Appendix C

*Information related to materials found on scuttled vessels that may have potentially hazardous effects on the marine environment**

*****The text provided in this appendix is an excerpt from the 2003 "*Draft Policy Statement of the National Marine Sanctuary Program: Artificial Reef Permitting Guidelines.*"

Scuttled Vessels

The scuttling of vessels requires particular attention in this policy because of their size and potential toxicological effects on the environment. As discussed above, sunken ships potentially attract divers away from natural reefs and thus may be beneficial to natural reefs in NMSs. However, there is a wide array of concerns that must be addressed before intentionally sinking a ship.

The removal of petroleum products, hazardous materials, paint cans, batteries, plastics, oil, and fuel is specified on the U.S. Coast Guard's Ocean Disposal/Artificial Reef Inspection form. Additionally, under the Toxic Substances Control Act (TSCA), the EPA has the authority to gather information on and regulate chemical substances and mixtures imminently hazardous or presenting unreasonable risk of injury to public health or the environment. Despite these controls, some materials of concern may still remain on items used as artificial reef material. Such materials include: asbestos, polychlorinated biphenols (PCBs), iron, lead paint, and antifouling paint. The NMSP should consider the risks associated with materials remaining on vessels to be used as artificial reefs.

Asbestos is the name given to six naturally occurring minerals that are used as insulators and fire retardants. Several studies have investigated the effects of asbestos on fish (Batterman and Cook 1981, Belanger *et al.* 1990, Belanger *et al* 1986, Woodhead *et al.* 1983). The findings indicate that asbestos concentrations on the order of 10^6 to 10^8 fibers/L may cause epidermal lesions, epithelial hypertrophy, kidney damage, decreased orientation and swimming ability, degradation of the lateral line, reduced growth, and increased mortality in fish. Undisturbed, non-friable (not easily crumbled) asbestos has been found to be relatively harmless (Garcia and Salzwedel 1995, Montoya *et al* 1985).

PCBs may still exist in water-tight gaskets, cable insulation, paint, transformers, capacitors, and other components of decommissioned Navy vessels (Matore *et al.*1996, Eisler and Belisle 1996). These chemicals have been implicated in: reduced primary productivity in phytoplankton; reduced hatchability of contaminated fish and bird eggs; reproductive failure in seals; altered steroid levels and subsequent reproductive impairment in fish and sea stars; reduced fertilization efficiency in sea urchins; and reduced plasma retinal and thyroid hormone levels potentially leading to increased susceptibility to microbial infections, reproductive disorders and other pathological alternation in seals and other marine mammals (Adams and Slaughter-Williams 1988, Brouwer *et al.* 1989, Clark 1992, den Besten *et al*. 1991).

Antifouling paints typically containing tributyltin (TBT) and copper (Cu) are often used to paint vessel hulls to inhibit the growth of organisms below the water line. An IMO convention to control the use of harmful anti-fouling systems on ships was adopted on October 5, 2001. The convention will prohibit the use of harmful organotins, including TBT, in anti-fouling paints

used on ships and establish a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems. TBT has been found to be toxic to non-target, non-fouling organisms at low levels (approximately 7.5-10.5 ng TBT/L). One of its most marked effects has been the induction of shell thickening and growth anomalies in oysters and imposex[2] in the dogwhelk *Nucella lapillus* potentially leading to sterility (Gibbs *et al.* 1998). The discovery of the highly toxic nature of TBT-based paints has led many countries to ban the use of these paints for non-aluminum hulled vessels less than 25 meters in length. Copper, though an effective antifoulant, has not been shown to cause extensive effects on non-target organisms at relatively low levels. When present in high concentrations, however, copper can be toxic to aquatic life (Sorrenson 1991). In a study conducted when a cargo ship collided with part of the Great Barrier Reef and remained grounded for 12 days, sediment containing 8.0 mg kg super(-1) TBT, 72 mg kg super(-1) Cu and 92 mg kg super(-1) Zn was found to significantly inhibit larval settlement and metamorphosis (Negri *et al.* 2002). At this level of contamination, larvae survived but contracted to a spherical shape and swimming and searching behavior ceased. At higher contamination levels, 100% mortality was recorded. These results indicate that the contamination of sediment by anti-fouling paint has the potential to significantly reduce coral recruitment in the immediate vicinity of the site and that this contamination may threaten the recovery of the resident coral community unless the paint is removed.

Iron, an essential element like copper, can be contributed to the environment from steel hulls of sunken vessels. As an essential element, iron levels will tend to be closely regulated by organisms, and thus, it is unlikely that any pollution-derived effects will be observed except in severe and localized cases (Thompson 1990). Corals living in seawater with high iron concentrations have been shown to incorporate the iron into their skeletons (Brown *et al.* 1991). Studies on phytoplankton and macroalgae indicate that in areas where plant nutrients such as nitrate and phosphate are abundant the availability of iron is actually a limiting factor in growth and biomass (Coale *et al.* 1996, Frost 1996, Matsunaga *et al.* 1994, Takeda 1998, Wells *et al.* 1995). Hence the concern of unnatural iron inputs from artificial reefs seems to center not on the occurrence of adverse toxicological effects in marine organisms, but rather on the alteration of the composition of natural assemblages of algae and species which compete with algae.

Lead paint has been used on the interiors of some vessels. Lead has no biological function and, therefore, exhibits accumulation trends in organisms (Thompson 1990). Corals have been shown to incorporate lead into their skeletons (Dodge and Gilbert 1984). Unicellular algae and sea urchins appear to be the most sensitive marine organisms (Berhard 1980). Growth inhibition has been observed in the algae species *Thalassiosira pseudonana* and *Porphyridium marinum* exposed to lead as well as in sea urchins.

Despite the potential toxicological effects of the chemicals discussed above, adverse effects will not occur unless the chemicals are present at or above their effective concentrations. The South Carolina Department of Natural Resources completed an assessment in the mid-1990s on the levels of PCB and heavy metals in biota found on ex-military ships used as artificial reefs. Over 100 samples were collected from locations along the South Carolina coast. Of the 80 tissue samples analyzed for PCBs, only 19 were found to contain concentrations above the 100 ppb weight wet limit of quantitation and all were well below the U.S. Food and Drug Administration’s alert action level of 2000 ppb weight wet. (Note that being below safe levels for human consumption does not necessarily mean there are no adverse effects on the marine

organism itself.) No significant differences were detected in the tissues of organisms collected from vessels know to contain PCB-laden materials, vessels suspected to have PCB-laden materials, and natural hard bottom control sites. Although some of the collected samples were moderately high in a particular heavy metal, no clear correlation was found between high metal levels and a particular type of sample site. Gastropods, however, did contain much higher levels of lead, possibly attributed to the fact that they would graze directly on the painted surfaces. South Carolina concluded that the PCB and metal levels detected in the study did not indicate increased hazards around military ships used as artificial reefs.

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