/g dry (ppb)	6000	1600	720	640	10200	
group	Endpoint	name	site	rep	PCB	Cd	Cr	Cu	Pb	HI
navy	DEMERSAL FISH	Black Sea Bass	Vermillion	1	0.03	0.01	0.03	1.32	0.35	
navy	DEMERSAL FISH	Gag Grouper	Vermillion	1	0.00	0.97	4.43	1.79	0.45	
				HQavg	0.02	0.49	2.23	1.55	0.40	4.69
				HQmax	0.03	0.97	4.43	1.79	0.45	7.68
other	DEMERSAL FISH	Gray Triggerfish	Y-73 reef	1	0.03					
other	DEMERSAL FISH	Hake	Y-73 Reef	1	0.00	0.01	0.03	0.03	0.00	
other	DEMERSAL FISH	Hake	Y-73 reef	2	0.00					
other	DEMERSAL FISH	Leopard Toadfish	Y-73 Reef	1	0.03	0.01	0.03	0.03	0.00	
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	2	0.03					
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	3	0.03					
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	4	0.03					
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	5	0.00					
other	DEMERSAL FISH	Leopard Toadfish	Edisto	1	0.12	0.01	5.21	2.96	0.25	
other	DEMERSAL FISH	Leopard Toadfish	Edisto	2	0.03	0.01	1.09	2.13	0.29	
other	DEMERSAL FISH	Black Sea Bass	Eagle's Nest Tug	1	0.07	0.01	1.13	0.78	0.05	
other	DEMERSAL FISH	Gray Triggerfish	Eagle's Nest Tug	1	0.03	0.01	0.74	1.31	0.06	
other	DEMERSAL FISH	Hake	Eagle's Nest Tug	1		0.67	2.46	5.56	0.00	
other	DEMERSAL FISH	Leopard Toadfish	Eagle's Nest Tug	1	0.00	0.70	5.53	1.45	0.00	
other	DEMERSAL FISH	Sheepshead	Eagle's Nest Tug	1	0.03	0.01	0.77	1.28	0.08	
other	DEMERSAL FISH	Black Sea Bass	Comanche	1	0.00	0.01	0.03	0.56	0.00	
				HQavg	0.03	0.14	1.70	1.61	0.07	3.56
				HQmax	0.12	0.70	5.53	5.56	0.29	12.19
reference	DEMERSAL FISH	Oyster Toadfish	southern control s	1	0.00					
reference	DEMERSAL FISH	Oyster Toadfish	southern control s	2	0.00					
reference	DEMERSAL FISH	Bank Sea Bass	northern control s	1	0.03	0.01	0.80	1.22	0.04	
reference	DEMERSAL FISH	Black Sea Bass	northern control s	1	0.03	0.01	0.69	1.44	0.05	
reference	DEMERSAL FISH	Leopard Toadfish	northern control s	1	0.03	0.01	0.03	2.45	0.10	
reference	DEMERSAL FISH	Scorpion fish	northern control s	1	0.03	0.01	0.03	0.03	0.06	
reference	DEMERSAL FISH	Black Sea Bass	central control site	1	0.00	0.01	0.76	0.74	0.05	
reference	DEMERSAL FISH	Black Sea Bass	central control site	2	0.00	0.01	0.03	0.90	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control site	3	0.00	0.01	1.46	1.60	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control site	4	0.00	0.01	1.77	0.71	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control site	5	0.00					
reference	DEMERSAL FISH	Black Sea Bass	central control site	6	0.00					
reference	DEMERSAL FISH	Black Sea Bass	central control site	7	0.03					
reference	DEMERSAL FISH	Black Sea Bass	central control site	8	0.03					
reference	DEMERSAL FISH	Black Sea Bass	central control site	9	0.22					
reference	DEMERSAL FISH	Gag Grouper	central control site	1	0.00	0.01	1.09	1.01	0.00	
reference	DEMERSAL FISH	Gray Triggerfish	central control site	1	0.00	0.01	7.78	0.78	0.00	
reference	DEMERSAL FISH	Hake	central control site	1		0.85	2.56	0.31	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	1	0.03	0.01	0.03	1.02	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	2	0.03	0.29	0.50	2.24	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	3	0.03	0.01	1.12	0.51	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	4	0.00					
reference	DEMERSAL FISH	Queen Angelfish	central control site	1	0.00	0.01	3.07	0.89	0.00	
reference	DEMERSAL FISH	Red Grouper	central control site	1	0.03	0.01	0.54	1.54	0.00	
reference	DEMERSAL FISH	Scamp	central control site	1	0.00	0.01	0.03	1.06	0.00	
reference	DEMERSAL FISH	Scamp	central control site	2	0.08	0.01	0.83	1.08	0.00	
				HQavg	0.03	0.07	1.28	1.08	0.02	2.48
				HQmax	0.22	0.85	7.78	2.45	0.10	11.41

HQ Invertebrates		NOED		ng/g dry (ppb)	3000	4500	720	36000	14150	20000	
group	Endpoint	name	site	rep	PCB	Cd	Cr	Cu	Ni	Pb	HI
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	1	0.39	0.77	0.03	0.04	0.00	0.00	
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	2	0.01						
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	1	0.08	0.00	0.80	0.61	0.00	0.04	
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	2		0.00	0.76	0.85	0.00	0.00	
navy	INVERTEBRATE	Florida Horse Conch	Vermillion	1	0.21	0.14	0.03	0.81	0.00	0.00	
navy	INVERTEBRATE	Sea Cucumber	Vermillion	1	0.18	0.00	0.83	0.02	0.00	0.04	
navy	INVERTEBRATE	Shovelnose Lobster	Vermillion	1	0.01	1.18	0.03	0.61	0.00	0.00	
navy	INVERTEBRATE	Turkey Wing	Vermillion	1	0.37	0.84	0.03	0.08	0.00	0.06	
navy	INVERTEBRATE	Sponge1	Besty Ross	1	0.01						
navy	INVERTEBRATE	Sponge2		1	0.01						
navy	INVERTEBRATE	Turkey Wing	Besty Ross	1	0.01	1.09	6.21	0.16		0.20	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	2	0.01	0.79	3.45	0.22		0.20	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	3	0.01						
				HQavg	0.11	0.54	1.35	0.38	0.00	0.06	2.44
				HQmax	0.39	1.18	6.21	0.85	0.00	0.20	8.84
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 Reef	1	0.08	4.09	0.03	0.14	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	2	0.08						
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	3	0.01						
other	INVERTEBRATE	Lion's Paw Scallop	Y-73 Reef	1	0.08	2.99	0.03	0.02	0.00	0.05	
other	INVERTEBRATE	Lion's Paw Scallop	Y-73 reef	2	0.01						
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	1	0.26	1.42	0.70	0.10	0.00	0.00	
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	2	0.01	4.04	0.84	0.25	0.04	0.08	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	1	0.35	0.31	0.03	0.04	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	2		2.20	11.25	0.28	0.54	0.45	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	1	0.38	0.56	2.28	0.95	0.00	0.18	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	2	0.08	0.70	1.60	0.79	0.00	0.10	
other	INVERTEBRATE	Florida Spiny Jewel Box	Edisto	1		1.08	0.70	0.13	0.14	0.06	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	1	0.18	0.63	0.03	0.17	0.00	0.06	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	2	0.28	4.06	7.71	0.28	0.30	0.28	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	3	0.08	1.20	1.81	0.15		0.24	
other	INVERTEBRATE	Arc Shell	Eagle's Nest Tu	1	0.29	3.27	1.68	0.03	0.00	0.05	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest Tu	1	0.31	0.24	26.18	1.72	0.00	13.63	
other	INVERTEBRATE	Convex Slipper Shell	Eagle's Nest Tu	1		0.24	4.93	1.28		2.98	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	1	0.32	0.00	0.03	0.10	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	2		3.27	0.79	0.09	0.00	0.04	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	1	0.39	0.56	7.64	0.57	0.00	0.21	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	2		0.00	0.03	1.07	0.00	0.10	
other	INVERTEBRATE	Crested Oyster	Eagle's Nest LC	1	0.01	0.00	0.03	14.44	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	1	0.01	0.61	0.03	0.08	0.00	0.08	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	2	0.01						
other	INVERTEBRATE	Common American Auger	Comanche	1	0.29	0.00	0.03	1.89	0.00	0.31	
other	INVERTEBRATE	Crested Oyster	Comanche	1	0.01						
other	INVERTEBRATE	Purse Shell	Comanche	1	0.01						
				HQavg	0.15	1.43	3.11	1.12	0.05	0.86	6.72
				HQmax	0.39	4.09	26.18	14.44	0.54	13.63	59.27
reference	INVERTEBRATE	Common American Auger	northern contro	1 0		1.81	3.74	1.58	1.59	0.13	
reference	INVERTEBRATE	Florida Spiny Jewel Box	northern contro	1 0		1.56	3.14	0.23	0.24	0.10	
reference	INVERTEBRATE	Crested Oyster	central control s	1 0	0.01						
reference	INVERTEBRATE	Florida Horse Conch	central control s	1 0	0.17	0.00	0.73	6.29	0.00	0.02	
reference	INVERTEBRATE	Shovelnose Lobster	central control s	1 0	0.01	1.86	0.76	0.22	0.00	0.00	
				HQavg	0.06	1.31	2.09	2.08	0.46	0.06	6.06
				HQmax	0.17	1.86	3.74	6.29	1.59	0.13	13.77

HQ for fish	LOED			ng/g dry (ppb)	7200	3600	1740	3200	16080	
group	Endpoint	name	site	rep	PCB	Cd	Cr	Cu	Pb	HI
navy	DEMERSAL FISH	Black Sea Bass	Vermillion	1	0.03	0.00	0.01	0.26	0.22	
navy	DEMERSAL FISH	Gag Grouper	Vermillion	1	0.00	0.43	1.83	0.36	0.29	
				HQavg	0.02	0.22	0.92	0.31	0.26	1.72
				HQmax	0.03	0.43	1.83	0.36	0.29	2.94
other	DEMERSAL FISH	Gray Triggerfish	Y-73 reef	1	0.03					
other	DEMERSAL FISH	Hake	Y-73 Reef	1	0.00	0.00	0.01	0.01	0.00	
other	DEMERSAL FISH	Hake	Y-73 reef	2	0.00					
other	DEMERSAL FISH	Leopard Toadfish	Y-73 Reef	1	0.03	0.00	0.01	0.01	0.00	
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	2	0.03					
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	3	0.03					
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	4	0.03					
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	5	0.00					
other	DEMERSAL FISH	Leopard Toadfish	Edisto	1	0.10	0.00	2.15	0.59	0.16	
other	DEMERSAL FISH	Leopard Toadfish	Edisto	2	0.03	0.00	0.45	0.43	0.19	
other	DEMERSAL FISH	Black Sea Bass	Eagle's Nest Tug	1	0.06	0.00	0.47	0.16	0.03	
other	DEMERSAL FISH	Gray Triggerfish	Eagle's Nest Tug	1	0.03	0.00	0.31	0.26	0.04	
other	DEMERSAL FISH	Hake	Eagle's Nest Tug	1		0.30	1.02	1.11	0.00	
other	DEMERSAL FISH	Leopard Toadfish	Eagle's Nest Tug	1	0.00	0.31	2.29	0.29	0.00	
other	DEMERSAL FISH	Sheepshead	Eagle's Nest Tug	1	0.03	0.00	0.32	0.26	0.05	
other	DEMERSAL FISH	Black Sea Bass	Comanche	1	0.00	0.00	0.01	0.11	0.00	
				HQavg	0.03	0.06	0.70	0.32	0.05	1.16
				HQmax	0.10	0.31	2.29	1.11	0.19	3.99
reference	DEMERSAL FISH	Oyster Toadfish	southern control s	1	0.00					
reference	DEMERSAL FISH	Oyster Toadfish	southern control s	2	0.00					
reference	DEMERSAL FISH	Bank Sea Bass	northern control s	1	0.03	0.00	0.33	0.24	0.03	
reference	DEMERSAL FISH	Black Sea Bass	northern control s	1	0.03	0.00	0.29	0.29	0.03	
reference	DEMERSAL FISH	Leopard Toadfish	northern control s	1	0.03	0.00	0.01	0.49	0.06	
reference	DEMERSAL FISH	Scorpion fish	northern control s	1	0.03	0.00	0.01	0.01	0.04	
reference	DEMERSAL FISH	Black Sea Bass	central control site	1	0.00	0.00	0.31	0.15	0.03	
reference	DEMERSAL FISH	Black Sea Bass	central control site	2	0.00	0.00	0.01	0.18	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control site	3	0.00	0.00	0.60	0.32	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control site	4	0.00	0.00	0.73	0.14	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control site	5	0.00					
reference	DEMERSAL FISH	Black Sea Bass	central control site	6	0.00					
reference	DEMERSAL FISH	Black Sea Bass	central control site	7	0.03					
reference	DEMERSAL FISH	Black Sea Bass	central control site	8	0.03					
reference	DEMERSAL FISH	Black Sea Bass	central control site	9	0.19					
reference	DEMERSAL FISH	Gag Grouper	central control site	1	0.00	0.00	0.45	0.20	0.00	
reference	DEMERSAL FISH	Gray Triggerfish	central control site	1	0.00	0.00	3.22	0.16	0.00	
reference	DEMERSAL FISH	Hake	central control site	1		0.38	1.06	0.06	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	1	0.03	0.00	0.01	0.20	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	2	0.03	0.13	0.21	0.45	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	3	0.03	0.00	0.46	0.10	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	4	0.00					
reference	DEMERSAL FISH	Queen Angelfish	central control site	1	0.00	0.00	1.27	0.18	0.00	
reference	DEMERSAL FISH	Red Grouper	central control site	1	0.03	0.00	0.22	0.31	0.00	
reference	DEMERSAL FISH	Scamp	central control site	1	0.00	0.00	0.01	0.21	0.00	
reference	DEMERSAL FISH	Scamp	central control site	2	0.06	0.00	0.34	0.22	0.00	
				HQavg	0.02	0.03	0.53	0.22	0.01	0.81
				HQmax	0.19	0.38	3.22	0.49	0.06	4.34

HQ Invertebrates		LOED		ng/g dry (ppb)	5500	6450	5400	40500	141500	101750	
group	Endpoint	name	site	rep	PCB	Cd	Cr	Cu	Ni	Pb	HI
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	1	0.21	0.53	0.00	0.04	0.00	0.00	
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	2	0.00						
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	1	0.05	0.00	0.11	0.54	0.00	0.01	
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	2		0.00	0.10	0.76	0.00	0.00	
navy	INVERTEBRATE	Florida Horse Conch	Vermillion	1	0.11	0.10	0.00	0.72	0.00	0.00	
navy	INVERTEBRATE	Sea Cucumber	Vermillion	1	0.10	0.00	0.11	0.02	0.00	0.01	
navy	INVERTEBRATE	Shovelnose Lobster	Vermillion	1	0.00	0.82	0.00	0.55	0.00	0.00	
navy	INVERTEBRATE	Turkey Wing	Vermillion	1	0.20	0.59	0.00	0.07	0.00	0.01	
navy	INVERTEBRATE	Sponge1	Besty Ross	1	0.00						
navy	INVERTEBRATE	Sponge2		1	0.00						
navy	INVERTEBRATE	Turkey Wing	Besty Ross	1	0.00	0.76	0.83	0.14		0.04	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	2	0.00	0.55	0.46	0.19		0.04	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	3	0.00						
				HQavg	0.06	0.37	0.18	0.34	0.00	0.01	0.96
				HQmax	0.21	0.82	0.83	0.76	0.00	0.04	2.66
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 Reef	1	0.05	2.85	0.00	0.12	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	2	0.05						
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	3	0.00						
other	INVERTEBRATE	Lion’s Paw Scallop	Y-73 Reef	1	0.05	2.09	0.00	0.02	0.00	0.01	
other	INVERTEBRATE	Lion’s Paw Scallop	Y-73 reef	2	0.00						
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	1	0.14	0.99	0.09	0.09	0.00	0.00	
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	2	0.00	2.82	0.11	0.22	0.00	0.02	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	1	0.19	0.21	0.00	0.04	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	2		1.53	1.50	0.25	0.05	0.09	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	1	0.20	0.39	0.30	0.84	0.00	0.03	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	2	0.05	0.49	0.21	0.70	0.00	0.02	
other	INVERTEBRATE	Florida Spiny Jewel Box	Edisto	1		0.75	0.09	0.12	0.01	0.01	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	1	0.10	0.44	0.00	0.15	0.00	0.01	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	2	0.15	2.83	1.03	0.25	0.03	0.06	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	3	0.05	0.84	0.24	0.14		0.05	
other	INVERTEBRATE	Arc Shell	Eagle's Nest Tu	1	0.16	2.28	0.22	0.03	0.00	0.01	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest Tu	1	0.17	0.16	3.49	1.53	0.00	2.68	
other	INVERTEBRATE	Convex Slipper Shell	Eagle's Nest Tu	1		0.17	0.66	1.13		0.58	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	1	0.17	0.00	0.00	0.09	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	2		2.28	0.11	0.08	0.00	0.01	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	1	0.21	0.39	1.02	0.51	0.00	0.04	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	2		0.00	0.00	0.95	0.00	0.02	
other	INVERTEBRATE	Crested Oyster	Eagle's Nest LC	1	0.00	0.00	0.00	12.84	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	1	0.00	0.43	0.00	0.07	0.00	0.01	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	2	0.00						
other	INVERTEBRATE	Common American Auger	Comanche	1	0.16	0.00	0.00	1.68	0.00	0.06	
other	INVERTEBRATE	Crested Oyster	Comanche	1	0.00						
other	INVERTEBRATE	Purse Shell	Comanche	1	0.00						
				HQavg	0.08	1.00	0.41	0.99	0.01	0.17	2.66
				HQmax	0.21	2.85	3.49	12.84	0.05	2.68	22.13
reference	INVERTEBRATE	Common American Auger	northern contro	1 0		1.26	0.50	1.41	0.16	0.02	
reference	INVERTEBRATE	Florida Spiny Jewel Box	northern contro	1 0		1.09	0.42	0.21	0.02	0.02	
reference	INVERTEBRATE	Crested Oyster	central control s	1 0	0.00						
reference	INVERTEBRATE	Florida Horse Conch	central control s	1 0	0.09	0.00	0.10	5.59	0.00	0.00	
reference	INVERTEBRATE	Shovelnose Lobster	central control s	1 0	0.00	1.29	0.10	0.20	0.00	0.00	
				HQavg	0.03	0.91	0.28	1.85	0.05	0.01	3.13
				HQmax	0.09	1.29	0.50	5.59	0.16	0.02	7.66

HQ for fish	**Dolphin TRV**			ng/g dry (ppb)	**1270**	**108140**	
group	Endpoint	name	site	rep	**PCB**	**Cu**	**HI**
navy	DEMERSAL FISH	Black Sea Bass	Vermillion	1	0.16	0.01	
navy	DEMERSAL FISH	Gag Grouper	Vermillion	1	0.02	0.01	
				HQavg	0.09	0.01	0.10
				HQmax	0.16	0.01	0.17
other	DEMERSAL FISH	Gray Triggerfish	Y-73 reef	1	0.16		
other	DEMERSAL FISH	Hake	Y-73 Reef	1	0.02	0.00	
other	DEMERSAL FISH	Hake	Y-73 reef	2	0.02		
other	DEMERSAL FISH	Leopard Toadfish	Y-73 Reef	1	0.16	0.00	
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	2	0.16		
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	3	0.16		
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	4	0.16		
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	5	0.02		
other	DEMERSAL FISH	Leopard Toadfish	Edisto	1	0.56	0.02	
other	DEMERSAL FISH	Leopard Toadfish	Edisto	2	0.16	0.01	
other	DEMERSAL FISH	Black Sea Bass	Eagle's Nest Tug	1	0.32	0.00	
other	DEMERSAL FISH	Gray Triggerfish	Eagle's Nest Tug	1	0.16	0.01	
other	DEMERSAL FISH	Hake	Eagle's Nest Tug	1		0.03	
other	DEMERSAL FISH	Leopard Toadfish	Eagle's Nest Tug	1	0.02	0.01	
other	DEMERSAL FISH	Sheepshead	Eagle's Nest Tug	1	0.16	0.01	
other	DEMERSAL FISH	Black Sea Bass	Comanche	1	0.02	0.00	
				HQavg	0.15	0.01	0.16
				HQmax	0.56	0.03	0.60
reference	DEMERSAL FISH	Oyster Toadfish	southern control s	1	0.02		
reference	DEMERSAL FISH	Oyster Toadfish	southern control s	2	0.02		
reference	DEMERSAL FISH	Bank Sea Bass	northern control s	1	0.16	0.01	
reference	DEMERSAL FISH	Black Sea Bass	northern control s	1	0.16	0.01	
reference	DEMERSAL FISH	Leopard Toadfish	northern control s	1	0.16	0.01	
reference	DEMERSAL FISH	Scorpion fish	northern control s	1	0.16	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control site	1	0.02	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control site	2	0.02	0.01	
reference	DEMERSAL FISH	Black Sea Bass	central control site	3	0.02	0.01	
reference	DEMERSAL FISH	Black Sea Bass	central control site	4	0.02	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control site	5	0.02		
reference	DEMERSAL FISH	Black Sea Bass	central control site	6	0.02		
reference	DEMERSAL FISH	Black Sea Bass	central control site	7	0.16		
reference	DEMERSAL FISH	Black Sea Bass	central control site	8	0.16		
reference	DEMERSAL FISH	Black Sea Bass	central control site	9	1.06		
reference	DEMERSAL FISH	Gag Grouper	central control site	1	0.02	0.01	
reference	DEMERSAL FISH	Gray Triggerfish	central control site	1	0.02	0.00	
reference	DEMERSAL FISH	Hake	central control site	1		0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	1	0.16	0.01	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	2	0.16	0.01	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	3	0.16	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	4	0.02		
reference	DEMERSAL FISH	Queen Angelfish	central control site	1	0.02	0.01	
reference	DEMERSAL FISH	Red Grouper	central control site	1	0.16	0.01	
reference	DEMERSAL FISH	Scamp	central control site	1	0.02	0.01	
reference	DEMERSAL FISH	Scamp	central control site	2	0.37	0.01	
				HQavg	0.13	0.01	0.13
				HQmax	1.06	0.01	1.08

HQ Invertebrates		TSV		ng/g dry (ppb)	1580	135170	
group	Endpoint	name	site	rep	PCB	Cu	HI
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	1	0.74	0.01	
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	2	0.02		
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	1	0.16	0.16	
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	2		0.23	
navy	INVERTEBRATE	Florida Horse Conch	Vermillion	1	0.39	0.22	
navy	INVERTEBRATE	Sea Cucumber	Vermillion	1	0.34	0.01	
navy	INVERTEBRATE	Shovelnose Lobster	Vermillion	1	0.02	0.16	
navy	INVERTEBRATE	Turkey Wing	Vermillion	1	0.70	0.02	
navy	INVERTEBRATE	Sponge1	Besty Ross	1	0.02		
navy	INVERTEBRATE	Sponge2		1	0.02		
navy	INVERTEBRATE	Turkey Wing	Besty Ross	1	0.02	0.04	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	2	0.02	0.06	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	3	0.02		
				HQavg	0.20	0.10	0.30
				HQmax	0.74	0.23	0.97
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 Reef	1	0.16	0.04	
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	2	0.16		
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	3	0.02		
other	INVERTEBRATE	Lion's Paw Scallop	Y-73 Reef	1	0.16	0.01	
other	INVERTEBRATE	Lion's Paw Scallop	Y-73 reef	2	0.02		
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	1	0.50	0.03	
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	2	0.02	0.07	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	1	0.67	0.01	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	2		0.08	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	1	0.71	0.25	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	2	0.16	0.21	
other	INVERTEBRATE	Florida Spiny Jewel Box	Edisto	1		0.04	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	1	0.34	0.05	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	2	0.53	0.07	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	3	0.16	0.04	
other	INVERTEBRATE	Arc Shell	Eagle's Nest Tu	1	0.55	0.01	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest Tu	1	0.59	0.46	
other	INVERTEBRATE	Convex Slipper Shell	Eagle's Nest Tu	1		0.34	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	1	0.60	0.03	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	2		0.02	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	1	0.73	0.15	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	2		0.28	
other	INVERTEBRATE	Crested Oyster	Eagle's Nest LC	1	0.02	3.85	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	1	0.02	0.02	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	2	0.02		
other	INVERTEBRATE	Common American Auger	Comanche	1	0.56	0.50	
other	INVERTEBRATE	Crested Oyster	Comanche	1	0.02		
other	INVERTEBRATE	Purse Shell	Comanche	1	0.02		
				HQavg	0.29	0.30	0.59
				HQmax	0.73	3.85	4.58
reference	INVERTEBRATE	Common American Auger	northern contro	1 0		0.42	
reference	INVERTEBRATE	Florida Spiny Jewel Box	northern contro	1 0		0.06	
reference	INVERTEBRATE	Crested Oyster	central control s	1 0	0.02		
reference	INVERTEBRATE	Florida Horse Conch	central control s	1 0	0.32	1.68	
reference	INVERTEBRATE	Shovelnose Lobster	central control s	1 0	0.02	0.06	
				HQavg	0.12	0.55	0.67
				HQmax	0.32	1.68	1.99

HQ for fish	Herring Gull TRV			ng/g dry (ppb)	3330	26850	18520	870370	1433330	20930	
group	Endpoint	name	site	rep	PCB	Cd	Cr	Cu	Ni	Pb	HI
navy	DEMERSAL FISH	Black Sea Bass	Vermillion	1	0.06	0.00	0.00	0.00	0.00	0.17	
navy	DEMERSAL FISH	Gag Grouper	Vermillion	1	0.01	0.06	0.17	0.00	0.00	0.22	
				HQavg	0.03	0.03	0.09	0.00	0.00	0.20	0.35
				HQmax	0.06	0.06	0.17	0.00	0.00	0.22	0.51
other	DEMERSAL FISH	Gray Triggerfish	Y-73 reef	1	0.06						
other	DEMERSAL FISH	Hake	Y-73 Reef	1	0.01	0.00	0.00	0.00	0.00	0.00	
other	DEMERSAL FISH	Hake	Y-73 reef	2	0.01						
other	DEMERSAL FISH	Leopard Toadfish	Y-73 Reef	1	0.06	0.00	0.00	0.00	0.00	0.00	
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	2	0.06						
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	3	0.06						
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	4	0.06						
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	5	0.01						
other	DEMERSAL FISH	Leopard Toadfish	Edisto	1	0.22	0.00	0.20	0.00	0.01	0.12	
other	DEMERSAL FISH	Leopard Toadfish	Edisto	2	0.06	0.00	0.04	0.00	0.00	0.14	
other	DEMERSAL FISH	Black Sea Bass	Eagle's Nest T	1	0.12	0.00	0.04	0.00	0.00	0.03	
other	DEMERSAL FISH	Gray Triggerfish	Eagle's Nest T	1	0.06	0.00	0.03	0.00	0.00	0.03	
other	DEMERSAL FISH	Hake	Eagle's Nest T	1		0.04	0.10	0.00		0.00	
other	DEMERSAL FISH	Leopard Toadfish	Eagle's Nest T	1	0.01	0.04	0.21	0.00		0.00	
other	DEMERSAL FISH	Sheepshead	Eagle's Nest T	1	0.06	0.00	0.03	0.00	0.00	0.04	
other	DEMERSAL FISH	Black Sea Bass	Comanche	1	0.01	0.00	0.00	0.00	0.00	0.00	
				HQavg	0.06	0.01	0.07	0.00	0.00	0.04	0.17
				HQmax	0.22	0.04	0.21	0.00	0.01	0.14	0.62
reference	DEMERSAL FISH	Oyster Toadfish	southern contr	1	0.01						
reference	DEMERSAL FISH	Oyster Toadfish	southern contr	2	0.01						
reference	DEMERSAL FISH	Bank Sea Bass	northern contr	1	0.06	0.00	0.03	0.00	0.00	0.02	
reference	DEMERSAL FISH	Black Sea Bass	northern contr	1	0.06	0.00	0.03	0.00	0.00	0.02	
reference	DEMERSAL FISH	Leopard Toadfish	northern contr	1	0.06	0.00	0.00	0.00	0.00	0.05	
reference	DEMERSAL FISH	Scorpion fish	northern contr	1	0.06	0.00	0.00	0.00	0.00	0.03	
reference	DEMERSAL FISH	Black Sea Bass	central control	1	0.01	0.00	0.03	0.00	0.00	0.02	
reference	DEMERSAL FISH	Black Sea Bass	central control	2	0.01	0.00	0.00	0.00	0.00	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control	3	0.01	0.00	0.06	0.00	0.00	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control	4	0.01	0.00	0.07	0.00	0.00	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control	5	0.01						
reference	DEMERSAL FISH	Black Sea Bass	central control	6	0.01						
reference	DEMERSAL FISH	Black Sea Bass	central control	7	0.06						
reference	DEMERSAL FISH	Black Sea Bass	central control	8	0.06						
reference	DEMERSAL FISH	Black Sea Bass	central control	9	0.40						
reference	DEMERSAL FISH	Gag Grouper	central control	1	0.01	0.00	0.04	0.00	0.00	0.00	
reference	DEMERSAL FISH	Gray Triggerfish	central control	1	0.01	0.00	0.30	0.00	0.00	0.00	
reference	DEMERSAL FISH	Hake	central control	1		0.05	0.10	0.00		0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control	1	0.06	0.00	0.00	0.00	0.00	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control	2	0.06	0.02	0.02	0.00	0.00	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control	3	0.06	0.00	0.04	0.00	0.00	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control	4	0.01						
reference	DEMERSAL FISH	Queen Angelfish	central control	1	0.01	0.00	0.12	0.00	0.00	0.00	
reference	DEMERSAL FISH	Red Grouper	central control	1	0.06	0.00	0.02	0.00	0.00	0.00	
reference	DEMERSAL FISH	Scamp	central control	1	0.01	0.00	0.00	0.00	0.00	0.00	
reference	DEMERSAL FISH	Scamp	central control	2	0.14	0.00	0.03	0.00	0.00	0.00	
				HQavg	0.05	0.00	0.05	0.00	0.00	0.01	0.11
				HQmax	0.40	0.05	0.30	0.00	0.00	0.05	0.81

HQ Invertebrates		Herring Gull TRV		ng/g dry (ppb)	4170	33560	23150	1087960	4300000	62780	
group	Endpoint	name	site	rep	PCB	Cd	Cr	Cu	Ni	Pb	HI
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	1	0.28	0.10	0.00	0.00	0.00	0.00	
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	2	0.01						
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	1	0.06	0.00	0.02	0.02	0.00	0.01	
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	2		0.00	0.02	0.03	0.00	0.00	
navy	INVERTEBRATE	Florida Horse Conch	Vermillion	1	0.15	0.02	0.00	0.03	0.00	0.00	
navy	INVERTEBRATE	Sea Cucumber	Vermillion	1	0.13	0.00	0.03	0.00	0.00	0.01	
navy	INVERTEBRATE	Shovelnose Lobster	Vermillion	1	0.01	0.16	0.00	0.02	0.00	0.00	
navy	INVERTEBRATE	Turkey Wing	Vermillion	1	0.26	0.11	0.00	0.00	0.00	0.02	
navy	INVERTEBRATE	Sponge1	Besty Ross	1	0.01						
navy	INVERTEBRATE	Sponge2		1	0.01						
navy	INVERTEBRATE	Turkey Wing	Besty Ross	1	0.01	0.15	0.19	0.01		0.06	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	2	0.01	0.11	0.11	0.01		0.07	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	3	0.01						
				HQavg	0.08	0.07	0.04	0.01	0.00	0.02	0.22
				HQmax	0.28	0.16	0.19	0.03	0.00	0.07	0.73
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 Reef	1	0.06	0.55	0.00	0.00	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	2	0.06						
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	3	0.01						
other	INVERTEBRATE	Lion's Paw Scallop	Y-73 Reef	1	0.06	0.40	0.00	0.00	0.00	0.02	
other	INVERTEBRATE	Lion's Paw Scallop	Y-73 reef	2	0.01						
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	1	0.19	0.19	0.02	0.00	0.00	0.00	
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	2	0.01	0.54	0.03	0.01	0.00	0.03	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	1	0.25	0.04	0.00	0.00	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	2		0.29	0.35	0.01	0.00	0.14	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	1	0.27	0.07	0.07	0.03	0.00	0.06	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	2	0.06	0.09	0.05	0.03	0.00	0.03	
other	INVERTEBRATE	Florida Spiny Jewel Box	Edisto	1		0.14	0.02	0.00	0.00	0.02	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	1	0.13	0.09	0.00	0.01	0.00	0.02	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	2	0.20	0.54	0.24	0.01	0.00	0.09	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	3	0.06	0.16	0.06	0.01		0.08	
other	INVERTEBRATE	Arc Shell	Eagle's Nest Tu	1	0.21	0.44	0.05	0.00	0.00	0.01	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest Tu	1	0.22	0.03	0.81	0.06	0.00	4.34	
other	INVERTEBRATE	Convex Slipper Shell	Eagle's Nest Tu	1		0.03	0.15	0.04		0.95	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	1	0.23	0.00	0.00	0.00	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	2		0.44	0.02	0.00	0.00	0.01	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	1	0.28	0.08	0.24	0.02	0.00	0.07	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	2		0.00	0.00	0.04	0.00	0.03	
other	INVERTEBRATE	Crested Oyster	Eagle's Nest LC	1	0.01	0.00	0.00	0.48	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	1	0.01	0.08	0.00	0.00	0.00	0.02	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	2	0.01						
other	INVERTEBRATE	Common American Auger	Comanche	1	0.21	0.00	0.00	0.06	0.00	0.10	
other	INVERTEBRATE	Crested Oyster	Comanche	1	0.01						
other	INVERTEBRATE	Purse Shell	Comanche	1	0.01						
				HQavg	0.11	0.19	0.10	0.04	0.00	0.27	0.71
				HQmax	0.28	0.55	0.81	0.48	0.00	4.34	6.46
reference	INVERTEBRATE	Common American Auger	northern contro	1 0		0.24	0.12	0.05	0.01	0.04	
reference	INVERTEBRATE	Florida Spiny Jewel Box	northern contro	1 0		0.21	0.10	0.01	0.00	0.03	
reference	INVERTEBRATE	Crested Oyster	central control s	1 0	0.01						
reference	INVERTEBRATE	Florida Horse Conch	central control s	1 0	0.12	0.00	0.02	0.21	0.00	0.01	
reference	INVERTEBRATE	Shovelnose Lobster	central control s	1 0	0.01	0.25	0.02	0.01	0.00	0.00	
				HQavg	0.04	0.18	0.07	0.07	0.00	0.02	0.37
				HQmax	0.12	0.25	0.12	0.21	0.01	0.04	0.74

HQ for fish	Cormorant TRV			ng/g dry (ppb)	3200	25780	17780	835560	1376000	20090	
group	Endpoint	name	site	rep	PCB	Cd	Cr	Cu	Ni	Pb	HI
navy	DEMERSAL FISH	Black Sea Bass	Vermillion	1	0.06	0.00	0.00	0.00	0.00	0.18	
navy	DEMERSAL FISH	Gag Grouper	Vermillion	1	0.01	0.06	0.18	0.00	0.00	0.23	
				HQavg	0.03	0.03	0.09	0.00	0.00	0.21	0.36
				HQmax	0.06	0.06	0.18	0.00	0.00	0.23	0.53
other	DEMERSAL FISH	Gray Triggerfish	Y-73 reef	1	0.06						
other	DEMERSAL FISH	Hake	Y-73 Reef	1	0.01	0.00	0.00	0.00	0.00	0.00	
other	DEMERSAL FISH	Hake	Y-73 reef	2	0.01						
other	DEMERSAL FISH	Leopard Toadfish	Y-73 Reef	1	0.06	0.00	0.00	0.00	0.00	0.00	
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	2	0.06						
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	3	0.06						
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	4	0.06						
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	5	0.01						
other	DEMERSAL FISH	Leopard Toadfish	Edisto	1	0.22	0.00	0.21	0.00	0.01	0.13	
other	DEMERSAL FISH	Leopard Toadfish	Edisto	2	0.06	0.00	0.04	0.00	0.00	0.15	
other	DEMERSAL FISH	Black Sea Bass	Eagle's Nest Tug	1	0.13	0.00	0.05	0.00	0.00	0.03	
other	DEMERSAL FISH	Gray Triggerfish	Eagle's Nest Tug	1	0.06	0.00	0.03	0.00	0.00	0.03	
other	DEMERSAL FISH	Hake	Eagle's Nest Tug	1		0.04	0.10	0.00		0.00	
other	DEMERSAL FISH	Leopard Toadfish	Eagle's Nest Tug	1	0.01	0.04	0.22	0.00		0.00	
other	DEMERSAL FISH	Sheepshead	Eagle's Nest Tug	1	0.06	0.00	0.03	0.00	0.00	0.04	
other	DEMERSAL FISH	Black Sea Bass	Comanche	1	0.01	0.00	0.00	0.00	0.00	0.00	
				HQavg	0.06	0.01	0.07	0.00	0.00	0.04	0.18
				HQmax	0.22	0.04	0.22	0.00	0.01	0.15	0.65
reference	DEMERSAL FISH	Oyster Toadfish	southern control s	1	0.01						
reference	DEMERSAL FISH	Oyster Toadfish	southern control s	2	0.01						
reference	DEMERSAL FISH	Bank Sea Bass	northern control s	1	0.06	0.00	0.03	0.00	0.00	0.02	
reference	DEMERSAL FISH	Black Sea Bass	northern control s	1	0.06	0.00	0.03	0.00	0.00	0.02	
reference	DEMERSAL FISH	Leopard Toadfish	northern control s	1	0.06	0.00	0.00	0.00	0.00	0.05	
reference	DEMERSAL FISH	Scorpion fish	northern control s	1	0.06	0.00	0.00	0.00	0.00	0.03	
reference	DEMERSAL FISH	Black Sea Bass	central control site	1	0.01	0.00	0.03	0.00	0.00	0.02	
reference	DEMERSAL FISH	Black Sea Bass	central control site	2	0.01	0.00	0.00	0.00	0.00	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control site	3	0.01	0.00	0.06	0.00	0.00	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control site	4	0.01	0.00	0.07	0.00	0.00	0.00	
reference	DEMERSAL FISH	Black Sea Bass	central control site	5	0.01						
reference	DEMERSAL FISH	Black Sea Bass	central control site	6	0.01						
reference	DEMERSAL FISH	Black Sea Bass	central control site	7	0.06						
reference	DEMERSAL FISH	Black Sea Bass	central control site	8	0.06						
reference	DEMERSAL FISH	Black Sea Bass	central control site	9	0.42						
reference	DEMERSAL FISH	Gag Grouper	central control site	1	0.01	0.00	0.04	0.00	0.00	0.00	
reference	DEMERSAL FISH	Gray Triggerfish	central control site	1	0.01	0.00	0.31	0.00	0.00	0.00	
reference	DEMERSAL FISH	Hake	central control site	1		0.05	0.10	0.00		0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	1	0.06	0.00	0.00	0.00	0.00	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	2	0.06	0.02	0.02	0.00	0.00	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	3	0.06	0.00	0.05	0.00	0.00	0.00	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	4	0.01						
reference	DEMERSAL FISH	Queen Angelfish	central control site	1	0.01	0.00	0.12	0.00	0.00	0.00	
reference	DEMERSAL FISH	Red Grouper	central control site	1	0.06	0.00	0.02	0.00	0.00	0.00	
reference	DEMERSAL FISH	Scamp	central control site	1	0.01	0.00	0.00	0.00	0.00	0.00	
reference	DEMERSAL FISH	Scamp	central control site	2	0.15	0.00	0.03	0.00	0.00	0.00	
				HQavg	0.05	0.00	0.05	0.00	0.00	0.01	0.12
				HQmax	0.42	0.05	0.31	0.00	0.00	0.05	0.84

HQ for fish	**Shark TRV**			ng/g dry (ppb)	**3530**
group	Endpoint	name	site	rep	**PCB**
navy	DEMERSAL FISH	Black Sea Bass	Vermillion	1	0.06
navy	DEMERSAL FISH	Gag Grouper	Vermillion	1	0.01
				HQavg	0.03
				HQmax	0.06
other	DEMERSAL FISH	Gray Triggerfish	Y-73 reef	1	0.06
other	DEMERSAL FISH	Hake	Y-73 Reef	1	0.01
other	DEMERSAL FISH	Hake	Y-73 reef	2	0.01
other	DEMERSAL FISH	Leopard Toadfish	Y-73 Reef	1	0.06
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	2	0.06
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	3	0.06
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	4	0.06
other	DEMERSAL FISH	Leopard Toadfish	Y-73 reef	5	0.01
other	DEMERSAL FISH	Leopard Toadfish	Edisto	1	0.20
other	DEMERSAL FISH	Leopard Toadfish	Edisto	2	0.06
other	DEMERSAL FISH	Black Sea Bass	Eagle's Nest Tug	1	0.12
other	DEMERSAL FISH	Gray Triggerfish	Eagle's Nest Tug	1	0.06
other	DEMERSAL FISH	Hake	Eagle's Nest Tug	1	
other	DEMERSAL FISH	Leopard Toadfish	Eagle's Nest Tug	1	0.01
other	DEMERSAL FISH	Sheepshead	Eagle's Nest Tug	1	0.06
other	DEMERSAL FISH	Black Sea Bass	Comanche	1	0.01
				HQavg	0.05
				HQmax	0.20
reference	DEMERSAL FISH	Oyster Toadfish	southern control s	1	0.01
reference	DEMERSAL FISH	Oyster Toadfish	southern control s	2	0.01
reference	DEMERSAL FISH	Bank Sea Bass	northern control s	1	0.06
reference	DEMERSAL FISH	Black Sea Bass	northern control s	1	0.06
reference	DEMERSAL FISH	Leopard Toadfish	northern control s	1	0.06
reference	DEMERSAL FISH	Scorpion fish	northern control s	1	0.06
reference	DEMERSAL FISH	Black Sea Bass	central control site	1	0.01
reference	DEMERSAL FISH	Black Sea Bass	central control site	2	0.01
reference	DEMERSAL FISH	Black Sea Bass	central control site	3	0.01
reference	DEMERSAL FISH	Black Sea Bass	central control site	4	0.01
reference	DEMERSAL FISH	Black Sea Bass	central control site	5	0.01
reference	DEMERSAL FISH	Black Sea Bass	central control site	6	0.01
reference	DEMERSAL FISH	Black Sea Bass	central control site	7	0.06
reference	DEMERSAL FISH	Black Sea Bass	central control site	8	0.06
reference	DEMERSAL FISH	Black Sea Bass	central control site	9	0.38
reference	DEMERSAL FISH	Gag Grouper	central control site	1	0.01
reference	DEMERSAL FISH	Gray Triggerfish	central control site	1	0.01
reference	DEMERSAL FISH	Hake	central control site	1	
reference	DEMERSAL FISH	Leopard Toadfish	central control site	1	0.06
reference	DEMERSAL FISH	Leopard Toadfish	central control site	2	0.06
reference	DEMERSAL FISH	Leopard Toadfish	central control site	3	0.06
reference	DEMERSAL FISH	Leopard Toadfish	central control site	4	0.01
reference	DEMERSAL FISH	Queen Angelfish	central control site	1	0.01
reference	DEMERSAL FISH	Red Grouper	central control site	1	0.06
reference	DEMERSAL FISH	Scamp	central control site	1	0.01
reference	DEMERSAL FISH	Scamp	central control site	2	0.13
				HQavg	0.05
				HQmax	0.38

HQ Invertebrates		Sea Turtle TRV		ng/g dry (ppb)	10890	375930	259260	930360	20066670	292960	
group	Endpoint	name	site	rep	PCB	Cd	Cr	Cu	Ni	Pb	HI
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	1	0.11	0.01	0.00	0.00	0.00	0.00	
navy	INVERTEBRATE	Alantic Winged Oyster	Vermillion	2	0.00						
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	1	0.02	0.00	0.00	0.02	0.00	0.00	
navy	INVERTEBRATE	Atlantic Hairy Triton	Vermillion	2		0.00	0.00	0.03	0.00	0.00	
navy	INVERTEBRATE	Florida Horse Conch	Vermillion	1	0.06	0.00	0.00	0.03	0.00	0.00	
navy	INVERTEBRATE	Sea Cucumber	Vermillion	1	0.05	0.00	0.00	0.00	0.00	0.00	
navy	INVERTEBRATE	Shovelnose Lobster	Vermillion	1	0.00	0.01	0.00	0.02	0.00	0.00	
navy	INVERTEBRATE	Turkey Wing	Vermillion	1	0.10	0.01	0.00	0.00	0.00	0.00	
navy	INVERTEBRATE	Sponge1	Besty Ross	1	0.00						
navy	INVERTEBRATE	Sponge2		1	0.00						
navy	INVERTEBRATE	Turkey Wing	Besty Ross	1	0.00	0.01	0.02	0.01		0.01	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	2	0.00	0.01	0.01	0.01		0.01	
navy	INVERTEBRATE	Turkey Wing	Besty Ross	3	0.00						
				HQavg	0.03	0.01	0.00	0.01	0.00	0.00	0.06
				HQmax	0.11	0.01	0.02	0.03	0.00	0.01	0.19
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 Reef	1	0.02	0.05	0.00	0.01	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	2	0.02						
other	INVERTEBRATE	Alantic Winged Oyster	Y-73 reef	3	0.00						
other	INVERTEBRATE	Lion's Paw Scallop	Y-73 Reef	1	0.02	0.04	0.00	0.00	0.00	0.00	
other	INVERTEBRATE	Lion's Paw Scallop	Y-73 reef	2	0.00						
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	1	0.07	0.02	0.00	0.00	0.00	0.00	
other	INVERTEBRATE	Turkey Wing	Y-73 Reef	2	0.00	0.05	0.00	0.01	0.00	0.01	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	1	0.10	0.00	0.00	0.00	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Edisto	2		0.03	0.03	0.01	0.00	0.03	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	1	0.10	0.01	0.01	0.04	0.00	0.01	
other	INVERTEBRATE	Atlantic Deer Cowrie	Edisto	2	0.02	0.01	0.00	0.03	0.00	0.01	
other	INVERTEBRATE	Florida Spiny Jewel Box	Edisto	1		0.01	0.00	0.01	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	1	0.05	0.01	0.00	0.01	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	2	0.08	0.05	0.02	0.01	0.00	0.02	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest Tu	3	0.02	0.01	0.01	0.01		0.02	
other	INVERTEBRATE	Arc Shell	Eagle's Nest Tu	1	0.08	0.04	0.00	0.00	0.00	0.00	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest Tu	1	0.08	0.00	0.07	0.07	0.00	0.93	
other	INVERTEBRATE	Convex Slipper Shell	Eagle's Nest Tu	1		0.00	0.01	0.05		0.20	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	1	0.09	0.00	0.00	0.00	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Eagle's Nest LC	2		0.04	0.00	0.00	0.00	0.00	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	1	0.11	0.01	0.02	0.02	0.00	0.01	
other	INVERTEBRATE	Common Slipper Shell	Eagle's Nest LC	2		0.00	0.00	0.04	0.00	0.01	
other	INVERTEBRATE	Crested Oyster	Eagle's Nest LC	1	0.00	0.00	0.00	0.56	0.00	0.00	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	1	0.00	0.01	0.00	0.00	0.00	0.01	
other	INVERTEBRATE	Alantic Winged Oyster	Comanche	2	0.00						
other	INVERTEBRATE	Common American Auger	Comanche	1	0.08	0.00	0.00	0.07	0.00	0.02	
other	INVERTEBRATE	Crested Oyster	Comanche	1	0.00						
other	INVERTEBRATE	Purse Shell	Comanche	1	0.00						
				HQavg	0.04	0.02	0.01	0.04	0.00	0.06	0.17
				HQmax	0.11	0.05	0.07	0.56	0.00	0.93	1.72
reference	INVERTEBRATE	Common American Auger	northern contro	1 0		0.02	0.01	0.06	0.00	0.01	
reference	INVERTEBRATE	Florida Spiny Jewel Box	northern contro	1 0		0.02	0.01	0.01	0.00	0.01	
reference	INVERTEBRATE	Crested Oyster	central control s	1 0	0.00						
reference	INVERTEBRATE	Florida Horse Conch	central control s	1 0	0.05	0.00	0.00	0.24	0.00	0.00	
reference	INVERTEBRATE	Shovelnose Lobster	central control s	1 0	0.00	0.02	0.00	0.01	0.00	0.00	
				HQavg	0.02	0.02	0.01	0.08	0.00	0.00	0.12
				HQmax	0.05	0.02	0.01	0.24	0.00	0.01	0.33

Supplemental Fish HQ		**WHOLE BODY**	TSV	Bcv	NOED	LOED	$D_{HerringGull}$	$D_{Cormorant}$	$D_{Dolphin}$	D_{Shark}
		ng/g dry weight	**1750**	**24305.05**	**6000**	**7200**	**3330**	**3200**	**1270**	**3530**
site	species	ID	**PCB**	**PCB**	**PCB**	**PCB**	**PCB**	**PCB**	**PCB**	**PCB**
Target	Black Seabass	FS-01-SB-T	0.05	0.00	0.01	0.01	0.03	0.03	0.07	0.03
Target	Black Seabass	FS-02-SB-T	0.10	0.01	0.03	0.02	0.05	0.05	0.13	0.05
Target	Black Seabass	FS-03-SB-T	0.12	0.01	0.03	0.03	0.06	0.06	0.16	0.06
Target	Black Seabass	FS-04-SB-T	0.10	0.01	0.03	0.02	0.05	0.05	0.13	0.05
Target	Black Seabass	FS-05-SB-T	0.03	0.00	0.01	0.01	0.01	0.01	0.04	0.01
Target	Black Seabass	FS-06-SB-T	0.11	0.01	0.03	0.03	0.06	0.06	0.16	0.06
Target	Black Seabass	FS-07-SB-T	0.22	0.02	0.07	0.05	0.12	0.12	0.31	0.11
Target	Black Seabass	FS-08-SB-T	0.16	0.01	0.05	0.04	0.09	0.09	0.23	0.08
Target	Black Seabass	FS-09-SB-T	0.04	0.00	0.01	0.01	0.02	0.02	0.06	0.02
Target	Black Seabass	FS-10-SB-T	0.06	0.00	0.02	0.01	0.03	0.03	0.08	0.03
Target	Black Seabass	FS-11-SB-T	0.09	0.01	0.03	0.02	0.05	0.05	0.13	0.05
Target	Vermilion Snapper	FS-01-VS-T	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Target	Vermilion Snapper	FS-02-VS-T	0.02	0.00	0.01	0.00	0.01	0.01	0.03	0.01
Target	Vermilion Snapper	FS-03-VS-T	0.02	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Target	Vermilion Snapper	FS-04-VS-T	0.03	0.00	0.01	0.01	0.02	0.02	0.04	0.02
Target	Vermilion Snapper	FS-05-VS-T	0.10	0.01	0.03	0.03	0.05	0.06	0.14	0.05
Target	Vermilion Snapper	FS-06-VS-T	0.02	0.00	0.01	0.00	0.01	0.01	0.02	0.01
Target	Vermilion Snapper	FS-07-VS-T	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Target	Vermilion Snapper	FS-08-VS-T	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Target	Vermilion Snapper	FS-09-VS-T	0.05	0.00	0.01	0.01	0.03	0.03	0.07	0.02
Target	Vermilion Snapper	FS-10-VS-T	0.04	0.00	0.01	0.01	0.02	0.02	0.05	0.02
Target	Vermilion Snapper	FS-11-VS-T	0.09	0.01	0.03	0.02	0.05	0.05	0.13	0.05
Target	Vermilion Snapper	FS-12-VS-T	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Target	Vermilion Snapper	FS-13-VS-T	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Target	Vermilion Snapper	FS-14-VS-T	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Target	Vermilion Snapper	FS-15-VS-T	0.04	0.00	0.01	0.01	0.02	0.02	0.05	0.02
Target	Vermilion Snapper	FS-16-VS-T	0.02	0.00	0.01	0.00	0.01	0.01	0.03	0.01
Target	Vermilion Snapper	FS-17-VS-T	0.03	0.00	0.01	0.01	0.01	0.02	0.04	0.01
Target	Vermilion Snapper	FS-18-VS-T	0.02	0.00	0.01	0.00	0.01	0.01	0.03	0.01
Target	Vermilion Snapper	FS-19-VS-T	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Target	Vermilion Snapper	FS-20-VS-T	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Target	White Grunt	FS-01-WG-T	0.17	0.01	0.05	0.04	0.09	0.09	0.24	0.09
Target	White Grunt	FS-02-WG-T	3.22	0.23	0.94	0.78	1.69	1.76	4.44	1.60
Target	White Grunt	FS-03-WG-T	0.23	0.02	0.07	0.06	0.12	0.12	0.31	0.11
Target	White Grunt	FS-04-WG-T	0.19	0.01	0.05	0.05	0.10	0.10	0.26	0.09
Target	White Grunt	FS-05-WG-T	0.06	0.00	0.02	0.01	0.03	0.03	0.08	0.03
Target	White Grunt	FS-06-WG-T	0.14	0.01	0.04	0.03	0.07	0.08	0.19	0.07
Target	White Grunt	FS-07-WG-T	0.09	0.01	0.02	0.02	0.04	0.05	0.12	0.04
Target	White Grunt	FS-08-WG-T	0.12	0.01	0.03	0.03	0.06	0.06	0.16	0.06
Target	White Grunt	FS-09-WG-T	0.86	0.06	0.25	0.21	0.45	0.47	1.19	0.43
Target	White Grunt	FS-10-WG-T	1.63	0.12	0.48	0.40	0.86	0.89	2.25	0.81
Target	White Grunt	FS-11-WG-T	0.10	0.01	0.03	0.02	0.05	0.05	0.13	0.05
Target	White Grunt	FS-12-WG-T	1.08	0.08	0.32	0.26	0.57	0.59	1.49	0.54
Target	White Grunt	FS-13-WG-T	0.10	0.01	0.03	0.03	0.05	0.06	0.14	0.05
Target	White Grunt	FS-14-WG-T	0.16	0.01	0.05	0.04	0.08	0.09	0.22	0.08
Target	White Grunt	FS-15-WG-T	1.45	0.10	0.42	0.35	0.76	0.79	2.00	0.72
Target	White Grunt	FS-16-WG-T	0.92	0.07	0.27	0.22	0.48	0.50	1.27	0.46
Target	White Grunt	FS-17-WG-T	0.42	0.03	0.12	0.10	0.22	0.23	0.58	0.21

Supplemental Fish HQ		**WHOLE BODY**	TSV	Bcv	NOED	LOED	$D_{HerringGull}$	$D_{Cormorant}$	$D_{Dolphin}$	D_{Shark}
		ng/g dry weight	**1750**	**24305.05**	**6000**	**7200**	**3330**	**3200**	**1270**	**3530**
site	species	ID	**PCB**	**PCB**	**PCB**	**PCB**	**PCB**	**PCB**	**PCB**	**PCB**
Target	White Grunt	FS-18-WG-T	3.06	0.22	0.89	0.74	1.61	1.67	4.21	1.52
Target	White Grunt	FS-19-WG-T	0.10	0.01	0.03	0.02	0.05	0.05	0.14	0.05
Target	White Grunt	FS-20-WG-T	0.26	0.02	0.08	0.06	0.14	0.14	0.36	0.13
		AverageHQ	0.32	0.02	0.09	0.08	0.17	0.17	0.43	0.16
		MaxHQ	3.22	0.23	0.94	0.78	1.69	1.76	4.44	1.60
Referenc	Black Seabass	FS-01-SB-R	0.10	0.01	0.03	0.02	0.05	0.05	0.13	0.05
Referenc	Black Seabass	FS-02-SB-R	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Referenc	Black Seabass	FS-03-SB-R	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Referenc	Black Seabass	FS-04-SB-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Black Seabass	FS-05-SB-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Black Seabass	FS-06-SB-R	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Referenc	Black Seabass	FS-07-SB-R	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Referenc	Black Seabass	FS-08-SB-R	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Referenc	Black Seabass	FS-09-SB-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Black Seabass	FS-10-SB-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Black Seabass	FS-11-SB-R	0.04	0.00	0.01	0.01	0.02	0.02	0.05	0.02
Referenc	Black Seabass	FS-12-SB-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Black Seabass	FS-13-SB-R	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Referenc	Black Seabass	FS-14-SB-R	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Referenc	Black Seabass	FS-15-SB-R	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Referenc	Black Seabass	FS-16-SB-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Black Seabass	FS-17-SB-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Black Seabass	FS-18-SB-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Black Seabass	FS-19-SB-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Black Seabass	FS-20-SB-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Vermilion Snapper	FS-01-VS-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Vermilion Snapper	FS-02-VS-R	0.03	0.00	0.01	0.01	0.02	0.02	0.05	0.02
Referenc	Vermilion Snapper	FS-03-VS-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Vermilion Snapper	FS-04-VS-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Vermilion Snapper	FS-05-VS-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Vermilion Snapper	FS-06-VS-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Vermilion Snapper	FS-07-VS-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Vermilion Snapper	FS-08-VS-R	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.00
Referenc	Vermilion Snapper	FS-09-VS-R	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Referenc	Vermilion Snapper	FS-10-VS-R	0.02	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Vermilion Snapper	FS-11-VS-R	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Referenc	Vermilion Snapper	FS-12-VS-R	0.03	0.00	0.01	0.01	0.01	0.02	0.04	0.01
Referenc	Vermilion Snapper	FS-13-VS-R	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Referenc	Vermilion Snapper	FS-14-VS-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Vermilion Snapper	FS-15-VS-R	0.03	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Referenc	Vermilion Snapper	FS-16-VS-R	0.02	0.00	0.01	0.00	0.01	0.01	0.03	0.01
Referenc	Vermilion Snapper	FS-17-VS-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Vermilion Snapper	FS-18-VS-R	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.00
Referenc	Vermilion Snapper	FS-19-VS-R	0.02	0.00	0.01	0.01	0.01	0.01	0.03	0.01
Referenc	Vermilion Snapper	FS-20-VS-R	0.02	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	Vermilion Snapper	FS-21-VS-R	0.02	0.00	0.00	0.00	0.01	0.01	0.02	0.01

Supplemental Fish HQ		**WHOLE BODY**	TSV	Bcv	NOED	LOED	$D_{HerringGull}$	$D_{Cormorant}$	$D_{Dolphin}$	D_{Shark}
		ng/g dry weight	**1750**	**24305.05**	**6000**	**7200**	**3330**	**3200**	**1270**	**3530**
site	species	ID	**PCB**	**PCB**	**PCB**	**PCB**	**PCB**	**PCB**	**PCB**	**PCB**
Referenc	Vermilion Snapper	FS-22-VS-R	0.02	0.00	0.01	0.00	0.01	0.01	0.02	0.01
Referenc	White Grunt	FS-01-WG-R	0.03	0.00	0.01	0.01	0.02	0.02	0.04	0.02
Referenc	White Grunt	FS-02-WG-R	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Referenc	White Grunt	FS-03-WG-R	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Referenc	White Grunt	FS-04-WG-R	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Referenc	White Grunt	FS-05-WG-R	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Referenc	White Grunt	FS-06-WG-R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Referenc	White Grunt	FS-07-WG-R	0.10	0.01	0.03	0.02	0.05	0.05	0.13	0.05
Referenc	White Grunt	FS-08-WG-R	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Referenc	White Grunt	FS-09-WG-R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Referenc	White Grunt	FS-10-WG-R	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Referenc	White Grunt	FS-11-WG-R	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Referenc	White Grunt	FS-12-WG-R	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Referenc	White Grunt	FS-13-WG-R	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01
Referenc	White Grunt	FS-14-WG-R	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Referenc	White Grunt	FS-15-WG-R	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Referenc	White Grunt	FS-16-WG-R	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Referenc	White Grunt	FS-17-WG-R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Referenc	White Grunt	FS-18-WG-R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Referenc	White Grunt	FS-19-WG-R	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Referenc	White Grunt	FS-20-WG-R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		AverageHQ	0.02	0.001	0.005	0.004	0.009	0.009	0.02	0.01
		MaxHQ	0.10	0.01	0.03	0.02	0.05	0.05	0.13	0.05

Appendix 8. LEACHRATE Computations for the REEFEX Study

Appendix 8 A steady state model of PCB release from solid materials containing PCBs on the ex-VERMILION

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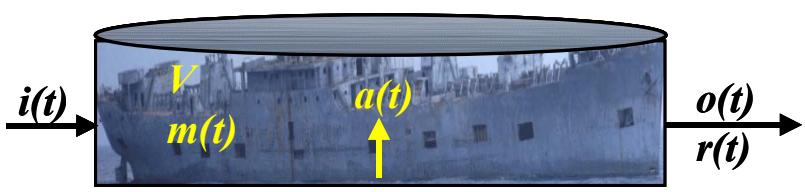
Please see Section **10 References** for References Cited in this Appendix.

Introduction

Water chemistry data from the study area were not available for the ecorisk screening; therefore data from the leach rate study (George 1999, George and In 2002a, George and In 2002b, George et al. 2004, 2005) were used to model the instantaneous steady state concentration of total PCBs in a well-mixed volume of water around a sunken ship (Figure A8-1). The leach rate model used to estimate the steady state concentration is similar to the approach used to estimate PCB concentrations associated with potential releases from sinking the ex-SPIEGLE GROVE (Phillips and Casey 2001) and the approach proposed for the development of a Prospective Risk Assessment Model (PRAM, NEHC 2000b, 2001b). The analysis was also used to evaluate the relative importance of PCB loadings from the various types of solids onboard the ship.

The leach rate study was conducted to determine the leaching rates of selected shipboard solid materials containing PCBs under shallow water conditions (1 bar and 25° C, George and In 2002a, George and In 2002b, George et al. 2004, 2005). The leaching tests were performed on intact solids that contained known amounts of PCBs. The materials tested and percent PCB in the solids (in parenthesis) were felt gaskets (23.00%), electric cabling (0.12%), paint (0.04%), rubber (0.16%), foam insulation (0.89%), and bulkhead insulation (0.044%) (George and In 2002a). The leaching rates of pure Aroclor 1254 and 1268 were also measured. The leaching rate of Aroclor 1254 (George and In 2002a) was used in this analysis as an analogue for PCBs dissolved within residual oils & greases[1] remaining on the ship following purging of fuel tanks and reservoirs (JJMA 1998).

V = Well mixed volume of water around the ship
m(t) = mass of PCBs present in water around ship



a(t) = rate of leaching from solids containing PCBs on the sunken ship
o(t) = ***i(t)*** = Rate of exchange with surrounding water
r(t) = mass of PCBs removed due to flushing

Other loss terms = 0

Figure A.8-1. Model used to estimate the instantaneous steady state concentration of total PCBs in a well-mixed volume of water around a sunken ship.

[1] Aroclor 1254 is a conservative analog for non-mobile, non-dispersing, non-soluble oils & greases with Aroclor 1254 in them.

Leach Rate Estimates

The leach rate determinations consisted of measuring the release rates of PCBs from the solid materials in a simulated shallow water environment (1 bar and 25° C, George and In 2002a, George and In 2002b, George et al 2004, 2005). The leach rate experiments derived the leaching behavior for each type of solid tested. The leaching behavior was characterized by three leaching domains as a function of time (Figure A.8-2): equilibration (Region 1), maximum (Region 2), and steady state (Region 3). Typically, the leach rate experiments were conducted over the course of a year before the experiment was terminated (14 – 16 months) and the leaching behavior was obtained for Total PCB (Figure A.8-3) and individual congeners for each of the solids (George and In 2002b, George et al 2004, 2005). The empirical long-term average leach rate (point "A" in Figure A.8-2) was used as the leach rate for the model calculations. The empirical long-term average leach rate is considered the upper limit of the long-term leaching behavior of the solid (Figure A.8-3). This assumes that the leach rate is constant and equal to the leach rate measured when the experiment was terminated and does not account for the statistically significant, monotonically decreasing leach rate suggested by the data (Figure A.8-3, George and In 2002b, George et al 2004, 2005).

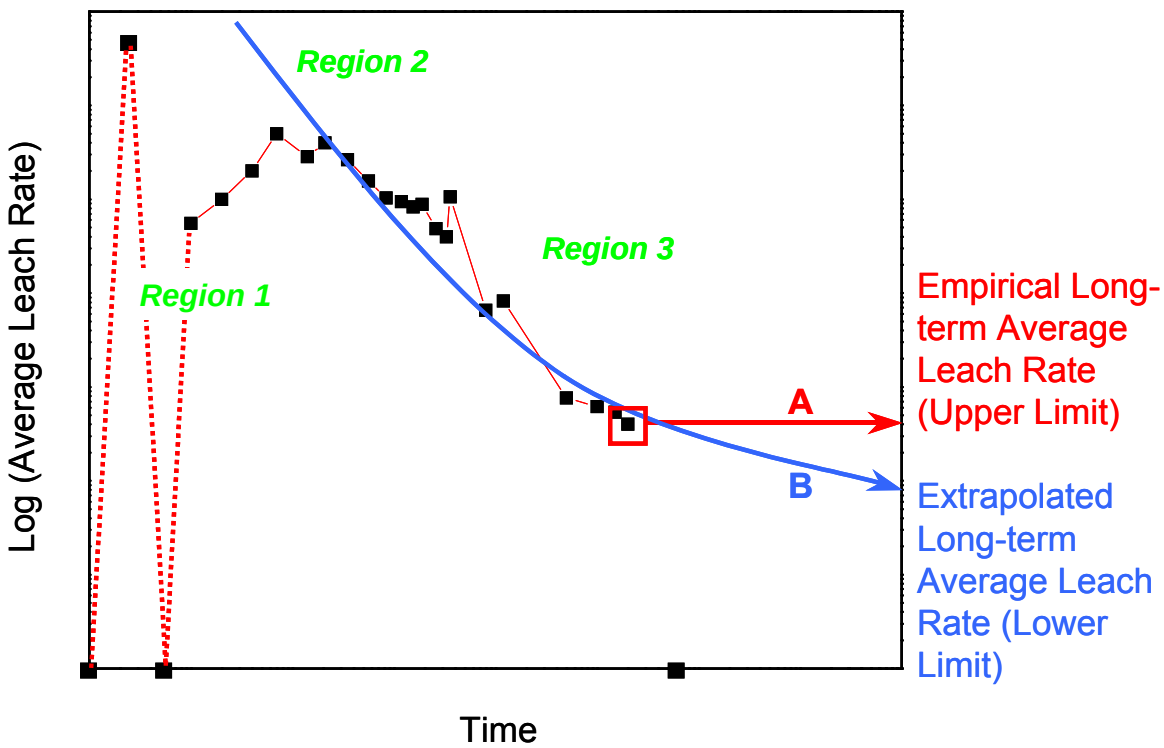


Figure A.8-2. Hypothetical leaching domains and the empirical long-term average leach rate (A) and extrapolated long-term average leach rate (B). From George and In 2002b.

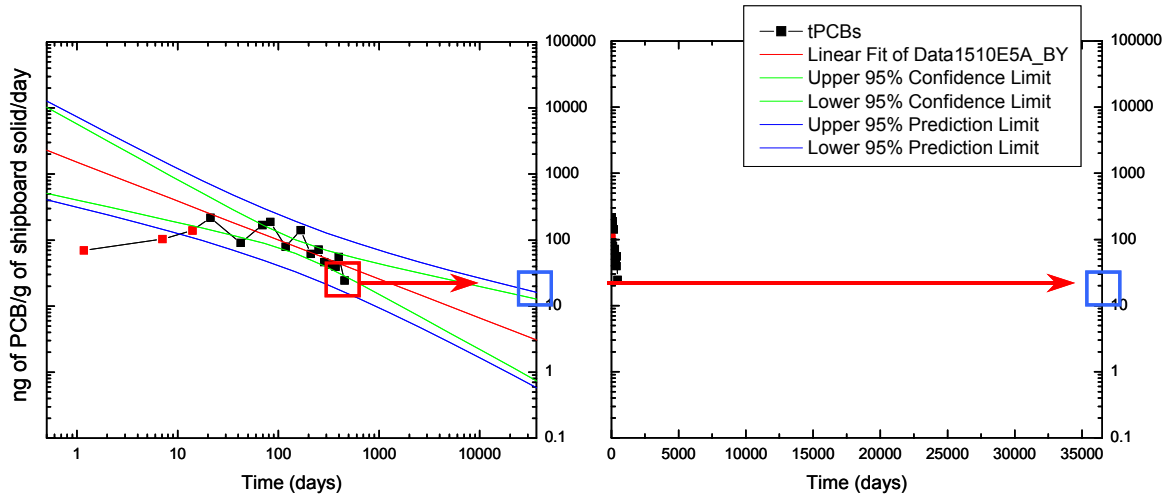


Figure A.8-3. Empirically derived short-term leach rate curve (left figure) and extrapolated long-term leach rate curve (right figure) for Total PCB from bulkhead insulation (with Total PCB concentrations ≤ 0.044% PCB). From George and In 2002b.

Model Development

If $m(t)$ is the mass of the PCB in the volume of water at time t, the rate of change will be $m'(t)$. If the PCB is being added at the rate of $a(t)$ and being removed at the rate of $r(t)$, the rate of change is:

$$dm/dt = m'(t) = \text{rate of addition} - \text{rate of removal} \quad [1]$$

$$m'(t) = a(t) - r(t) \quad [2]$$

At steady state, the rate of the PCB addition $a(t)$ is a constant obtained from the experimental leach rate curve for each solid laden with PCBs (George and In 2002a, George and In 2002b). Also $r(t)$ depends on the concentration, $c(t)$, of the mixture and flow rate out at time t. If $o(t)$ is the flow rate out then,

$$r(t) = c(t)o(t) \quad [3]$$

But since we are assuming steady state the flow rate out is constant, the rate will be equal to the concentration times the outfall rate.

$$r = co \quad [4]$$

So, the concentration depends on the mass of PCB in the volume of water (V) surrounding the ship at time t.

$$c(t) = m(t)/V(t) \quad [5]$$

For an instantaneous time, assuming the concentration is at steady state, $a(t)$ and $r(t)$ are constant, so the equation above becomes

$$c = m/V \quad [6]$$

The differential equation describing this problem is

$$m'(t) = a(t) - m(t)o(t)/V(t) \quad [7]$$

The model assumes that there is no loss of PCB from adsorption, degradations, bioaccumulation, or partitioning, but simply focuses on the maximum "available" PCB released into the environment (all other loss terms are set to zero, Figure A.8-1). This greatly simplifies the modeling exercise and allows the relative importance of leaching from the solid materials on the ship to be evaluated. The processes of adsorption, degradations, bioaccumulation, and partitioning are addressed by more detailed model constructs to evaluate PCB fate and potential effects in the environment (Richter et al. 1994, PRAM NEHC 2000b, 2001b) and is beyond the scope of this screening level ecorisk assessment.

The model parameters were estimated as follows. The volume of water that contains the ship (V) was determined from the dimensions of the ex-VERMILION : length 139.95 m (459 ft 2 in), beam 19.20 m (63 ft), and height 16.76 m (55 ft)[2] as 45,052,457 liters (45,052.5 m^3). The average current velocity was obtained from the South Atlantic Bight Synoptic Offshore Observational Network (SABSOON), which is a real-time oceanographic observational network located on the southeastern continental shelf of the U.S. (Skidaway Institute of Oceanography 2002). Current data from Station M2 of the SABSOON network were used to estimate bottom currents at the ex-VERMILLION reef. Located about 60 miles offshore of Savannah, GA at 31.533^o N -80.233^o W, Station M2 records bottom currents at about the same depth (28 m, 91 ft) and location on the continental shelf as the ex-VERMILION reef. The long-term average current velocity observed for bottom currents at Station M2 was 0.25 m/s for u (current in the "x" direction) and 0.25 m/s for v (current in the "y" direction), resulting in an average velocity (ν) of 0.35 m/s (30,240 m/day) (Skidaway Institute of Oceanography 2002).

Since, the flow rate $Q = \nu A$ [8]

with the area (A) being the height of the reef times beam, then the exchange rate was calculated as:

$$i = o = Q/V \quad [9]$$

[2] Before she was sunk the VERMILION was cut down to the O1 level, leaving her at a height of 55 ft.

The excel worksheets used to input the assumptions (Assumptions), estimate PCB loading (Load Estimate), solve the model equations (Calculations), compare the results to benchmarks (Benchmarks) and evaluate the consequences of reducing PCB loading (Reductions) are appended to this section.

Loading Estimates

In the late 1980s the South Carolina Department of Natural Resources (SCDNR) created artificial reefs consisting of sunken ex-U.S. Navy and Army ship hulls. The reefs were constructed as part of SCDNR Marine Artificial Reef Program (Bell 2001, SCDNR 2002). One such reef was created about 30 miles off the coast of South Carolinia in 110 ft of water by sinking the ex-VERMILION (amphibious cargo ship LKA 107) (see Appendix 3D). The ex-VERMILION was obtained by the State of South Carolina in 1987 from the U.S. Maritime Administration's (MARAD) inactive reserve fleet in the James River near Ft. Eustis, Virginia. The 460 foot-long (139 m) ship was towed to Wilmington, North Carolina where it was cleaned, stripped and prepared for its new role as reef material by a private marine contractor and ship breaker. The goal of the artificial reef program was to enhance recreational fishing opportunities by developing carefully designed, permitted, and monitored artificial reefs (SCDNR 1987).

The vessel was prepared to acceptable standards for artificial reef construction activity in the U.S. at that time (Stone, 1985). A letter application to the Department of Transportation from SCDNR documented the procedures used to prepare the ship (SCDNR 1987, see Appendix 3d). All commonly encountered potential shipboard pollutants such as fuels, oils, solid or liquid chemicals, liquid PCBs (electrical transformers and switchboards) and floatable materials such as plastics or wood were removed and properly disposed of by the contractor. To facilitate use of the ship in 110 feet of water and minimize its risk as a possible hazard to navigation, the overall height of the vessel was reduced to no greater than 55 feet (17 m) above the keel. All structure above the O1 level was removed. Large holes were cut in the sides of the ship and between watertight bulkheads. Removing or welding internal doors and hatches open further breached internal watertight integrity (Photo A8-1). After final inspection by U.S. Coast Guard Marine Safety Office Wilmington, the vessel was towed to its final destination and sunk by the use of explosive charges set by U.S. Navy Explosive Ordnance Disposal personnel (EOD Mobile Unit Six). The Vermilion sank quickly, and settled in an upright position on barren flat sand bottom 110 feet (33 m) deep, approximately 32 miles southeast of the port of Georgetown, SC.

When the Vermilion and other similar ships were prepared for sinking in the 1980's, SCDNR was not aware that solid materials containing PCBs were present onboard the vessel. Therefore, no effort was made to remove specific materials for this reason. When all materials above the O1 level (superstructure) were removed, some materials that likely contained PCBs were also removed. No effort was made to remove gaskets, cable runs, or other solid materials that may of contained PCBs in other parts of the ship. In the case where hatches or watertight doors were removed, they were often just thrown inside the ship, unless they were deemed to be of value to the contractor, then they were retained for scrap (some gaskets were left behind, others were removed).

The potential leaching of PCBs from the ex-VERMILION was estimated using the empirical leaching rates of total PCB measured for felt gaskets, electric cable, paint, rubber, foam insulation, and

Photo A8-4. The ex-VERMILION prior to sinking (photo by SCDNR).

bulkhead insulation (George and In 2002a, 2002b, 2003, George et al 2004, 2005). The leaching rate of Aroclor 1254 (George and In 2002a) was used as an analogue for PCBs dissolved within residual oils & greases. Based on information available about the types of materials and PCB concentrations estimated to be present on the ex-AGERHOLM (JJMA 1998), low, average, and high PCB loading scenarios were developed to simulate the leaching of PCBs from ex-VERMILION and estimate the instantaneous steady state concentration of total PCB around the ship. Because the ex-VERMILION is about 3 times larger in volume than the ex-AGERHOLM, the estimated mass of solid materials containing PCBs was multiplied by the ratio of the volume ratio of the two ships $V_{ex\text{-}VERMILION} : V_{ex\text{-}AGERHOLM}$ [3] (see page Assumptions-1). The estimated concentrations were compared to the PCB water benchmarks and multiplied by bioconcentration factors to project the resulting PCB concentration in fish and shellfish.

The load estimates of material containing PCBs on the ex-VERMILION were estimated from data developed for the ex-AGERHOLM (see page Load Estimates-1). JJMA (1998) reported that there were three types of HVAC gaskets, felt, paper, and rubber. The highest proportion of PCBs was, by far, associated with the felt gaskets and felt gaskets were the only gasket material tested by George and In (2002a, 2002b, 2003). Therefore, only felt gaskets were used in the estimate of PCB

[3] This assumes that there is 3.3 times more of each type of PCB-laden solids on the larger ex-VERMILION than on the ex-AGERHOLM.

loading from gasket material on the ex-VERMILION. Based on JJMA (1998) data, about 100 lbs of felt gaskets were on the ex-AGERHOLM when she was sunk. The mass of PCBs associated with the felt gasket material was estimated as 0.082 lbs for the low case (see page Load Estimates-1, cell F5), 20.041 lbs for the average case (see page Load Estimates-1, cell H5) and 40 lbs for the high case (see page Load Estimates-1, cell J5). This results in a weight fraction of 0.00082, 0.20041, and 0.4 PCB per unit solid material for the low, average, and high cases, respectively. (Note that the worksheets are color-coded to show that the cells in yellow were used for the low case, the cells in green were the changes used for the average case, and the cells in rose were the changes used for the high case.)

JJMA (1998) reported that there was 33,444 lbs of electrical cabling present on the ex-AGERHOLM when she went down. The average and high mass of PCBs present in the cabling was estimated by JJMA (1998) as 14.75 lbs and 20.2 lbs, respectively (see page Load-Estimates-1, cells H8 and J8). The low PCB mass was estimated using the value measured for cabling sampled on the ex-VERMILION, one sample = 7.33 ppm, (Martore et al. 1998, cell f8).

The low, average, and high PCB loading from paint, foam insulation, and bulkhead insulation were obtained by assuming that the PCB weight fraction remained the same but that the amount of material on the ship varied according to available estimates. JJMA (1998) estimated that there could of been as much as 197,000 lbs of paint for the high case, 123,200 lbs of paint for the average case, and 49,280 lbs of paint for the low case on the ex-AGERHOLM when she slipped beneath the waves. The amounts of foam insulation and bulkhead insulation were estimated as 1% and 10% of the 200 lbs of foam insulation reported by JJMA (1998). The PCB mass reported by JJMA (1998) for paint and foam insulation and the PCB mass measured in the bulkhead insulation tested by George and In (2002a, b, 2003) were used to determine the weight fraction of PCB per unit solid material (see page Load Estimates-1, rows 9-11 for paint, rows 14-16 for foam insulation, and rows 17-19 for bulkhead insulation).

JJMA (1998) estimated that there was 7,090 lbs of residual oils & greases present on the ex-AGERHOLM before she was used for target practice. The residual oils & greases are what are estimated to remain on the ship after the fuel and other storage tanks are pumped and drained according to Coast Guard regulations (T. Pape, formerly of JJMA, personal communication). The PCB loading from the oils & greases was estimated by assuming that the amount of oils & greases remained constant but the concentration of PCBs dissolved in the oils & greases ranged from 0.02 lbs for the low case, 4.16 lbs for the average case, and 8.3 lbs for the high case (see page Load Estimates-1, cells F12, H12, and J12).

JJMA (1998) also estimated that 3,300 lbs of rubber products were on the ex-AGERHOLM before she was blasted to the depths. Only two rubber samples were reported in the JJMA report (1998), one was nondetected and the other was 56 ppm. The low concentration was obtained by using the minimum of the two samples as ND/2 = 50/2 = 25 ppm. The average concentration was reported by JJMA (1998) as 28 ppm, and the high concentration was estimated as the maximum of both samples 56 ppm (see page Load Estimates-1, cells F13, H13, and J13).

The mass of the solid materials containing PCBs on the ex-VERMILION was arrived at by multiplying the estimates for the ex-AGERHOLM by a scale factor of 3.33 to account for greater size of the ex-VERMILION (see page Calculations – 1). Of course this imparts uncertainty to the loading

estimates, because there are fundamental differences in the materials present on a troop transport ship (noncombatant) versus a destroyer (combatant). In addition, because most of the super structure was removed from the ex-VERMILLON when she was cut down to the O1 level, any PCB containing solids in those compartments were also removed. The differences in the amounts of solid materials that could contain PCBs between the ex-VERMILION and ex-AGERHOLM are summarized below (T. Pape, formerly of JJMA, personal communication):

1. Felt Gaskets. Because the ex-VERMILION was a troop transport ship, there is more berthing areas, ducts, vents, etc. on the ex-VERMILION (per unit volume) than the ex-AGERHOLM, therefore scaling by volume probably underestimates total amount of felt gaskets.
2. Cabling. There is less electrical cabling on a noncombatant (per unit volume), so scaling by volume probably overestimates the amount of electrical cabling.
3. Paint. Scaling by volume is probably a good estimate of the total paint present. The biggest uncertainty about paint is how many layers of paint?
4. Rubber. Scaling by volume probably is a good estimate. There are similar numbers of compartments per volume on both types of ships.
5. Foam Insulation. The amount of foam insulation is a function of surface area, scaling by volume is probably a good estimate.
6. Oils & Greases. Most oils & greases onboard the vessels are likely present as films and residues. Scaling by volume probably overestimates the amount of oils & greases present on the ex-VERMILION. Size is not a good indicator of hydraulic and power plant systems.
7. Bulkhead Insulation. Scaling by volume is probably a good estimate, but a noncombatant troop ship like the ex-VERMILION has more living space and more "comfort" materials for sound dampening etc. Therefore scaling by volume could slightly under estimate the amount of bulkhead insulation present.

In comparison, the estimated total pounds of PCBs onboard the two ships is:

	Low Case	Medium Case	High Case
AGERHOLM	2.9 lbs	45 lbs	80 lbs
VERMILION	9.5 lbs	150 lbs	267 lbs

Leach Rate Computations

The leach rate computations are shown on pages Calculations – 1 to Calculations – 3. The mass of Total PCB and fraction of Total PCBs present in each of the solid materials for each case are shown on page Calculations – 1. The high case resulted in 50% of PCBs (133 lbs) being present in felt gasket material, 25% was associated with electrical cables, 12% was in the paint, 10% was present (dissolved) in the residual oils & greases, and only 0.1% of the PCBs were present in the bulkhead insulation. For the average case, felt gaskets, electric cable, paint, and oils & greases accounted for 44%, 32%, 13%, and 9% of the mass of PCBs on the ship, respectively (see column H). For the low case, paints accounted for about 85% of the mass of PCB on the ship (cell H7) and electric cable accounted for about 9% of the mass of PCB.

The leach rates reported by George and In (2002a, b, 2003, see page Calculations – 2columnI) were applied to the mass of PCBs present on the ex-VERMILION to derive the release rate *a(t)*. These leach rate values represent the maximum PCB release for PCB molecules present in the solid up to the weight fraction in the solid tested, and includes the effect of transport being inhibited by the solid matrix (stationary phase) in which the PCBs reside. This is why the rate is expressed as shipboard-solid-specific and normalized to the mass of shipboard solid tested, rather than to the mass of PCBs in the solid tested. The highest leach rate was for oils & greases, because the leaching rate of pure Aroclor 1254 was used as a proxy for PCBs in oils & greases. The leaching of PCBs from oils & greases was obtained by assuming that all the PCBs within oils & greases were present as Aroclor 1254 and that the Aroclor leached at the same rate as the pure Aroclor measured in the laboratory leaching experiment. This overestimates the leaching, because pure Aroclor 1254 probably has a higher leach rate than Aroclor 1254 dissolved in oils & greases. It represents the highest possible leaching, if PCBs were present in non-mobile, non-soluble, non-dispersing residual oils & greases[4]. Bulkhead insulation had the highest leaching rate of the solid materials tested, followed by foam insulation, felt gaskets, and rubber (column I). When the leaching rate of PCB was normalized to the unit PCB present in the shipboard solid material tested (column M) the leaching rate for bulkhead insulation was orders of magnitude higher than the other materials. Felt gaskets and electric cabling had the lowest leaching rate, and paint, foam insulation, and rubber had about the same leaching rate.

The release rate, exchange rate, and resulting PCB concentrations are shown on page Calculations – 3. The release rate (*a*, column N) was obtained by multiplying the leaching rate by the mass of PCBs present in each of the solid materials on the ship. By dividing the release rate by the exchange rate (*o*, column O) the instantaneous steady state PCB concentration was derived for each solid (column P). By summing the steady state concentrations for each solid material, the total steady state water concentration of PCB was obtained (see rows 13, 23, and 33). The estimated steady state PCB concentration contributed from each of the solids is shown in Figure A.8-4. The PCBs released from the high case were almost two orders of magnitude higher (75 times higher) than the low case and about twice as high as the average case (Figure A.8-4). The PCBs leached from oils & greases contributed most of the loading for the medium (88%) and high (75%) cases. Bulkhead insulation was also an important contributor for the high case (13%).

In the high case, 50% of the PCBs present on the ship came from felt gaskets, but the felt gaskets only accounted for less than 5% of the PCBs released (Figure A.8-5). Although bulkhead insulation accounted for only 0.1% of the total PCB mass on the ship (300 kg of material, 133 g [0.3 lbs] of PCB), the bulkhead insulation accounted for more than 12% of the PCBs released from the ship (Figure A.8-5). For the low case with the major sources of PCBs greatly reduced, paints contained 85% of the mass of PCBs and accounted for 68% of the PCBs released (Figure A.8-5).

Based on the experimental leaching rates it would take on the order of 65,000 to 677,000 years to leach all the PCBs from the felt gaskets, about 74,000 years to leach out of electric cable, 19,000 years to leach out of paint, 12,000 years to leach out foam insulation, and 6,000 years to leach out of rubber. On the other hand, PCBs would leach out of bulkhead insulation within 50 years and leach out of oils & greases in less than 1,000 years (see page Calculation – 3).

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[4] If oils & greases were present as mobile, soluble, and dispersing liquids then the dispersion of any PCBs contained in the oils & greases into the environment would be increased.

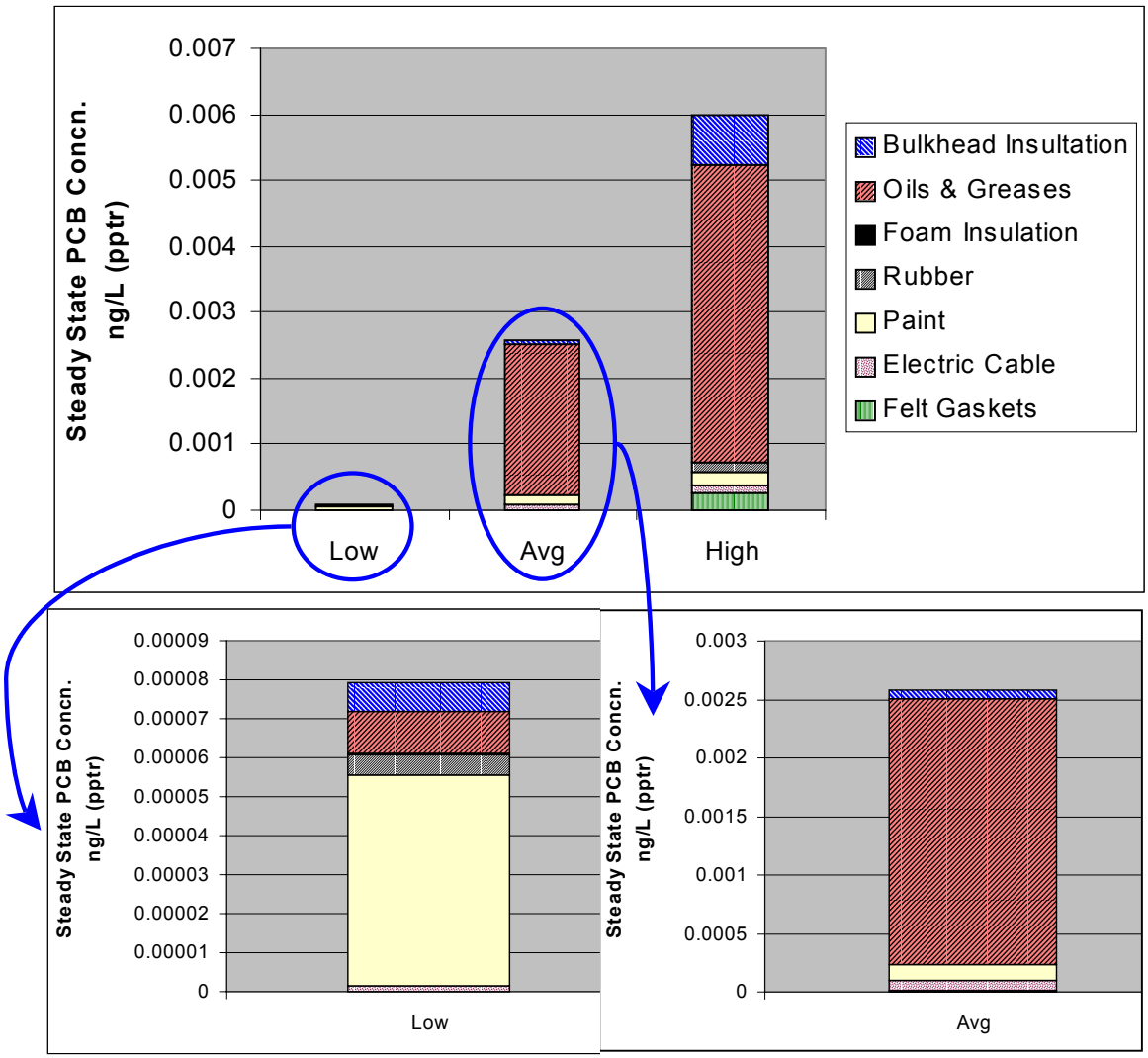
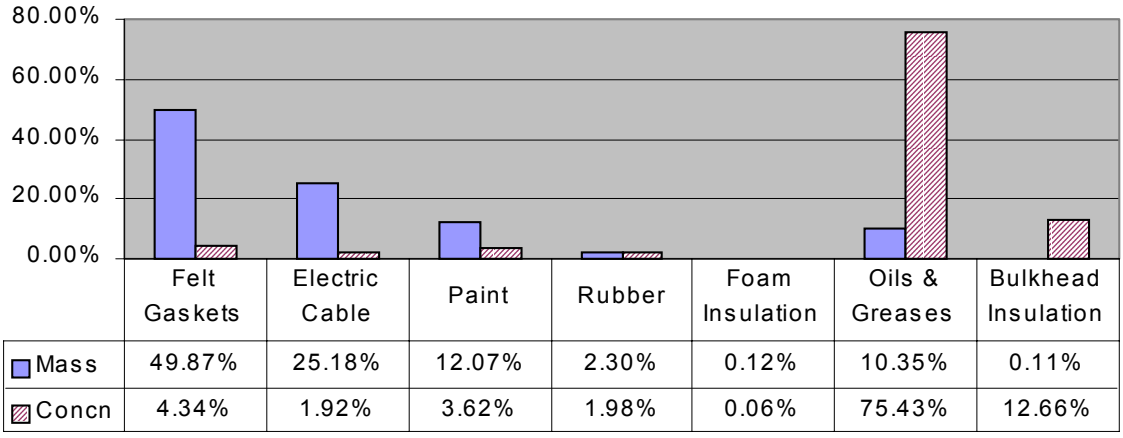


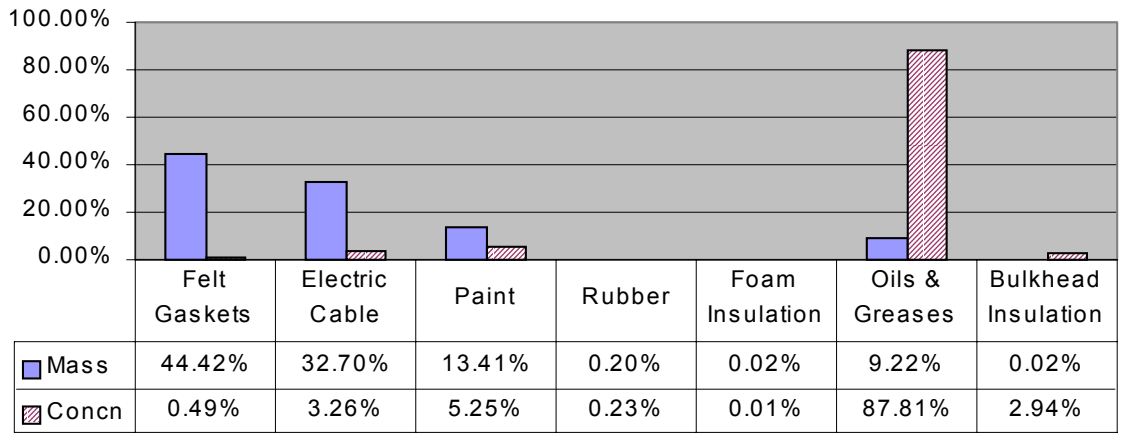
Figure A.8-4. The steady state concentration of Total PCB released per day contributed from each solid material estimated from the low, average, and high loading cases for the ex-VERMILION.

Comparison to Benchmarks

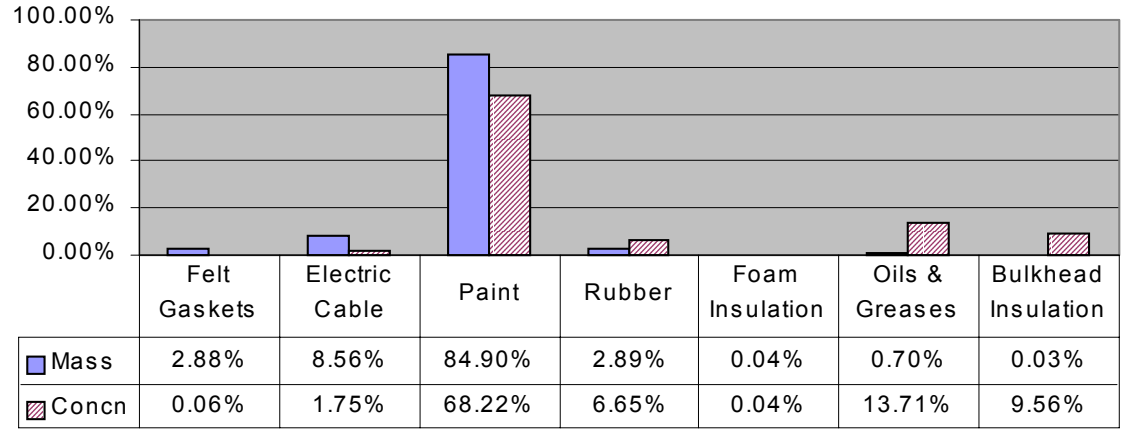
The comparison between the steady state concentrations estimated from the leaching rates and the water column benchmarks showed that the estimated water concentrations were well below the water quality benchmarks (see page Benchmarks – 1). The projected tissue concentrations ranged from 0.06 – 4.85 ng/g dry weight (ppb) for fish tissue and 0.01 – 0.93 ng/g dry weight (ppb) for invertebrate tissue. These concentrations were also well below the PCB tissue residue benchmarks of 1.27 – 24.3 ug/g dry weight (ppm) for fish and 2.18 – 10 ug/g dry weight (ppm) for invertebrates (see page Benchmark – 1, Table 3).



	Felt Gaskets	Electric Cable	Paint	Rubber	Foam Insulation	Oils & Greases	Bulkhead Insulation
Mass	49.87%	25.18%	12.07%	2.30%	0.12%	10.35%	0.11%
Concn	4.34%	1.92%	3.62%	1.98%	0.06%	75.43%	12.66%



	Felt Gaskets	Electric Cable	Paint	Rubber	Foam Insulation	Oils & Greases	Bulkhead Insulation
Mass	44.42%	32.70%	13.41%	0.20%	0.02%	9.22%	0.02%
Concn	0.49%	3.26%	5.25%	0.23%	0.01%	87.81%	2.94%



	Felt Gaskets	Electric Cable	Paint	Rubber	Foam Insulation	Oils & Greases	Bulkhead Insulation
Mass	2.88%	8.56%	84.90%	2.89%	0.04%	0.70%	0.03%
Concn	0.06%	1.75%	68.22%	6.65%	0.04%	13.71%	9.56%

Figure A.8-5. The percent of total PCBs and the percent of total PCBs released in the steady state concentration for each of the solid materials under the high, average, and low case scenarios.

Reducing PCB Loading

The results from the empirical leaching studies and hypothetical steady state model were used to evaluate the consequences of removing materials from the ship to reduce PCB loading. In general, removing the materials with the highest leachrates would result in the greatest reduction in PCB loading per unit material removed. Based on the empirical upper bound of the leachrate obtained from the solids tested (George and In 2002a, 2002b, 2003, George et al 2004, 2005) removing 0.001 kg (1 g) of pure Aroclor 1254 would reduce leaching by the same amount as removing 0.004 kg of pure Aroclor 1268, 0.143 kg of bulkhead insulation, 1.855 kg of foam insulation, 3.8 kg of felt gaskets, 5.3 kg of rubber products, 56.5 kg of paint, or 80 kg of electrical cable (Table A8-1(A)).

For the solid materials tested in the laboratory leaching experiments, the effect of decreasing PCB loading by reducing the amount of solid materials containing PCBs was evaluated using the steady state model Table A8-1(B). The steady state model takes into account both the quantity and concentration of PCBs in the materials estimated to be on the ship when it was sunk. For the high case, removing 0.143 kg (143 g) of bulkhead insulation would be equivalent to removing 0.209 kg of felt gaskets, 15.2 kg of rubber products, 33 kg of foam insulation, 158 kg of electrical cable, or 495 kg of paint (Table A8-1(B)). The reduction in the fraction of PCBs present in felt gaskets, electric cable, rubber, and oils & greases for the average and low cases means that more of those materials would have to be removed to result in the same decrease in the amount of PCBs released (Table A8-1(B)). Based on the average loading scenario, removing about 150 g of bulkhead insulation would result in about the same reduction in PCB loading as removing 4 kg of felt gaskets, 30 kg of foam insulation, 200 kg of electrical cable, 300 kg of rubber products, or 500 kg of paint. Because considerably more effort is required to remove certain types of materials than others, the most cost-effective approach would be to remove the relatively accessible bulkhead insulation from living compartments.

No empirical data of the leaching rate of PCB contained in oils & greases are available, therefore in the steady state model it was assumed that PCBs dissolved in oils & greases would leach at the same rate as pure Aroclor 1254. This may be a very conservative estimate of loading from oils & greases, because it does not take into account differences in leaching that could be caused by interactions between the oils & greases and the fraction of PCBs contained with the matrix. Based on the estimates provided by JJMA (1998), the weight fraction of PCBs in oils & greases ranged from 2.8 x 10^{-6} to 0.0012 (see Load Estimates – 1), which is far lower than the weight fraction of PCBs in pure Aroclor (1.0). If the oils & greases act to increase PCB mobility and increase dispersion into the environment, then the Aroclor 1254 leachrate might actually underestimate the release rate. However, if oils & greases were actually present as mobile fluids they would be rapidly solubilized and dispersed soon after the ship was sunk. Due to the uncertainty about oils & greases the prudent course of action would be to use extra care to clean up oils & greases in areas where they may of come into contact with PCBs. The apparent importance of PCB loading from oils & greases and the doubt about the leachrate of PCBs contained in oils & greases is a major source of uncertainty in this analysis.

Summary

The leach rate computations for the REEFEX study were used to estimate water column PCB concentrations using the latest leachrate data. Empirical estimates of PCB leaching rates were developed for felt gaskets, electric cable, paint, rubber, foam insulation, Aroclor 1254 (oils & greases),

and bulkhead insulation (George and In 2002a, 2002b, 2003, George et al 2004, 2005). Based on information available about the types of materials and PCB concentrations estimated to be present on the ex-AGERHOLM (JJMA 1998), low, average and high PCB loading scenarios were developed to simulate the leaching of PCBs from the ex-VERMILION and estimate the instantaneous steady state concentration of total PCB around the ship. The estimated concentrations were compared to the PCB water benchmarks and multiplied by bioconcentration factors to project the resulting PCB concentration in fish and shellfish. The results showed that there was negligible risk of exceeding water column or tissue benchmarks for any of the loading scenarios evaluated.

Although the analysis of shipboard leaching scenarios is fraught with uncertainty, it provides a very good indication of the relative importance of PCB loading from the ship under hypothetical conditions. The lack of empirical data on PCB leaching in oils & greases was identified as a major source of uncertainty in the analysis. The model showed that residual oils & greases and bulkhead insulation were the most important sources of PCB loading. Based on the average loading scenario, removing about 150 g of bulkhead insulation would result in about the same reduction in PCB loading as removing about 4 kg of felt gaskets, 30 kg of foam insulation, 200 kg of electrical cable, 300 kg of rubber products, or 500 kg of paint. Because considerably more effort is required to remove certain types of materials than others, removing relatively small quantities of bulkhead insulation and using extra care to clean up oils & greases in areas where they may of come into contact with PCBs would greatly reduce the amount of PCBs leached and therefore further reduce the potential risk of exposure to PCBs.

References

For references cited please see Section 10.

Spreadsheet Calculations

Assumptions
Load Estimates
Calculations
Benchmarks
Reductions

Table A.8-1. The equivalent decrease in PCBs released from the ship as a result of removing different amounts of solid materials containing PCBs. (A) The decrease obtained using only the laboratory-derived empirical long-term average release rate (upper limit). (B) The decrease obtained using the steady state model of High, Average, and Low loading cases developed for the exVERMILION.

(A)				Leaching rate of PCB				**AMOUNT REMOVED**	***DECREASE in RELEASE***	
Material				ng of PCB released/ g Solid/day				kg shipboard solid removed	ng PCBs released/day	
Felt Gaskets				0.93				3.769	3,505.35	
Electric Cable				0.044				79.667	3,505.35	
Paint				0.062				56.538	3,505.35	
Rubber				0.66				5.311	3,505.35	
Foam Insulation				1.89				1.855	3,505.35	
Pure Aroclor 1254				3505.35				0.001	3,505.35	
Pure Aroclor 1268				838.00				0.004	3,505.35	
Bulkhead Insulation				24.45				0.143	3,505.35	
Oils & Greases				No Empirical Data						
(B)										
Using HIGH CASE MODEL RELEASE PER DAY										
	Total Weight of Material (kg)		Fraction of PCB in solid	Leaching rate of PCB		Leaching rate of PCB	Release Rate (a)	**AMOUNT REMOVED**	***DECREASE in RELEASE***	
Material	kg PCB-containing Material	g PCB in solid	g PCB/g of solid	ng of PCB released/ g Solid/day		ng PCB released/ g PCB in solid/ day	ng PCB released/day	kg shipboard solid removed	ng PCBs released/day	
Felt Gaskets	151.182	60,473	0.40000	9.63	m	41.87	2,531,966	0.209	3,505.35	
Electric cable	50,559.718	30,539	0.00060	0.04		36.67	1,119,753	158.276	3,505.35	
Paint	298,009.495	14,634	0.00005	0.06		144.19	2,110,076	495.066	3,505.35	
Rubber	4,988.998	2,794	0.00056	0.66		412.50	1,152,459	15.175	3,505.35	
Foam Insulation	302.364	151	0.00050	1.89		212.36	32,105	33.013	3,505.35	
Bulkhead Insulation	301.864	133	0.00044	24.45			7,380,565	0.143	3,505.35	
Using AVERAGE CASE MODEL RELEASE PER DAY										
Felt Gaskets	151.182	30,298	0.20041	0.93		4.04	122,511	4.326	3,505.35	
Electric Cable	50,559.718	22,299	0.00044	0.044		36.67	817,641	216.757	3,505.35	
Paint	186,255.934	9,146	0.00005	0.062		144.19	1,318,797	495.066	3,505.35	
Rubber	4,988.998	140	0.00003	0.66		412.50	57,623	303.494	3,505.35	
Foam Insulation	30.236	15	0.00050	1.89		212.36	3,210	30.236	3,210.49	n
Bulkhead Insultation	30.236	13	0.00044	24.45		55,568.18	739,279	0.143	3,505.35	
Using LOW CASE MODEL RELEASE PER DAY										
Felt Gaskets	151.182	124	0.00082	0.93		4.04	501.27	151.182	501.27	n
Electric Cable	50559.718	369	0.00001	0.04		36.67	13533.15	13095.953	3,505.35	
Paint	74502.374	3659	0.00005	0.06		144.19	527518.88	495.066	3,505.35	
Rubber	4988.998	125	0.00003	0.66		412.50	51449.04	339.913	3,505.35	
Foam Insulation	3.024	2	0.00050	1.89		212.36	321.05	3.024	321.05	n
Bulkhead Insulation	3.024	1	0.00044	24.45		55568.18	73927.88	0.143	3,505.35	
k	Aroclor 1254 used as a proxy for Aroclor 1254 in grease and non mobile oils									
m	Max empirical leachrate used as estimate, because material has higher concentration than material tested.									
n	All material removed from ship									

	A	B	C	D	E	F	G	H
1	**ASSUMPTIONS:**							
2		**Ship**	**ex-VERMILION**	**ex-AGERHOLM**	**Units**	**ex-VERMILION**	**ex-AGERHOLM**	**Units**
3	**Ship specs:**	Displacement (light)	8,635	2,425	ton			ton
4		Displacement (full)	13,910	3,460	ton			ton
5		Length	140.0	119.0	m	459.17	390.50	ft
6		Beam	19.2	12.4	m	63.00	40.83	ft
7		Draft	8.0	4.4	m	26.33	14.33	ft
8		Height	16.8	9.1	m	55.00	29.94	ft[a]
9		Speed	16.5		kts	16.5		kts
10		Reef Volume	45052.5	13517.1	m^3	1591012.5	477353.3	ft^3
11		Ratio V_vermilion:V_agerholm		3.333			3.333	
12								
13	**Physical specs:**	Depth ship sunk =	100		feet			
14		Pressure =	1 to 3		bar			
15		Temperature =	25		C			
16								
17	**Model specs:**	Volume of water in model =	45,052,457		L	11,901,601		gals
18		water velocity (v) =	0.35		m/s			
19		water velocity (v) =	30,240.0		m/day			
20		Q=v*A =	9,734,529.2		m^3/day			
21		Volume of water per day =	9,734,529,176		L			
22		Exhange Rate =	216.1		1/day			
23								
24	**EPA water quality criteria**							
25		**Chronic**	0.03		ug/L	0.03		ug/L
26		**Acute**	10		ug/L	10		ug/L
27								
28	**Load Estimates**	Obtained from JJMA 1998 for ex-Agerholm						
29								
30	**PCB Leaching Rates**							
31		Obtained from George and In 2002a, b						
32								
33	[a]	Height of Agerholm estimated from the height:draft ratio for the Vermilion; Vermilion height:draft ratio = 2.089						

	I	J	K	L	M	N	O	P	Q
1									
2		**Reference**							
3		http://www.navsource.org/archives/10/02107.htm							
4									
5									
6									
7									
8	2.089	= Vermilion height:draft ratio							
9									
10									
11									
12									
13									
14									
15									
16									
17		http://environ.spawar.navy.mil/sbpcbe/reefex/techdocs/TWG_Meetings/6th_REEFEXtwg/spiegel.pdf							
18		http://www.skio.peachnet.edu/projects/sabsoon_web/tower.html							
19									
20									
21									
22									
23									
24									
25		US EPA see Table 3							
26		US EPA see Table 3							
27									
28									
29									
30									
31									
32									
33									

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		**LOAD ESTIMATES**		Data from JJMA (1998) "Weight Estimates for PCBs and Selected Metals sunk on EX-USS AGERHOLM (DD 826)"										
2			Total Mass	Total Mass		Mass of PCB (lbs)						Weight Fraction PCB/Solid Material		
3		Material	Kg	lbs		Low		Avg		High		Low	Avg	High
4		HVAC Felt	104.33	230		0.09310		20.89655		41.700		0.000405	0.090855	0.181304
5		**Felt Gasket**	45.36	100		0.08200		20.04100		40.000		0.000820	0.200410	0.400000
6		Paper Gasket	40.82	90		0.00990		0.45495		0.900		0.000110	0.005055	0.010000
7		Rubber Gasket	18.14	40		0.00120		0.40060		0.800		0.000030	0.010015	0.020000
8		**Electrical Cable**	15169.49	33443		0.24413	d	14.75000		20.200		7.3E-06	0.000441	0.000604
9		**Paint (Low)**	22353.03	49280		2.42000						0.000049		
10		**Paint (Average)**	55882.58	123200				6.05000	h				0.000049	
11		**Paint (High)**	89412.13	197120						9.680				0.000049
12		**Oils and Greases**	3215.97	7090		0.02000		4.16000		8.300		2.82E-06	0.000587	0.001171
13		**Rubber Products**	1496.85	3300		0.08250	e	0.09240	f	1.848	g	0.000025	0.000028	0.000560
14		**Foam Insulation (Low)**	0.91	2	a	0.00100						0.000500		
15		**Foam Insulation (Average)**	9.07	20	b	0.01000		0.01000		0.010			0.000500	
16		**Foam Insulation (High)**	90.72	200		0.10000		0.10000		0.100				0.000500
17		**Bulkhead Insulation (Low)**	0.91	2	a	0.00088	i					0.000440		
18		**Bulkhead Insulation (Med)**	9.07	20	b	0.00880	i						0.000440	
19		**Bulkhead Insulation (High)**	90.57	200	c	0.08800	i							0.00044
20														
21	a	Estimated as 1% of "High" mass												
22	b	Estimated as 10% of "High" mass												
23	c	Estimated as same amount of foam insulation												
24	d	Estimated using the value measured for cabling on the ex-VERMILION; 1 sample = 7.33 ppm (Martore et al. 1998)												
25	e	Estimated using min of both samples = ND/2 = 25 ppm												
26	f	Estimated using average of both samples = 28 ppm												
27	g	Estimated using max of both samples = 56 ppm												
28	h	Note average should be 6.05 lbs not 12.1 lbs as shown on p10 of JJMA 1998												
29	i	Estimated to be same concentration as sample tested by George and In 2002a, b												
30		**Case Using "Low" Estimates from JJMA**												
31		**Case Using "Average" Estimates from JJMA**												
32		**Case Using "High" Estimates from JJMA**												

	A	B	C	D	E	F	G	H
1	**CALCULATIONS:**	Scale Factor =	3.33	Vermilion was 3.3 times larger than Agerholm			2.20462	lbs/kg
2	***TO FIND CONCENTRATION AT STEADY STATE***	**Class of PCB Material:**	**Total Weight of Material (kg)**	**Total Weight of Material (g)**	**Fraction of PCB in solid**	**Mass of PCB in shipboard solid material**	**lbs PCB**	**Fraction of Total PCB on Ship**
3			***kg PCB-containing Material***	***g PCB-containing Material***	***g PCB/g of PCB-containting material***	***g PCB in solid***	***lbs PCB***	
4	**Case Using "Low" Estimates from JJMA**							
5	**Based on Emprical Leaching Data**	Felt Gaskets	151.18	151,181.8	0.00082	123.97	0.2733	2.88%
6		Electric Cable	50,559.72	50,559,717.6	0.0000073	369.09	0.8137	8.56%
7		Paint	74,502.37	74,502,373.7	4.91071E-05	3,658.60	8.06583	84.90%
8		Rubber	4,989.00	4,988,998.2	0.000025	124.72	0.27497	2.89%
9		Foam Insulation	3.02	3,023.6	0.0005	1.51	0.00333	0.04%
10		Bulkhead Insulation	3.02	3,023.6	0.00044	1.33	0.00293	0.03%
11	***Estimated based on Aroclor 1254***		***kg Oils & Grease***	***g Oils & Greases***	***g Aroclor/g Oils & Greases***	***g Aroclor 1254 in Oils & Greases***	***lbs Aroclor***	
12		Oils & Greases	10,718.79	10,718,787.1	2.82087E-06	30.24	0.06666	0.70%
13	**Total**					4,309.46	9.5	lbs
14	**Case Using "Average" Estimates from JJMA**							
15	**Based on Emprical Leaching Data**	Felt Gaskets	151.18	151,181.8	0.20041	30,298.34	66.7964	44.42%
16		Electric Cable	50,559.72	50,559,717.6	0.000441049	22,299.31	49.1616	32.70%
17		Paint	186,255.93	186,255,934.2	4.91071E-05	9,146.50	20.1646	13.41%
18		Rubber	4,989.00	4,988,998.2	0.000028	139.69	0.30797	0.20%
19		Foam Insulation	30.24	30,236.4	0.0005	15.12	0.03333	0.02%
20		Bulkhead Insultation	30.24	30,236.4	0.00044	13.30	0.02933	0.02%
21	***Estimated based on Aroclor 1254***		***kg Oils & Grease***	***g Oils & Greases***	***g Aroclor/g Oils & Greases***	***g Aroclor 1254 in Oils & Greases***	***lbs Aroclor***	
22		Oils & Greases	10,718.79	10,718,787.1	0.000586742	6,289.16	13.8652	9.22%
23	**Total**					68,201.42	150.4	lbs
24	**Case Using "High" Estimates from JJMA**							
25	**Based on Emprical Leaching Data**	Felt Gaskets	151.18	151,181.8	0.4	60,472.71	133.319	49.87%
26		Electric cable	50,559.72	50,559,717.6	0.000604013	30,538.72	67.3263	25.18%
27		Paint	298,009.49	298,009,494.7	4.91071E-05	14,634.39	32.2633	12.07%
28		Rubber	4,989.00	4,988,998.2	0.00056	2,793.84	6.15936	2.30%
29		Foam Insulation	302.36	302,363.5	0.0005	151.18	0.3333	0.12%
30		Bulkhead Insulation	301.86	301,863.6	0.00044	132.82	0.3	0.11%
31	***Estimated based on Aroclor 1254***		***kg Oils & Grease***	***g Oils & Greases***	***g Aroclor/g Oils & Greases***	***g Aroclor 1254 in Oils & Greases***	***lbs Aroclor***	
32		Oils & Greases	10,718.79	10,718,787.1	0.001170663	12,548.09	27.6638	10.35%
33	**Total**					121,271.74	267.4	lbs
34	[k]	Aroclor 1254 used as a proxy for Aroclor 1254 in grease and non mobile oils						
35	[m]	This is max empirical LR from LRS used as estimate, because JJMA loading is higher than the material tested in the LRS.						

	A	B	I	J	K	L	M
1	**CALCULATIONS:**	Scale Factor =					
2	***TO FIND CONCENTRATION AT STEADY STATE***	**Class of PCB Material:**	**Leaching rate of PCB (per unit Shipboard Solid)**		**Weight Fraction of PCB in Specific Shipboard Solid tested in laboratory**		**Leaching rate of PCB (per unit PCB in Specific Solid Tested)**
3			***ng of PCB released/ g Shipboard Solid/day***		***g PCB in solid/ g Shipboard Solid***		***ng PCB released/ g PCB in solid/ day***
4	**Case Using "Low" Estimates from JJMA**						
5	**Based on Emprical Leaching Data**	Felt Gaskets	0.93		0.23		4.04
6		Electric Cable	0.044		0.0012		36.67
7		Paint	0.062		0.00043		144.19
8		Rubber	0.66		0.0016		412.50
9		Foam Insulation	1.89		0.0089		212.36
10		Bulkhead Insulation	24.45		0.00044		55,568.18
11	***Estimated based on Aroclor 1254***		***ng of PCB released/ g Aroclor 1254/day***				
12		Oils & Greases	3505.35	k			
13	**Total**						
14	**Case Using "Average" Estimates from JJ**						
15	**Based on Emprical Leaching Data**	Felt Gaskets	0.93		0.23		4.04
16		Electric Cable	0.044		0.0012		36.67
17		Paint	0.062		0.00043		144.19
18		Rubber	0.66		0.0016		412.50
19		Foam Insulation	1.89		0.0089		212.36
20		Bulkhead Insultation	24.45		0.00044		55,568.18
21	***Estimated based on Aroclor 1254***		***ng of PCB released/ g Aroclor 1254/day***				
22		Oils & Greases	3505.35	k			
23	**Total**						
24	**Case Using "High" Estimates from JJMA**						
25	**Based on Emprical Leaching Data**	Felt Gaskets	9.63	m	0.23		41.87
26		Electric cable	0.044		0.0012		36.67
27		Paint	0.062		0.00043		144.19
28		Rubber	0.66		0.0016		412.50
29		Foam Insulation	1.89		0.0089		212.36
30		Bulkhead Insulation	24.45		0.00044		55,568.18
31	***Estimated based on Aroclor 1254***		***ng of PCB released/ g Aroclor 1254/day***				
32		Oils & Greases	3505.35	k			
33	**Total**						
34	k	Aroclor 1254 used as a					
35	m	This is max empirical L					

	A	B	N	O	P	Q	R
1	**CALCULATIONS:**	Scale Factor =					
2	***TO FIND CONCENTRATION AT STEADY STATE***	**Class of PCB Material:**	**Release Rate (*a*)**	**Exchange Rate (*o*)**	**Concentration (*m*)**		
3			***ng PCB released/day***	***L/day***	***ng PCB/L***	***Fraction of Total PCBs in the water***	***Years to release***
4	**Case Using "Low" Estimates from JJMA**						
5	**Based on Emprical Leaching Data**	Felt Gaskets	501.27	9,734,529,176.1	5.14936E-08	0.06%	677,567
6		Electric Cable	13,533.15	9,734,529,176.1	1.39022E-06	1.75%	74,720
7		Paint	527,518.88	9,734,529,176.1	5.41905E-05	68.22%	19,001
8		Rubber	51,449.04	9,734,529,176.1	5.28521E-06	6.65%	6,642
9		Foam Insulation	321.05	9,734,529,176.1	3.29804E-08	0.04%	12,901
10		Bulkhead Insulation	73,927.88	9,734,529,176.1	7.5944E-06	9.56%	49
11	***Estimated based on Aroclor 1254***		***ng PCB released/day*** (Col I) x (Col F)				
12		Oils & Greases	105,989.00	9,734,529,176.1	1.08879E-05	13.71%	782
13	**Total**				**0.0000794**	pptr	
14	**Case Using "Average" Estimates from JJ**						
15	**Based on Emprical Leaching Data**	Felt Gaskets	122,510.67	9,734,529,176.1	1.25852E-05	0.49%	677,567
16		Electric Cable	817,641.38	9,734,529,176.1	8.39939E-05	3.26%	74,720
17		Paint	1,318,797.21	9,734,529,176.1	0.000135476	5.25%	19,001
18		Rubber	57,622.93	9,734,529,176.1	5.91944E-06	0.23%	6,642
19		Foam Insulation	3,210.49	9,734,529,176.1	3.29804E-07	0.01%	12,901
20		Bulkhead Insultation	739,278.83	9,734,529,176.1	7.5944E-05	2.94%	49
21	***Estimated based on Aroclor 1254***		***ng PCB released/day*** (Col I) x (Col F)				
22		Oils & Greases	22,045,711.96	9,734,529,176.1	0.002264692	87.81%	782
23	**Total**				**0.002579**	pptr	
24	**Case Using "High" Estimates from JJMA**						
25	**Based on Emprical Leaching Data**	Felt Gaskets	2,531,965.90	9,734,529,176.1	0.000260102	4.34%	65,435
26		Electric cable	1,119,752.94	9,734,529,176.1	0.000115029	1.92%	74,720
27		Paint	2,110,075.53	9,734,529,176.1	0.000216762	3.62%	19,001
28		Rubber	1,152,458.59	9,734,529,176.1	0.000118389	1.98%	6,642
29		Foam Insulation	32,104.89	9,734,529,176.1	3.29804E-06	0.06%	12,901
30		Bulkhead Insulation	7,380,564.57	9,734,529,176.1	0.000758184	12.66%	49
31	***Estimated based on Aroclor 1254***		***ng PCB released/day*** (Col I) x (Col F)				
32		Oils & Greases	43,985,434.92	9,734,529,176.1	0.004518496	75.43%	782
33	**Total**				**0.005990**	pptr	
34	[k]	Aroclor 1254 used as a					
35	[m]	This is max empirical L					

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Compairson of concentrations computed from LEACHRATE data to water benchmarks and estimates of fish and shellfish concentrations.**													
2			Water Concentration			Fish Tissue Benchmarks (dry weight)					Invertebrate Tissue Benchmarks (Dry Weight)			
3			***Chronic***	***Acute***		TSV	NOED	LOED	Bcv		TSV	NOED	LOED	Bcv
4			ug/L	ug/L		ug/g	ug/g	ug/g	ug/g		ug/g	ug/g	ug/g	ug/g
5			0.03	10.00		1.75	6.00	7.20	24.30		2.18	3.00	5.50	4.68
6		***(m)***												
7		**Estimated**	Hazard Quotients											
8		**Concentration (ng of PCB/ liter)**	**HQchronic**	**HQacute**		**Fish Concentraton**						**Invertebrate Concentration**		
9		***ng/L***	***Conc/ Chronic***	***Conc/Acute***		***BCF L/kg***	***BCF L/g***	***ng/g wet***	***ng/g dry***		***BCF L/kg***	***BCF L/g***	***ng/g wet***	***ng/g dry***
10	**Case Using "Low" Estimates from JJMA**	**0.000079**	0.000003	7.943E-09		202542.1	202.5	**0.02**	**0.06**		31200	31.2	**0.00**	**0.01**
11	**Case Using "Average" Estimates from JJMA**	**0.002579**	0.000086	0.0000003		202542.1	202.5	**0.52**	**2.09**		31200	31.2	**0.08**	**0.40**
12	**Case Using "High" Estimates from JJMA**	**0.005990**	0.000200	0.0000006		202542.1	202.5	**1.21**	**4.85**		31200	31.2	**0.19**	**0.93**

Evaluation of Reducing PCB Loadings													
		Total Weight of Material (kg)	Total Weight of Material (g)	Fraction of PCB in solid	Mass of PCB in shipboard solid material	lbs PCB	Fraction of Total PCB on Ship	Leaching rate of PCB (per unit Shipboard Solid)		Weight Fraction of PCB in Specific Shipboard Solid tested in laboratory		Leaching rate of PCB (per unit PCB in Specific Solid Tested)	Release Rate (a)	***DECREASE in RELEASE***
Material	Shipboard solid removed	kg PCB-containing Material	g PCB-containing Material	g PCB/g of PCB-containting material	g PCB in solid	lbs PCB		ng of PCB released/ g Shipboard Solid/day		g PCB in solid/ g Shipboard Solid		ng PCB released/ g PCB in solid/ day	ng PCB released/day	ng PCB released/day
Using Long-Term Empirical Laboratory Release Rate only														
	g removed													
Felt Gaskets	3,769							0.93						3505.35
Electric Cable	79,667							0.044						3505.35
Paint	56,538							0.062						3505.35
Rubber	5,311							0.66						3505.35
Foam Insulation	1,855							1.89						3505.35
Pure Aroclor 1254	1							3505.35						3505.35
Pure Aroclor 1268	4							838.00						3505.35
Bulkhead Insulation	143							24.45						3505.35
Oils and Greases								No Empirical Data						

Reduction

Evaluation of Reducing PCB Loadings														
		Total Weight of Material (kg)	Total Weight of Material (g)	Fraction of PCB in solid	Mass of PCB in shipboard solid material	lbs PCB	Fraction of Total PCB on Ship	Leaching rate of PCB (per unit Shipboard Solid)		Weight Fraction of PCB in Specific Shipboard Solid tested in laboratory		Leaching rate of PCB (per unit PCB in Specific Solid Tested)	Release Rate (a)	***DECREASE in RELEASE***
Material	Shipboard solid removed	kg PCB-containing Material	g PCB-containing Material	g PCB/g of PCB-containting material	g PCB in solid	lbs PCB		ng of PCB released/ g Shipboard Solid/day		g PCB in solid/ g Shipboard Solid		ng PCB released/ g PCB in solid/ day	ng PCB released/day	ng PCB released/day
Using HIGH CASE MODEL RELEASE PER DAY														
BASE CONDITION														
Felt Gaskets		151.18	151,182	0.40000	60,472.71	133.32	0.4987	9.63	m	0.23000		41.87	2,531,965.90	
Electric cable		50,559.72	50,559,718	0.00060	30,538.72	67.33	0.2518	0.04		0.00120		36.67	1,119,752.94	
Paint		298,009.49	298,009,495	0.00005	14,634.39	32.26	0.1207	0.06		0.00043		144.19	2,110,075.53	
Rubber		4,989.00	4,988,998	0.00056	2,793.84	6.16	0.0230	0.66		0.00160		412.50	1,152,458.59	
Foam Insulation		302.36	302,364	0.00050	151.18	0.33	0.0012	1.89		0.00890		212.36	32,104.89	
Bulkhead Insulation		301.86	301,864	0.00044	132.82	0.29	0.0011	24.45		0.00044		55,568.18	7,380,564.57	
Reduction														
Felt Gaskets		150.97	150,972.5	0.40000	60,388.99	133.13	0.5566	9.63	m	0.23000		41.87	2,528,460.55	3,505.35
Electric cable		50401.44	50,401,442.0	0.00060	30,443.12	67.12	0.2806	0.044		0.00120		36.67	1,116,247.59	3,505.35
Paint		297514.43	297,514,428.2	0.00005	14,610.08	32.21	0.1347	0.062		0.00043		144.19	2,106,570.18	3,505.35
Rubber		4973.82	4,973,823.6	0.00056	2,785.34	6.14	0.0257	0.66		0.00160		412.50	1,148,953.24	3,505.35
Foam Insulation		269.35	269,350.2	0.00050	134.68	0.30	0.0012	1.89		0.00890		212.36	28,599.54	3,505.35
Bulkhead Insulation		301.72	301,720.2	0.00044	132.76	0.29	0.0012	24.45		0.00044		55,568.18	7,377,059.22	3,505.35
						239.19								
Amount Removed	kg removed													
Felt Gaskets	0.209	150.97												
Electric cable	158.276	50401.44												
Paint	495.066	297514.43												
Rubber	15.175	4973.82												
Foam Insulation	33.013	269.35												
Bulkhead Insulation	0.143	301.72												

Reduction

Evaluation of Reducing PCB Loadings													
		Total Weight of Material (kg)	Total Weight of Material (g)	Fraction of PCB in solid	Mass of PCB in shipboard solid material	lbs PCB	Fraction of Total PCB on Ship	Leaching rate of PCB (per unit Shipboard Solid)		Weight Fraction of PCB in Specific Shipboard Solid tested in laboratory		Leaching rate of PCB (per unit PCB in Specific Solid Tested)	Release Rate (a)	***DECREASE in RELEASE***
Material	Shipboard solid removed	kg PCB-containing Material	g PCB-containing Material	g PCB/g of PCB-containting material	g PCB in solid	lbs PCB		ng of PCB released/ g Shipboard Solid/day		g PCB in solid/ g Shipboard Solid		ng PCB released/ g PCB in solid/ day	ng PCB released/day	ng PCB released/day
Using AVERAGE CASE MODEL RELEASE PER DAY														
BASE CONDITION														
Felt Gaskets		151.18	151,181.76	0.20041	30,298.34	66.80	0.4442	0.93		0.23000		4.04	122,510.67	
Electric Cable		50,559.72	50,559,717.59	0.00044	22,299.31	49.16	0.3270	0.044		0.00120		36.67	817,641.38	
Paint		186,255.93	186,255,934.17	0.00005	9,146.50	20.16	0.1341	0.062		0.00043		144.19	1,318,797.21	
Rubber		4,989.00	4,988,998.24	0.00003	139.69	0.31	0.0020	0.66		0.00160		412.50	57,622.93	
Foam Insulation		30.24	30,236.35	0.00050	15.12	0.03	0.0002	1.89		0.00890		212.36	3,210.49	
Bulkhead Insultation		30.24	30,236.35	0.00044	13.30	0.03	0.0002	24.45		0.00044		55,568.18	739,278.83	
Reduction														
Felt Gaskets		146.86	146,856.1	0.20041	29,431.42	64.89	0.2713	0.93		0.23000		4.04	119,005.32	3,505.35
Electric Cable		50342.96	50,342,960.6	0.00044	22,203.71	48.95	0.2047	0.044		0.00120		36.67	814,136.03	3,505.35
Paint		185760.87	185,760,867.7	0.00005	9,122.19	20.11	0.0841	0.062		0.00043		144.19	1,315,291.86	3,505.35
Rubber		4685.50	4,685,504.7	0.00003	131.19	0.29	0.0012	0.66		0.00160		412.50	54,117.58	3,505.35
Foam Insulation		0.00	0.0	0.00050	-	0.00	0.0000	1.89		0.00890		212.36	-	3,210.49
Bulkhead Insultation		30.09	30,093.0	0.00044	13.24	0.03	0.0001	24.45		0.00044		55,568.18	735,773.48	3,505.35
						134.27								
Amount Removed	kg removed													
Felt Gaskets	4.326	146.86												
Electric cable	216.757	50342.96												
Paint	495.066	185760.87												
Rubber	303.494	4685.50												
Foam Insulation	30.236	0.00												
Bulkhead Insulation	0.143	30.09												

Evaluation of Reducing PCB Loadings													
		Total Weight of Material (kg)	Total Weight of Material (g)	Fraction of PCB in solid	Mass of PCB in shipboard solid material	lbs PCB	Fraction of Total PCB on Ship	Leaching rate of PCB (per unit Shipboard Solid)	Weight Fraction of PCB in Specific Shipboard Solid tested in laboratory	Leaching rate of PCB (per unit PCB in Specific Solid Tested)	Release Rate (a)	***DECREASE in RELEASE***
Material	Shipboard solid removed	kg PCB-containing Material	g PCB-containing Material	g PCB/g of PCB-containting material	g PCB in solid	lbs PCB		ng of PCB released/ g Shipboard Solid/day	g PCB in solid/ g Shipboard Solid	ng PCB released/ g PCB in solid/ day	ng PCB released/day	ng PCB released/day
Using LOW CASE MODEL RELEASE PER DAY												
BASE CONDITION												
Felt Gaskets		151.18	151181.76	0.00082	123.97	0.27	0.03	0.93	0.23	4.04	501.27	
Electric Cable		50559.72	50559717.59	0.00001	369.09	0.81	0.09	0.04	0.00	36.67	13533.15	
Paint		74502.37	74502373.67	0.00005	3658.60	8.07	0.85	0.06	0.00	144.19	527518.88	
Rubber		4989.00	4988998.24	0.00003	124.72	0.27	0.03	0.66	0.00	412.50	51449.04	
Foam Insulation		3.02	3023.64	0.00050	1.51	0.00	0.00	1.89	0.01	212.36	321.05	
Bulkhead Insulation		3.02	3023.64	0.00044	1.33	0.00	0.00	24.45	0.00	55568.18	73927.88	
Reduction												
Felt Gaskets		0.00	0.0	0.00082	-	0.00	0.0000	0.93	0.23000	4.04	-	501.27
Electric cable		37463.76	37,463,764.9	0.00001	273.49	0.60	0.0025	0.044	0.00120	36.67	10,027.80	3,505.35
Paint		74007.31	74,007,307.2	0.00005	3,634.29	8.01	0.0335	0.062	0.00043	144.19	524,013.53	3,505.35
Rubber		4649.09	4,649,085.5	0.00003	116.23	0.26	0.0011	0.66	0.00160	412.50	47,943.69	3,505.35
Foam Insulation		0.00	0.0	0.00050	-	0.00	0.0000	1.89	0.00890	212.36	-	321.05
Bulkhead Insulation		2.88	2,880.3	0.00044	1.27	0.00	0.0000	24.45	0.00044	55,568.18	70,422.53	3,505.35
						8.87						
Amount Removed	kg removed											
Felt Gaskets	151.182	0.00										
Electric cable	13095.953	37463.76										
Paint	495.066	74007.31										
Rubber	339.913	4649.09										
Foam Insulation	3.024	0.00000										
Bulkhead Insulation	0.143	2.88										

[k] Aroclor 1254 used as a proxy for Aroclor 1254 in grease and non mobile oils

[m] This is max empirical LR from LRS used as estimate, because JJMA loading is higher than the material tested in the LRS.

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