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Comments to the United States Department of the Navy on the Draft Environmental Impact Statement on the Disposal of Decommissioned, Defueled Naval Submarine Reactor Plants.

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My comments will deal primarily with biological phenomenon or with pertinent physical or geological information published in the literature but omitted or ignored in the E.I.S. I am not qualified to evaluate the engineering aspects of this E.I.S. and have assumed that the models presented for corrosion, sinking and impact, etc. approximate real conditions. In addition most of my comments will concern the Atlantic disposal sites which are located in a deep-sea area with which I am reasonably familiar (Musick, 1976, 1979a; Musick, et al, 1975 Musick and Sulak, 1979; Markle and Musick,1974; Sedberry and Musick, 1978 ; Wenner and Musick, 1977).

Two Atlantic disposal areas have been proposed: The Lower Continental Rise Area off Virginia and North Carolina (72° 22.5'W-70° 30'W, 34° 45'N-37° 0.7.5'N), and the Hatteras Abyssal Plain Area southeast of Cape Hatteras North Carolina (71°W-75°W, 31°N-36°N). Both of these areas appear to satisfy the generic requirements for selection as radioactive waste dumpsites outlined on page 3-6 of the E.I.S. However, there are several potential problems that have not been addressed or convincingly resolved particularly with regard to the Lower Continental Rise Area. I shall deal with these in order below:

1. The E.I.S. draws heavily on a theoretical model for physical-biological transfer proposed by Robinson and Mullin at a workshop supported by Sandia in 1981 (Mullin and Gomez, 1981). Based on this model the E.I.S. states (page H-3 and elsewhere): "the transport of radionuclides from the ocean bottom to the surface reveals that biological transport is one-thousandth of the physical transport". The E.I.S. fails to note that this model was severaly criticized by other working groups at the same workshop.

For instance, the Radioecology group wrote: "... it appears to us that too much emphasis is being placed on large-scale physical ocenaography models and not enough on simple submodels of the biological and radioecological aspects of the radionuclides themselves." The Robinson-Mullin model is predicated on nuclides entering the water above a disposal site with the subsequent transport of the nuclides in the water away from the site. The E.I.S. uses the same sort of model (Appendix H) even though it states: "It is anticipated that a large fraction, perhaps as high as 95 percent of the corrosion product particles carrying radionuclides would settle to the ocean floor either through direct deposition or by removal by the detritus particles" (pp H-2, H-3). If this assertion be true, nuclide ocean dispersal models based on simple eddy diffusivity seem to be inappropriate. Rather, bioaccumulation within the benthos and subsequent concentration within benthopelagic predators may provide a more important pathway for dispersal of nuclides like Ni-59 away from abyssal dump sites.

2. The Lower Continental Rise Area is located in a region heavily influenced by the Western Boundary Undercurrent (WBUC); a point mentioned but not stressed in the E.I.S. The WBUC is characterized by a dense layer of suspended particulate matter called a nepheloid layer (Eittreim et al, 1976) which is maintained and transported by the current to the southwest. Gardiner and Sullivan (1981) recently discovered that such nepheloid layers in the deep sea may be subject to frequent and sudden increases in density caused by benthic storms. These density increases may be caused by resuspension of sediments during the passage of severe atmospheric storms. Radionuclides adhering to sediment particles could be resuspended, by benthic storms and carried by the nepheloid layer toward the continental slope to the southwest off North Carolina. The E.I.S. states that the WBUC is deeper than 1800 m.

This is incorrect. The WBUC sweeps to within the 1100 m isobath off North Carolina (Rowe and Menzies, 1968). Physical transport of radionuclides adhering to sediment particles transported by benthic storms might be orders of magnitude higher than that calculated on the basis of eddy diffusion models in the E.I.S. Models including inputs for transport mitigated by benthic storms directly to the 1000 m isobath off North Carolina should be included in the final E.I.S.

3. Radionuclides introduced into the nepheloid layer could enter benthopelagic food webs. Such webs are probably very important in the deep sea (Marshall and Merrett, 1977; Sedberry and Musick, 1978) and the biomass of benthopelagic organisms may equal or exceed that of benthic organisms in some deep sea regions. Transport of radionuclides by components of food webs may be important in two ways:

   a. The dominant benthopelagic predator/scavenger on the lower continental rise off Virginia and North Carolina is a large rattail fish, _Coyphaenoides armatus_ (Musick and Sedberry, 1979). Although we have studied the fishes in the vicinity of the Lower Continental Rise Area for ten years and have found _C. armatus_ to comprise as much as 90% of the biomass of fishes deeper than 2800 m, we have never captured any individuals with fully ripe gonads, nor have we captured more than a few small individuals (Middleton, 1979). We have suggested that _C. armatus_ may migrate to boreal latitudes to spawn, as one of its congeners is known to do (Musick and Sulak, 1979). Most macrourids including _C. armatus_ lay large numbers of pelagic eggs that probably develop in the upper part of the thermocline. These eggs may provide a means by which radionuclides could be transported migrations from below 1000 m to shallower depths (500-1000 m) (Middleton, 1979). While upslope these species are subject to predation by several large epipelagic predators such as blue sharks (Prionace glauca), and more importantly, sword fish (Xiphias gladius). The latter species is subject to a long-line fishery along the continental slope off North Carolina during the cooler months of the year. Among the benthic fauna, the red crab, Geryon quinquedens, is a dominant from 400 m to ca 1200 m. The juveniles live >1000 m and make an ontogenetic migration upslope as they grow (Haefner and Musick, 1974; Wigley et al, 1975). The species is the object of a developing fishery and is one of the most important underdeveloped resources off the East Coast. Crustaceans tend to concentrate Ni, but in general, Ni is highest in the chitonous exoskeleton and lowest in edible flesh (Eisler, 1981).

4. The information given in the E.I.S. and supporting documents (Talbert, 1982; and Appendices) about the biology of the Atlantic sites is woefully inadequate. Even much of the pertinent biological literature has not been cited.

5. The development of an exposure pathway model in Appendix I (I-2) is based on an equilibrium situation for isotope release. This might be justified if isotopes went into solution and were dispersed according to the eddy diffusion models criticized earlier. However, if (as the E.I.S. asserts) the major isotope released is Ni-59 as corrosion particles which settle in the sediments close to the submarines, will the build up of Ni-59 in the sediments be at a slower rate than the turnover rates of nickle in these sediments, or will Ni-59 become concentrated there? What are the turnover rates of nickle in the sediments at each of the Atlantic sites?

6. In Appendix J (J22-24), in the calculation of the "worst case dose commitment", a different method was used to compute the hypothetical concentration of isotopes in fish. Whereas in other models based on exposure of fish 250 km away from the dumpsite (after considerable dilution of isotopes) a recognized concentration factor of 5×10^2 was incorporated to reflect the tendency of fishes to concentrate Ni from the environment (Table: I-3). In the calculation of "worst case dose commitment" where fish are theoretically exposed to relatively higher concentrations of isotopes in the sediments, no concentration factor was used. Instead concentrations of isotopes in fish were calculated on the basis of average Ni concentration found in fish tissues (from the literature). Such measurements are usually given in μg/kg (Young, 1979). To the contrary, Greig et al (1976) showed that C. armatus, (the dominant large fish at the Lower Slope Area) concentrates Ni (.82 mg/kg) at a level an order of magnitude or more higher than that apparently used in the E.I.S.

In general, the Lower Continental Rise Area is a very poor choice for a nuclear waste site. The area is subject to strong periodic currents that sweep toward the 1000 m isobath off North Carolina. In addition, large migratory fishes are fairly common there. Conversely, the Hatteras Abyssal Plain Area is relatively tranquil (though subject to rare periodic turbity currents). The physical oceanography of this area (so far as known) would tend to minimize transport of isotopes away from a dump site there. In addition, contrary to that implied (out of ignorance) in the E.I.S., the fauna at the Lower Continental Rise Area and at the Hatteras Abyssal Plain Area are not essentially the same. Several workers have shown that the benthic macro-invertebrate fauna changes considerably between 4000 and 5000 m

(Menzies et al, 1973; Rex, 1981) with lower biomass and diversity in the deeper area. We have no data on fishes from directly within the Hatteras Abyssal Plain Area, but we have trawled at similar depths in the same water mass to the south and east. The fish fauna there is much lower in biomass than on the continental rise, and more importantly, the large migratory predator-scavengers like C. armatus are rare or absent.

My recommendations are to reject the Continental Rise Site, and to explore further the Hatteras Abyssal Plain Site. Of particular importance is further work on bottom currents there, particularly in the south-east corner (which seems geologically most acceptable), and a survey of the benthic and benthopelagic nekton. The latter objective can most efficiently be achieved by using deep otter trawls, although fish traps would be more appropriate for monitoring fishes immediately adjacent to sunken submarines after disposal. The concept of disposing of nuclear submarines as proposed by the U. S. Navy in the E.I.S. should not be rejected out of hand (as some environmental lay groups have suggested). The deep ocean, particularly the abyssal areas, may provide relatively remote sites where noxious wastes may be disposed of safely. Indeed, some long-lived xenobiotics such as DDT and PCB's ultimately reside in such deep-sea ecosystems after being transported there by natural, meteorological, oceanographic, and/or biological processes (Musick, 1979b). Faunal impact in abyssal areas would probably be insignificant from a demographic point of view. Even if the fauna were disturbed or destroyed over a 100 mi^2 area, a relatively small number of organisms would be involved because energy availability and density of organisms there is among the lowest of all habitable regions on the earth. In addition, the species that occur there have wide distributions over entire ocean basins, or even circumglobal. (Because of such low population densities such species could never support commercial fisheries.) Use of abyssal waste disposal areas such as the Hatteras Abyssal Plain, should be pursued only after adequate studies are made at specific sites in question. Much remains to be done at the Hatteras Site proposed in this E.I.S.

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