Artificial Reefing

Ex-ORISKANY Artificial Reef Project

Summary Document

January 2006
FINAL REPORT

PEO SHIPS

PROGRAM EXECUTIVE OFFICE SHIPS

Ex-ORISKANY
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Prepared for:
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Introduction

This document describes the U.S. Navy's (Navy) plan to sink a decommissioned aircraft carrier, the ex-ORISKANY, in shallow water approximately 22.5 nautical miles from Pensacola, Florida. Various fish and shellfish will eventually colonize the ship, making it an artifical reef. The U.S. Environmental Protection Agency (USEPA) must issue an approval for preparation and sinking of the ship because polychlorinated biphenyl (PCB)-containing solid materials remain onboard. The Toxic Substances Control Act of 1976 and the Federal PCB regulations, 40 CFR Part 761, govern the disposal approval process. To obtain the approval, the Navy prepared six technical reports that assess whether the slow release of PCBs from the artificial reef will cause unreasonable risk of adverse impact to human health or the environment.

This summary introduces the project and describes the six reports using a question-and-answer (Q&A) format.

Report Summary Table: Navy Reports on The ex-ORISKANY that Assess Risk To People and Marine Life From PCBs

Report	Purpose
Source Term Estimates	Describes the sources of PCBs onboard the ex-ORISKANY and the amount of PCBs in these sources. Used with PCB leach rates described in the Shallow-Water PCB Leach Rates Study to estimate PCB release from the vessel.
Shallow-Water PCB Leach Rates	Measures the amount of PCBs released over time from representative shipboard PCB-containing solid materials and provides the short-term dynamic and long-term stabilized leach rates required to estimate PCB release from the vessel for use in TDM and PRAM.
Time Dynamic Model (TDM)	Predicts the short-term environmental concentrations of PCBs in water and sediment around the reef for the initial two-year period after sinking. These predictions provide inputs for PRAM to model the short-term bioaccumulation of PCBs in the food chain.
Prospective Risk Assessment Model (PRAM)	Models the long-term environmental concentrations and bioaccumulation of PCBs in the food chain of the reef. Predicted short-term environmental concentrations from TDM are used as input to PRAM to predict bioaccumulation of PCBs in the food chain of the reef during the first two years after sinking. The model output is used to assess human health and ecological risks.
Ecological Risk Assessment (ERA)	Characterizes the ecological risk associated with PCB exposure of marine life at the reef.
Human Health Risk Assessment (HHRA)	Characterizes the human health risks associated with PCB exposure of divers on the reef, recreational anglers and children who consume fish from the reef, along with nursing infants and fetuses indirectly exposed to PCBs in recreationally caught fish from the reef.

General Description of the Proposed Artificial Reef Project

What is the ex-ORISKANY?
The ex-ORISKANY is a decommissioned Korean-war era Navy aircraft carrier.

What does the Navy want to do with the ex-ORISKANY?
The Navy proposes to sink this vessel at a site 22.5 nautical miles off Pensacola, Florida to provide an artificial reef habitat within the Escambia East Large Area Artificial Reef Site. The vessel will sit on the ocean floor 212 feet below the water surface under mean low water conditions.

How will the Navy sink the ship?
The Navy will pre-flood several tanks in the ship to improve stability before moving it from Beaumont, Texas, to Pensacola, Florida. At the site, the Navy will open with explosives 22 valves in the bottom of the hull in a way that will evenly fill the vessel with water. Numerous holes that were previously created to open the lower decks will allow air to escape. Several hours later, water will spill out of the hangar deck and the vessel will begin to sink.

What will the vessel be like when it sits on the bottom of the ocean?
The ship will sit on its keel and sink slightly into the sand, burying the open valves located on the bottom of the hull. Assuming that the vessel sinks 1 foot into the sand, the island of the carrier will be about 68 feet below the surface, and the flight deck surface will be about 130 feet below

the surface. The upper decks, including the hangar deck, will remain open and provide habitat for invertebrates and fish. However, much of the ship will be isolated from the outside ocean (all areas below the hangar deck), even though all doors and hatches will have been left open.

Depths from the Water Surface

What are the environmental conditions at the site?
The site is sandy with the nearest manmade recreational fishing reef more than 1.5 nautical miles from the proposed sinking site.

What marine life is present at the site?
The general area contains fish typically found offshore of the Florida coast, such as Spanish mackerel, black drum, snapper, bonito, flounder, red snapper, triggerfish and grouper. The site where the vessel will sit presently contains no or few animals due to the lack of hard surfaces on the bottom. Where limestone outcropping is present in the area, the surface contains organisms typical of the northern Gulf of Mexico, such as sea whips, sea fans, and sponges. Marine mammals, such as whales and dolphins, and sea turtles migrate through the area.

How will the site change after the ex-ORISKANY is sunk?
Eventually, the reef will be colonized by a wide range of marine invertebrates and fish. Encrusting animals will grow on the external surfaces of the ship and provide food for resident and migrating fish.

Potential for Exposure to PCBs onboard the ex-ORISKANY

Is there a concern with contaminants left onboard the ship?
Yes, there is a concern regarding the presence of polychlorinated biphenyls (PCBs) in solid materials, and the Navy has assessed these concerns in their six reports. The ship was extensively prepared for reefing without sacrificing vessel integrity, but some non-liquid PCBs remain onboard in electrical cable insulation, bulkhead insulation, paints, rubber products, and ventilation gaskets. No liquid PCBs remain onboard.

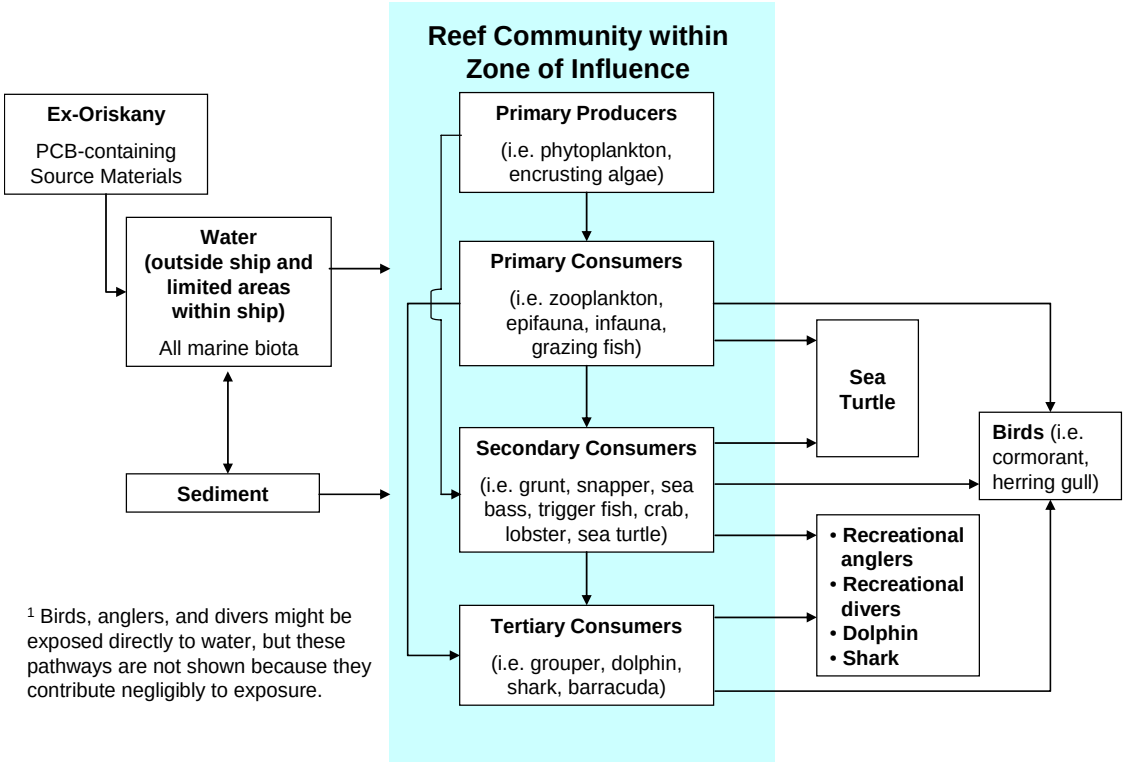
What are PCBs?
PCBs are man-made chemicals that were used in a wide variety of products, such as electrical transformers, capacitors, and the PCB-containing solid materials remaining onboard the ship. There are 209 different types of PCB molecules, which are collectively referred to simply as PCBs.

Why do environmental regulations require a USEPA approval to sink a ship with PCBs onboard?
PCBs are persistent organic pollutants that can accumulate in the food chain and can cause harm to people or marine life at high enough concentrations. Approval is based on evaluating whether predicted PCB concentrations exceed levels that could cause such harm.

How can PCBs get from the sunken ship to people or marine life?
PCBs can leach from the shipboard solids containing PCBs into the environment where they tend to accumulate in sediment and marine organisms such as the fish that people eat. The conceptual model shows the pathways for this accumulation.

Potential for Exposure to PCBs Onboard the ex-ORISKANY

Conceptual Model of PCB Exposure at the ex-ORISKANY Reef [1]



[1] Birds, anglers, and divers might be exposed directly to water, but these pathways are not shown because they contribute negligibly to exposure.

Potential for Exposure to PCBs Onboard the ex-ORISKANY

Will it be safe to eat the fish?
Yes, the HHRA Report shows that it will be safe to eat the fish obtained from the reef.

With respect to the PCBs, will it be safe to dive?
Yes. The HHRA Report shows that predicted PCB concentrations in water near the vessel are so low and diver exposure times are so short that no adverse effects on diver health are expected.

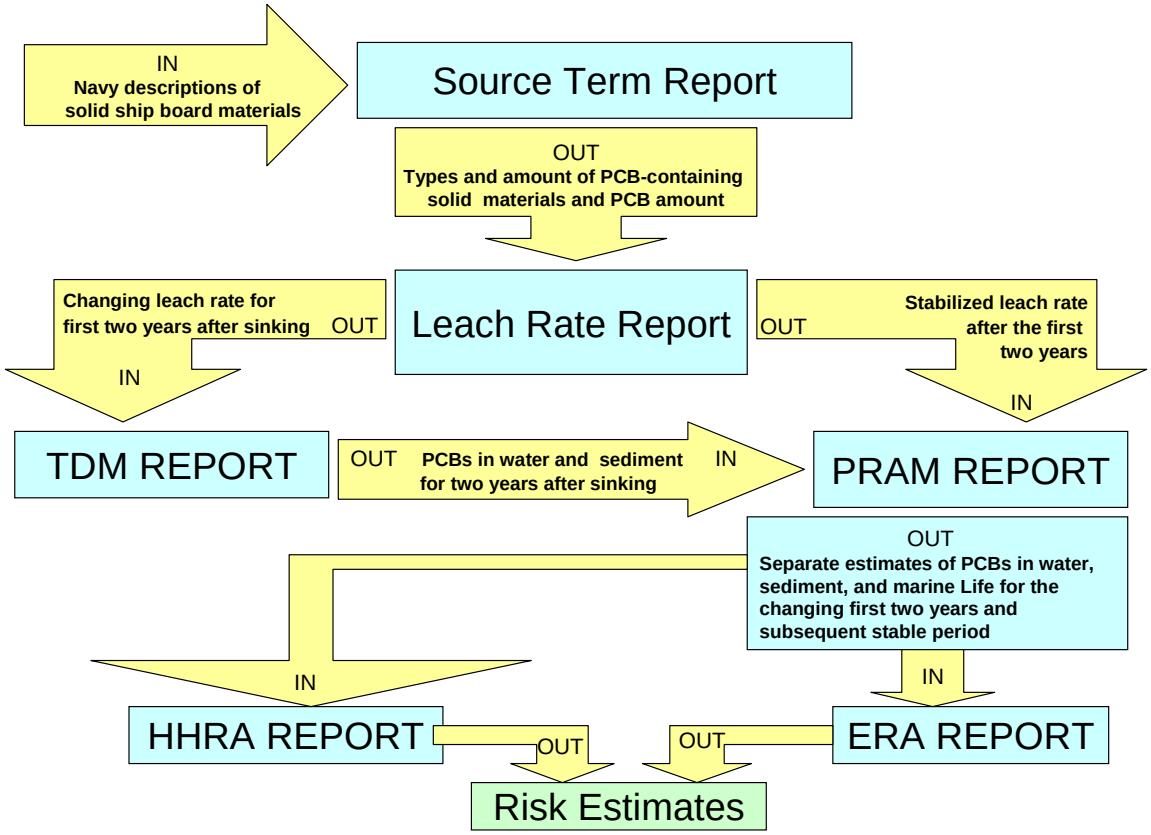
Will the marine life be safe?
The ERA Report evaluated the predicted PCB concentrations in water, sediment, and tissues of marine organisms expected to be associated with the reef to make sure that the PCBs would not impair water or sediment quality, or affect the growth, reproduction, or survival of marine life. The results show that it is unlikely that PCBs released from sinking the ex-ORISKANY will harm marine life.

Summary of Six ex-ORISKANY Reports

What is the collective purpose of the six reports?
Collectively, the reports estimate the risk of harm to human health and the marine environment due to PCBs present in the materials on the sunken ship.

What are the relationships among the six reports?
The reports provide information for one another as explained in the diagram below and in the Report Summary Table in the Introduction.

Relationships among Six ex-ORISKANY Reports



Report 1:
Source Term Estimates

How did the Navy decide what to sample and what are the sources of PCBs?
The Source Term Report explains that the Navy has a standard non-liquid PCB sampling protocol that they follow for deactivating ships. From past Navy and industry experience with sampling materials of concern for potential PCB, the materials sampled from the ex-ORISKANY have been shown to have a high potential to contain PCBs. All of the PCB concentration data come from materials sampled onboard the ex-ORISKANY.

What are the sources of PCBs aboard the ex-ORISKANY?
They are solid PCB-containing materials including, electrical cable insulation, bulkhead insulation, paint, compressed fiber ventilation gaskets, and rubber products (e.g., door gaskets, pipe hangers, mounts, etc). No liquid sources of PCBs remain on the ship.

How did the Navy determine how much PCB containing shipboard solid material remains onboard the ex-ORISKANY?
The Navy obtained this information by visually inspecting the ex-ORISKANY for the presence of components or items which are known to have high potential for containing PCBs. This was accomplished by reviewing all sampling data and other PCB related information done either as a part of the initial decommissioning or as part of the preparation for sale for scrapping of the ex-ORISKANY by Defense Reutilization and Marketing Service (DRMS), and collecting and analyzing additional shipboard solid materials for PCBs. In some cases, historical records on the weight and quantity of PCB-containing solid materials onboard the ex-ORISKANY were available. In cases where this information was not available, the Navy relied on weight and quantity data from two other ships (the ESSEX and the LEXINGTON) that are similar to the ex-ORISKANY.

What did the Navy do with this information?
The Navy used this information to define the amount of PCBs in shipboard solid materials to be left on board the ex-ORISKANY. This information was used with PCB leach rates specific to each type of solid material described in Report 2 (Shallow Water PCB Leach Rates) to determine the total amount of PCBs that might be released from the vessel.

Report 2:
Shallow-Water PCB Leach Rates

What is a leach rate?
Leach rate is how fast PCBs dissolve into the surrounding seawater from the various shipboard solid materials identified in Report 1 (Source Term Estimates). It is a measure of the amount of PCB released from the PCB-containing solid material per unit of time into seawater.

How did the Navy measure a leach rate?
The Navy took samples of each PCB-containing material to a laboratory and placed them in separate containers in artificial seawater. The amount of PCBs in the water samples was measured over time until the amount of leaching stabilized.

Where did the leach rate samples come from?
The Navy collected samples of PCB-containing solid materials from several different ships. Ships have the same types of PCB-containing solid materials, but the materials can have differing concentrations of PCBs.

How can we be sure that what we have observed in the laboratory is what will happen out in the environment?
We cannot be 100% sure because the vessel is not yet sunk; therefore, we must rely on model predictions. The actual leach rate was not measured for each environmental condition because there are so many different conditions in the sea that could affect leaching. Generally, leaching behaviors were observed to decrease with time as PCBs became depleted in the shipboard solids. In some cases, leaching was either not observed consistently (observed to be sporadic) or PCBs stopped leaching during the experiment. In these cases, enough data could not be collected to describe the leaching behavior and the maximum observed leach rate was used as to estimate release.

Did the measured leach rates change during the Navy's experiments?
Yes. All leach rates were observed to be higher initially and then they slowly decreased over time until the end of the experiments. Over time the rate of release is expected to come closer and closer to zero.

What did the Navy do with the leach rates?
The Navy used the leach rates to estimate how fast different PCB molecules might be released from each of the PCB-containing solid materials into the surrounding seawater after the ship sinks. The Navy used the leach rates for each material in two predictive models, the TDM and PRAM. The Navy also used this information to remove materials with higher leach rates, such as bulkhead insulation, during ship preparation.

Report 3:
Time Dynamic Model (TDM)

What is the TDM?
TDM refers to the Time Dynamic Model. It is the model that predicts the concentration of PCBs in water and sediment during the first two years (dynamic or rapidly changing period) after sinking the ship.

How are the leach rates used in this model?
The model combined variable PCB leach rates measured in the laboratory as described in Report 2 (Shallow-water PCB Leach Rate Estimates) with the PCB quantities estimated for the ex-ORISKANY in Report 1 (Source Term Estimate) to predict the amount of different types of PCB molecules released from the vessel during the first two years after sinking.

What do we mean by time dynamic?
We mean that conditions are changing over time. The leach rates are not constant (they are decreasing). The TDM predicts the PCB concentrations in sediment and water during the first two years after sinking. During this period, TDM predicts PCB concentrations and movement in one-minute intervals.

What did the Navy do with the predicted concentrations of PCBs in water and sediment?
The Navy used the concentrations of PCBs in water and sediment as inputs to PRAM to calculate the concentration of PCBs in marine life and risk to humans and marine life during the first two years after sinking. This was necessary because the leach rate experiments showed that the leach rate changed rapidly during the first two years. However, the risk is essentially the same during the 0-2 year period as predicted beyond the 2 year period.

Does TDM calculate marine life concentrations of PCBs?
No. TDM predicts water and sediment concentrations, which are then used in another model, PRAM, to calculate the bioconcentration of PCBs from water and bioaccumulation of PCBs in the reef food chain.

Are the fish and other marine life the same in that initial two-year period as in the subsequent stable period?
The reef food web is changing more so in the first two years compared to follow-on years and there is essentially no food to begin with. The Navy assumed that the fish and marine life at the site will change during the first two years after sinking because it will take time for the new reef to be colonized by marine organisms. For example, an upper-level predator could not take prey from the reef until the reef was developed enough to provide a source of food for that prey.

Report 4:
Prospective Risk Assessment Model (PRAM)

What is the PRAM?
PRAM is a computer model that simulates the marine environment and food web present at the reef to predict PCB accumulation in the food chain and risks to human health. PRAM uses the PCB leach rates and PCB quantities estimated to remain on the ex-ORISKANY to predict PCB concentrations in water inside and outside the vessel, sediment, air, and the food chain of the reef more than two years after sinking. PRAM also uses output from TDM to predict PCB concentrations in the food chain during the first two years after sinking. Finally, PRAM includes a risk module for predicting human health risks from eating fish caught from the artificial reef.

How does the model work?
The model works by using the PCB quantities estimated to remain on the ex-ORISKANY, leach rates, and other information to predict PCB concentrations in the environment and marine life in a series of imaginary boxes. Based on the chemical properties of PCBs, PRAM calculates the amount of PCBs present in every box defined in the model. Boxes in the model include the water inside the ship, water in the upper water column (near the surface) and lower water column (near the bottom), the air above the water, the sediment, and each component of the food chain that is expected at the reef.

What is the other information that PRAM uses?
Other information includes the physical properties of the water and sediment, water current speed outside the ship, water current speed inside the ship, and various biological properties such as fat content of the fish, weight, what they eat, and their energy requirements.

What leach rate does PRAM use?
PRAM uses a statistical estimate of the leach rate that is higher than the average leach rate for each PCB-containing solid material. For some types of PCBs and materials the leaching was so low that there were insufficient data to develop a statistical relationship for leaching. In those cases, the PRAM used the *maximum* observed leach rate.

Where do the PCBs go after they leach from the solid material onboard the ship?
PRAM uses the leach rate to estimate how fast PCBs leach from the onboard solid material by calculating the movement of PCBs into the environment and the reef food chain. Based on the assumption that PCBs would be transported in the water as a function of the bottom current observed near the site, PRAM calculates the concentration of PCBs in the water, sediment, and organisms around the reef.

What is the Zone of Influence in PRAM?
Zones of influence (ZOIs), represented as imaginary boxes in the area immediately around the ship that is influenced by the presence of the reef. The ZOI is represented in the model as a series of elongated donut-shaped volumes surrounding the ship. Each donut is about 15 meters thick. The circumference of the elongated donuts gets bigger as it gets further from the ship. PRAM calculates the concentrations of PCBs in each imaginary box within each donut-shaped volume.

Report 4:
Prospective Risk Assessment Model (PRAM)

What does PRAM do with the predicted concentrations of PCBs in water, sediment and fish?

PRAM uses these predictions to calculate risk to human health during the first two years of changing conditions and during the subsequent stable period. The output from PRAM was used to assess potential health risks to people (anglers and divers) and ecological risks to marine life.

Report 5:
Ecological Risk Assessment (ERA)

What is the ERA Report?
The ERA Report uses the concentrations of PCBs in sediment, water, and marine life predicted by TDM coupled with PRAM to estimate ecological risks to marine organisms living on or feeding on the reef.

How does the Navy make these estimates in the ERA?
The Navy chose animals that represent the various ecological habitats and life forms likely to occur on or near the sunken ship. They researched the scientific literature to describe the habits of these animals. They researched how different concentrations of PCBs in water, sediment, and animal tissue might harm these animals and developed benchmarks representing thresholds of harmful concentrations. They then compared the predicted concentrations of PCBs to selected benchmarks to characterize risk. These benchmarks are derived from previous studies that provide an indication of the level of PCBs that cause or do not cause an adverse effect to an animal.

Why didn't the Navy estimate risk to all the animals?
The ecological risk assessment used representative species that are know to be sensitive to effects from PCBs to assess the level of risk. Selection of appropriate species is always a challenge in an ecological risk assessment. The USEPA recommends selecting animals that represent different living and eating habits to represent the environment, which is a reef in this case. There is currently no reef in the area; therefore, the marine environment in the area is not currently characterized with high diversity or biomass. The specific animals selected were those that will be expected to be more sensitive to PCBs than other organisms at the reef. If there were unacceptable risks these would be the animals that are first affected.

Where did the Navy find the concentrations of PCBs that might be harmful to animals?
The Navy used toxicological data on the effects of PCBs on marine life that are available in the scientific literature.

How does the Navy tell when an animal might be at risk?
The Navy assumed that an animal was at risk whenever the predicted PCB concentration in water, sediment, or animal tissue was greater than the benchmark specific to that animal.

Will there be a risk to the marine life on or near the sunken ship?
The ERA evaluated the predicted PCB concentrations in water, sediment and tissues of marine organisms expected to be associated with the reef to make sure that the PCBs would not impair water or sediment quality, or affect the growth, reproduction or survival of marine life The exposure of PCBs to organisms living and feeding are below levels that would indicate harmful risk. Therefore, it is unlikely that PCBs released from sinking the ex-ORISKANY to create an underwater reef will harm the environment.

Report 6:
Human Health Risk Assessment (HHRA)

What is the HHRA Report?
The HHRA Report uses the concentrations of PCBs in water and marine life from PRAM to estimate risks associated with PCB exposure of divers on the reef, recreational anglers and children who consume fish from the reef, along with nursing infants and fetuses indirectly exposed to PCBs in recreationally caught fish from the reef.

What effects do PCBs have in humans?
PCBs may cause cancer in humans. For example, recent human epidemiological studies show an association between PCBs and an increased risk of non-Hodgkins lymphoma. Other studies suggest an association between exposure to PCBs and developmental effects in children and reproductive effects in adults.

What does the HHRA tell us?
The HHRA calculates the increased chance of getting cancer as a result of exposure to PCBs from the sunken ship. It also estimates whether that exposure will reach a level of concern for other negative health effects such as developmental effects in children.

What kind of exposure does the HHRA evaluate?
It evaluates the health risks from exposure to PCBs by eating fish or shellfish caught from the sunken ship. It also evaluates the human health risk to divers near the sunken ship.

How is human exposure estimated?
The HHRA predicts human exposure using information on the amount of fish that people eat from the sunken ship and over what time they eat these fish. For divers, the HHRA uses the amount of time a person dives in the area near the ship and the concentration of PCBs predicted in the water.

How do you know how much fish people will catch and eat from the sunken ship?
In 2004, the Navy conducted a survey of eighty anglers in the Pensacola area and used results of this survey along with information from the USEPA regarding recreational fish consumption in the Southeastern region of the U.S.

What are the predicted cancer risks from eating fish caught at or near the sunken ship?
The predicted cancer risks are lower than the USEPA regulatory levels of concern, with nearly all predictions less than a risk of one in a million and several predictions between a risk of one in one million and one in one hundred thousand.

Is there a hazard of contracting non-cancer illnesses from eating fish caught at or near the sunken ship?
The predicted hazard associated with contracting a non-cancer disease is lower than the USEPA regulatory levels of concern, meaning that all estimates of PCB exposure are lower than the exposure that USEPA regards as likely to be without an appreciable risk of deleterious effects during a lifetime. There is De Minimum risk, meaning little to no exposure due to low water concentrations and protective material (web suite), which essentially eliminates route of exposure.