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COLLEGE OF SCIENCES
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# RESIDENCE TIME OF PARTICLE REACTIVE POLLUTANTS IN THE COASTAL SEA BED: CONTROL BY RESUSPENSION AND SEA BED MIXING PROCESSES

By

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Final Report
For the period ended May 31, 1995

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# RESIDENCE TIME OF PARTICLE REACTIVE POLLUTANTS IN THE COASTAL SEA BED: CONTROL BY RESUSPENSION AND SEA BED MIXING PROCESSES

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## Purpose of Study

Our study was designed to develop methods and algorithms that will allow us to predict the residence time of particle-reactive pollutants in the coastal seabed. We have developed methods for computing the frequency and intensity of resuspension of bottom sediments by flow events, methods for computing the diffusion coefficient for biological mixing of the sea bed directly from the species structure and population density of the benthic infauna, and methods for establishing the rate of sedimentation by comparison of profiles of radioisotope of differing half lives.

## Background

Toxic pollutants entering estuarine and coastal waters are known to preferentially associate with the particulate phase, and their dispersal is therefore controlled by the natural cycle of fine sediment transport. A key aspect of this cycle is the exchange of sediment particles between the water column and the sea floor. As contaminated particles accumulate on the sea floor, they pass downward through a zone subject to biogenic mixing, and to resuspension by storm and tidal currents, with secondary release of the pollutant into the water column. Eventually, however, the sediment is so deeply buried that it is no longer accessible to these processes, and has have entered the zone of permanent burial. By measuring the rates of these competing processes (accumulation, mixing, resuspension), we will be able to predict hypothetical contaminant budgets under a variety of conditions.

## Approach

In order to determine potential pattern of contaminant dispersal on the floor of southern Chesapeake Bay, we have undertaken fluid dynamical, radiogeochemical and biological investigations. We have developed a numerical model of boundary layer physics that will allows us to compute the frequency and intensity of particle resuspension, from wind, wave, and tidal current data. We have also collected cores in order to measure radionuclide profiles. The radionuclides $^{234}Th$, $^{137}Cs$, and $^{210}Pb$ serve as proxies for the behavior of particle reactive pollutants. In addition, measurement of vertical concentration gradients of radionuclides with differing half lives has allowed us to estimate the other two critical rates, namely accumulation and mixing. We have also analyzed the composition of the benthic infaunal community as a function of depth. By applying random walk theory, we

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have generated independent estimates of biodiffusive mixing. Finally, we have developed computational schemes that have allowed us to predict scenarios of contaminant release.

## Results

Box cores and vibracores from the Baystem Plain of Southern Chesapeake Bay consist of a sandy clayey silt, containing a polychaete-molluscan community that extends, with vertically decreasing population density, to 30 cm depth. Calculations indicate depth-averaged biodiffusion coefficient for the upper 10 cm on the order of $1 \times 10^6\ cm^2 yr^{-1}$. Radiographs indicate that the silt is well mixed in the summertime when winds are mild and the fauna is most active; in the Winter, however, the top several centimeters are frequently current stratified. Accumulation rates on the Baystem Plain range from 0 mm $yr^{-1}$ near areas of tidal scour to 7 mm $yr^{-1}$ in protected marginal bays. Computations indicate that the annual resuspension depth due to wave-tide interaction ranges from 0.4 to 1.6 cm in the shallower portions of the Baystem Plain (Fig. 1), and may be several times greater when wind-driven currents coincide with these interactions.

Burial histories for hypothetical contaminant layers vary from "rapid entombment" in marginal coves where accumulation is rapid relative to mixing, to "slow release" scenarios near the Bay Mouth, where both mixing and resuspension are intense. In a sample computation of such a scenario (Fig. 2) a site starts with an initial loading of the seabed of 0.8 mg of a hypothetical contaminant per $cm^2$ of the sea floor. As burial proceeds, much of the particle-reactive contamination leaks away through upward diffusion of the contaminant, coupled with repeated storm flushing of the surface layer. Eventually the contaminant layer is deeper than burrowers can reach, and the seabed contamination stabilizes at 5.6 mg of contaminant per cm of the sea floor.

## Publications

Niedoroda, A. W., , D. J. P. Swift, G. T. F. Wong, and D. Dauer, 1993 Residence time of particle-reactive pollutants in the estuary bed, Lower Chesapeake Bay: numerical simulation of resuspension and contaminant loss. Program with Abstracts, Estuarine Research Conference, Hilton Head, SC., November 16-18

Swift, D. J. P., A. W. Niedoroda , G. T. F. Wong, and D. Dauer, 1993. Residence time of particle-reactive pollutants in the estuary bed, Lower Chesapeake Bay: Biology-based Estimates of sea bed mixing rates, Program with Abstracts, Estuarine Research Conference, Hilton Head, S.C.., November 16-18

Niedoroda, A. W., Reed, C. and Swift, D. J. P., in preparation. Environmental management of contaminated sediments: factors controlling contamination, burial, and redistribution.

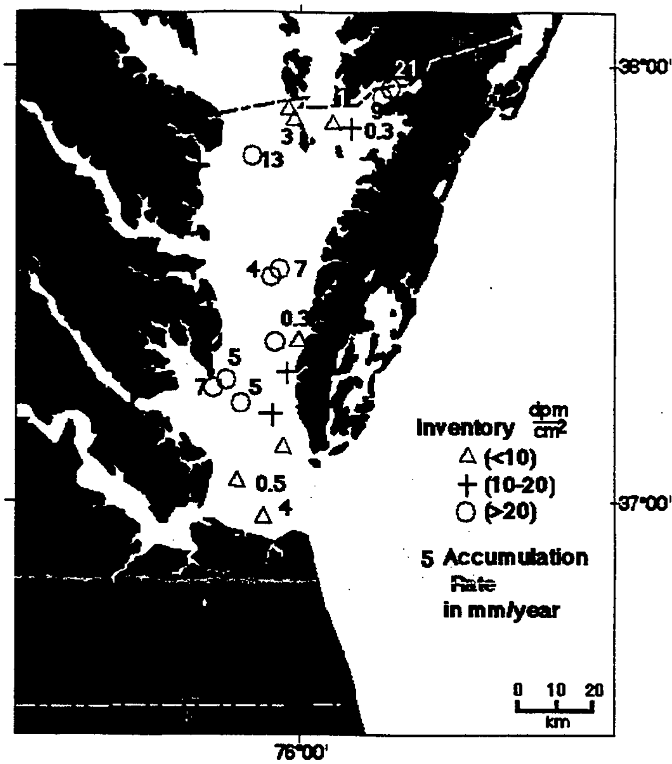


*Fig. 1. $^{210}Pb$ inventories and accumulation rates in Southern Chesapeake Bay.*

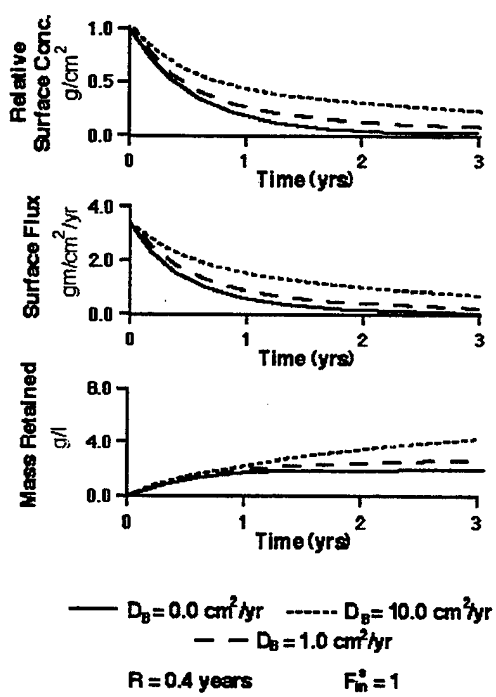


*Fig. 2. This model run illustrates a burial history in which bioturbation is significant. For moderate to high values of the biodiffusion coefficient, surface concentration and surface flux approach low but appreciable limiting values with time. Total mass released increases continuously.*