A HUMAN HEALTH RISK ASSESSMENT FOR POTENTIAL EXPOSURE TO POLYCHLORINATED BIPHENYLS (PCBs) FROM SUNKEN VESSELS USED AS ARTIFICIAL REEFS (FOOD- CHAIN SCENARIO)

FINAL REPORT

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Photo by SCDNR

5.4.6 Conclusions, Uncertainties, and Recommendations

Risks and hazards were acceptable for the ingestion of White Grunt, Black Sea Bass and Vermilion Snapper from both reef types (reference and target reef). The following discussion highlights the results of the RME deterministic risk evaluation and the 95th percentile risks from the probabilistic distributions.

The carcinogenic risks were 1 x 10^{-7} (estimated deterministically) and 5 x 10^{-8} (estimated probabilistically) for the long-term ingestion of White Grunt from the reference reef. These risks were below the EPA's acceptable risk range of 1 x 10^{-6} to 1 x 10^{-4}. The non-carcinogenic hazards were 0.01 (estimated deterministically) and 0.006 (estimated probabilistically) for the ingestion of White Grunt from the reference reef. These hazards were acceptable because they were below the hazard index of unity (1).

The carcinogenic risks were 1 x 10^{-5} (estimated deterministically) and 3 x 10^{-6} (estimated probabilistically) for the long-term ingestion of White Grunt from the target reef. These risks were within the EPA's acceptable risk range of 1 x 10^{-6} to 1 x 10^{-4}. The non-carcinogenic hazards were 0.9 (estimated deterministically) and 0.47 (estimated probabilistically) for the long-term ingestion of White Grunt from the target reef. These hazards were acceptable because they were below the hazard index of unity (1).

The carcinogenic risks were 2 x 10^{-7} (estimated deterministically) and 6 x 10^{-8} (estimated probabilistically) for the long-term ingestion of Black Sea Bass from the reference reef. These risks were below the EPA's acceptable risk range of 1 x 10^{-6} to 1 x 10^{-4}. The non-carcinogenic hazards were 0.02 (estimated deterministically) and 0.008 (estimated probabilistically) for the ingestion of Black Sea Bass from the reference reef. These hazards were acceptable because they were below the hazard index of unity (1).

The carcinogenic risks were 1 x 10^{-6} (estimated deterministically) and 4 x 10^{-7} (estimated probabilistically) for the long-term ingestion of Black Sea Bass from the target reef. These risks were within or below the EPA's acceptable risk range of 1 x 10^{-6} to 1 x 10^{-4}. The non-carcinogenic hazards were 0.1 (estimated deterministically) and 0.05 (estimated probabilistically) for the long-term ingestion of Black Sea Bass from the target reef. These hazards were acceptable because they were below the hazard index of unity (1).

The carcinogenic risks were 2 x 10^{-7} (estimated deterministically) and 6 x 10^{-8} (estimated probabilistically) for the long-term ingestion of Vermilion Snapper from the reference reef. These risks were below the EPA's acceptable risk range of 1 x 10^{-6} to 1 x 10^{-4}. The non-carcinogenic hazards were 0.02 (estimated deterministically) and 0.008 (estimated probabilistically) for the ingestion of Vermilion Snapper from the reference reef. These hazards were acceptable because they were below the hazard index of unity (1).

The carcinogenic risks were 4 x 10^{-7} (estimated deterministically) and 2 x 10^{-7} (estimated probabilistically) for the long-term ingestion of Vermilion Snapper from the target reef. These risks are below the EPA's acceptable risk range of 1 x 10^{-6} to 1 x 10^{-4}. The non-carcinogenic hazards were 0.04 (estimated deterministically) and 0.02 (estimated probabilistically) for the long-term ingestion of Vermilion Snapper from the target reef. These hazards were acceptable because they were below the hazard index of unity (1). The uncertainties associated with the risk assessment are identified below:

- Chemical Data. Data validation indicated that the data are considered of sufficient quality, as qualified during validation, for use in risk assessment. The sample populations from the combined sampling and analysis rounds (at least 20 samples of each species collected over each reef with 11 samples of Black Sea Bass collected over the target reef) were considered adequately representative of the background (reference) and target (site) conditions. The supplemental analysis round confirmed the supposition that the lipid and PCB concentration distributions observed in the first round of analyses were not an artifact of the analytical or preparative procedures.

- Exposure Assessment. The RME risks and hazards, calculated using the respective IRIS slope factor and reference dose, represent the high-end potential for the occurrence of cancer and non-cancer effects. They were based on high-end exposure point concentrations of PCBs in fish, and a number of exposure parameters, such as exposure duration and fish ingestion rate. It should be noted that the average risks and exposures based on central tendency values for the exposure parameters were many times lower. Another area of uncertainty is the FI term that represents the fraction of marine finfish intake that may potentially be contaminated with PCBs from the artificial reef. In assessing exposure in this HHRA, the FI value of 0.1 was assumed in the draft HHRA (NEHC 2002). In this final HHRA, in addition to 0.1, the values of 0.11 (RME) and 0.14 (CTE) were also used to characterize risks and hazards (NEHC 2003c and 2003d). Despite this approach to evaluate uncertainty, it should be noted that the FI term values were specific to the ex-VERMILLION reef. These values may not be applicable in exposure scenarios where the exposed population (marine anglers) also fish and ingest finfish from other artificial reefs that could contain residual PCBs.

- Toxicity Assessment. To be conservative, the lower of two reference doses (Aroclor 1016 and Aroclor 1254) available on IRIS was used in the HHRA. This RfD was applicable to Arochlor 1254. IRIS indicates that the uncertainty factor for this RfD is 300, and the level of confidence is medium. The use of this conservative RfD had resulted in higher hazards than those hazards derived with the higher (less conservative) RfD. Weathering of PCBs in the marine environment is expected, resulting in the PCB composition in the fish tissue being different from the fresh PCB used in the toxicity testing. Further, the total PCBs in fish were accurately measured, which were based on the sum of ten PCB homologue groups. The potential non-carcinogenic hazard from each homologue group, e.g., total trichlorobiphenyls, was assumed to be equivalent to the fresh PCB mixture (Aroclor 1254). While the use of the RfD for PCB 1254 may not reflect the actual mixture that was present, it should provide a conservative estimate of hazard, since it is the lower of the two available reference doses. Finally, the RfD has a built-in uncertainty factor of 300, which provides additional conservatism to the toxicity value.

  Similarly, for the carcinogenic slope factor, the value was also conservatively derived based on the 95% confidence level. PCB is classified as a B2 carcinogen that is based on limited human data and sufficient animal data. In other word, the human health carcinogenic concern is tentative. Concerning the use of TEQ and OPPT total toxicity factor in the HHRA, it can only be said that these approach or value has not gone through the formal EPA review process and published on IRIS. Use of toxicity values that have not undergone the same level of scrutiny and approval as the values presented in IRIS adds an additional degree of uncertainty to the conclusions.

- Risk Characterization. The risk characterization methodology followed was in accordance with EPA guidance (EPA 1989a and 1995a). This risk characterization method is widely accepted by the risk assessment community and the EPA program offices. The method is simple to use; however, it can be highly conservative, if the RME approach is followed. Therefore, EPA encourages the development of additional risk characterization results or risk descriptors that include the presentations of average and probabilistic risk and hazard (EPA 1992a). These descriptors were presented in this report. Nonetheless, the risk characterization methodology also has its limitations, which is expected for any simple model to predict risk outcomes from exposure input. These limitations and assumptions include: (1) that the dose response remains linear at chronic low dose exposure, and therefore, the adverse effect or incidence of tumor is directly proportional to the average daily intake over a lifetime, (2) that any exposure will cause an effect regardless of dose, (3) that pharmacokinetic effects are not considered (effects such as body burden, metabolism, and excretion could impact the toxic effect of PCBs on humans), (4) that antagonistic and potentiation by the presence of other chemicals or dietary intake on the toxic effects of PCBs does not occur, and (5) that genetic predisposition to the toxic effects of PCBs is not a consideration for the exposed population. Finally, it should be noted that total PCBs were quantified based on homologue analyses, and not based on Aroclor. The toxicity values provided in IRIS were based on Aroclor (fresh). While quantitation of total PCBs in this study is more accurate and accounts for all PCBs, the quantitation is expected to be more conservative than quantitation based on Aroclors.

  The uncertainty of the FI term is acknowledged and documented in NEHC 2003c and 2003d, and the risks and hazards associated with the uncertainty are also characterized and summarized in Tables 5-4 through 5-9. Based on these results, it can be concluded that the impact is relatively small for using an FI Term of 0.1 for both the RME and CTE evaluations (NEHC 2002) vs. the values of 0.14 for CTE and 0.11 for RME in this final HHRA. The angler survey data (Hammond et. al. 2003) support the FI Term of 0.1 used in the draft HHRA; minor difference between the various values (i.e., those recommended by EPA) would not have any significant impact on the conclusions of the HHRA. That is, within the limitations and uncertainties of the FI term, the HHRA would demonstrate no unacceptable risk or hazard. Overall, the risk characterization results based on this study are likely to be more conservative.

In conclusion, the chemical data showed that the PCBs in fish caught at the target reef were higher than the reference reef, particularly for the White Grunt. However, none of the RME and average risks and hazards, estimated deterministically or probabilistically, show exceedances for the ingestion of the White Grunt, Black Sea Bass or Vermilion Snapper caught at the reference and target reefs. Although PCBs aboard the ex-VERMILLION may be contributing to elevated PCB levels in fish at the target reef, PCB contamination at the reef is unlikely to pose a significant health risk to the sports fisherman from ingestion of the predominant sports fish species (White Grunt, Black Sea Bass or Vermilion Snapper) found at the target reef.

As identified in section 3.1, one of the primary goals of the risk assessment was to answer the following two risk management questions:

- *Is it likely that the sinking of former Navy vessels containing PCB-containing materials will pose an unacceptable risk to human health or the environment?*

- *How much PCB residue can remain on former Navy vessels used for building artificial reefs without resulting in an unacceptable risk?*

Based on the results of the Human Health and Ecological Risk Assessments for the ex-VERMILLION, it is unlikely that the sinking of other former Navy vessels containing PCB-containing materials to create artificial reef environments will pose an unacceptable risk as long as the following two conditions are true:

1) The ship is mitigated (removal of PCB-containing materials) to the same degree or more compared to the target reef (ex-VERMILLION) and,

2) The exposure scenario is similar to that found at the target reef (the ex-VERMILLION).

The question of how much PCB residue can safely remain onboard former Navy vessels used for artificial reef construction can be addressed by the Prospective Risk Assessment Model (PRAM) that is currently under development.

Based on the outcome of this human health risk assessment and the finding that the ecological risk assessment does not show an unacceptable risk for the ex-VERMILLION, the EPA/Navy have several options for risk management in the future construction of artificial reefs from ex-Navy vessels:

- EPA could allow States to use sunken Navy vessels for creating artificial reefs based on this report and the results of the ecological risk assessment.
- EPA could allow States to use sunken Navy vessels for creating artificial reefs based on this report and the results of the ecological risk assessment along with future results of the Prospective Risk Assessment Model.
- A test vessel with known PCB loading may be sunk and monitored for the release of PCBs from that ship for some defined time period. (Read the full HHRA Report)