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Effects of Upland and Shoreline Activities on the Chesapeake Bay

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EFFECTS OF UPLAND AND SHORELINE LAND USE ON THE CHESAPEAKE BAY

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DREDGING AND DISPOSAL IN THE CHESAPEAKE BAY

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ABSTRACT

The management questions involved in dredging and open water dredged material disposal revolve around three basic issues: 1) stability of the dredged material within the defined disposal area, 2) altered resource value of bottoms affected by dredged material, and 3) mobilization of toxins from contaminated dredged material. These issues encompass all aspects of the physical and biological character of a project site. The actual evaluation of dredging and dredged material disposal has generally concentrated on acute impacts to bottom dwelling organisms, benthos, and or to water column characteristics. This emphasis has resulted in ample evidence that many disposal practices have at least short term detrimental effects. With few exceptions, these studies have failed to assess the relationships between the benthos and the dredged material as a new sediment habitat, or the consequences of altering the hydrodynamic regime, or the resource value of the benthos.

Unless toxics are involved the natural process of recolonization or recruitment will return benthos to the disposal area. The key questions then for effective management of dredging and disposal revolve around longer-term processes that will influence recolonization, these are natural sediment dynamics, hydrodynamics, and biogenic activity.

INTRODUCTION

Most studies dealing with dredging and disposal usually find an acute impact that is relatively short lived (McCauley et al. 1977, Rosenberg 1977, Flemer et al. 1968, Diaz and Boesch 1977). In areas where the impacts are severe long-term disturbance may result, but these types of dredging projects, at least in the literature, are not the norm (Kaplan et al. 1975, Rosenberg 1977). In most areas where disposal effects are long-lived toxics or other factors usually play a significant role in the disturbance (Saila et al. 1972). Disregarding the case where toxics are involved, since dredged material that is classified as toxic is not disposed of in open water, initiation of recolonization by whatever means is usually quick.

Communities are well on their way to some recovery point within days or months depending upon the particulars of the environment concerned.

With the reality that dredging and disposal will occur and there will be some acute impact, any dredged material management plan must look beyond the acute and evaluate the consequences of dredging activities in the long-term. Consideration for long-term alteration to important processes that regulate the value of the habitat being managed should be paramount. The value of a habitat being either a direct, such as protection, or indirect, such as trophic support, ecological support for fisheries species is usually the ultimate concern for environmental management (Lunz et al. 1978, Lunz and Kendall 1982).

A management approach to dredging activities in open water needs then to consider the long-term stability of dredged material within a disposal area and potential for alteration of the bottom resource value. In this paper we will present how the physical and biological components of the environment interact with dredging activities.

MECHANISM OF IMPACT AND RESPONSE

Most studies dealing with dredge material disposal, in open water, usually find an acute impact that is relatively short lived. Initiation of recolonization, by immigration or recruitment, is usually quick with communities well on their way to "recovery" within days or months depending upon the physical character of the environment and the season.

The mechanisms of the impact in all cases can be reduced to several common elements:

1 - Physical disruption of benthos by burial.

2 - Instability of new sediment surface and changes in mass properties cause problems in support and respiration.

3 - Dredge material retains its original geochemical composition after disposal resembling digenetically mature deep sediments. The increased elemental flux and oxidation reactions when these sediments are placed on the surface pose potential toxic and low dissolved oxygen stress to the benthos.

4 - Changes in particle sizes available to benthos and loss of food value. While dredge material may be high in organic content it all tends to be highly refractive and unavailable to benthic feeders.

The responses of the benthos to these elements can also be summarized:

1 - Reduction of individuals and species through death which leads to reduction in standing crop and resource value.

2 - Physiological stress induced in survivors by increased elemental fluxes and lowered dissolved oxygen.

3 - Rechanneling of energy to maintain feeding, respiration, and support.

With time the process of recolonization, either through immigration or larval recruitment, quickly puts the benthos back into a recovery phase. Time then is the common element that lessens the physical disruption of the dredged material and guides the recovery phase.

LONG-TERM PROCESSES

There are three long-term processes that are important in the context of dredging and dredging impacts on habitat value. They are natural sediment dynamics, hydrodynamics and biogenic activity. These processes are at work continually to shape the benthos and determine to a great degree the resource value of the bottom to fisheries species. Dredging and disposal then need to be considered in light of how they fit within these long-term processes to either impact or enhance the value of a bottom. With this in mind less emphasis need be placed on acute effects.

NATURAL SEDIMENT DYNAMICS AND HYDRODYNAMICS

At one time or another all these elements fit into the natural dynamics of sedimentation. The problems come when the scales of events are compared between natural and dredging processes. For example, natural turbidity is generated from resuspension of surface sediments whereas dredging turbidity comes from the suspension of deeper deposits. A schematic representation of natural sediment dynamics is presented in Figure 1. This cycle is at work over the entire subtidal environment with the rates of flux from one state to another dependent upon weather and tides. The benthos have evolved within this natural sediment cycle and are adapted to the particular disruptions encountered in various environments.

Dredging and disposal alter this sediment cycle, at a localized level. For a short period of time turbidity is caused by deep deposits, the original sediment surface is buried leaving the new surface composed of deep sediments. After disposal hydrodynamic forces quickly bring the disposal area under the influence of natural sediment dynamics. The dredged material quickly starts to lose its digenetically mature character and is immediately covered by thin layers of natural sediment.

It is the adaption of the benthos to the workings of natural sediment dynamics that allows acute impacts of dredging to be short lived. Since new dredged material resembles more a deeper deposit initial colonizers tend to be the opportunistic species because of their wider environmental tolerances and tendency to live within the very surface sediments.

BIOGENIC ACTIVITY AND SUCCESSIONAL STAGE

An important factor in the colonization of opportunists is the thin veneer of natural sediments that quickly covers the dredged material. Early colonizers tend to be closely associated with the water-sediment interface and either suspension or surface deposit feed. These initial recolonizers immediately start to modify the sediments through irrigation and reworking. A successional sequence is then initiated in the dredged material that leads toward development of "climax" community and substrates (climax being used to describe the benthos and sediments from a similar natural habitat that has been undisturbed.).

The path sediment succession takes is most predictable being dependent on very general categories of benthic organisms, from initial surface dwellers to later deep infauna. The succession of the benthos is less predictable, from the onset it is directed by the makeup of the sediment. As species set and grow larger the amount of biogenic activity increases. Both sediment and benthic succession are interdependent, one does out proceed far without the other. Sediment succession is very dependent on initial stages of benthic succession while later stages of benthic succession will be delayed until "climax" sediment succession is reached. The lag and interplay of these two successions may account for the disparities in recovery times noted among the studies of acute dredging impacts.

On dredged material or any defaunated natural bottom the rate of recovery of the benthos is mainly a function of the long-term stability of the system. Dredging creates a localized biological vacuum that disrupts communities. Initially more individuals can temporarily occupy the new habitat. With time species interact and turnover, and depending on the sediment quality of the dredged material and barring toxicants the resource value of the benthos returns to some level.

A PRACTICAL EXAMPLE

Plans have been developed over the last 10 years to deepen the main navigation channel up the Chesapeake Bay to Baltimore from 42 to 50 feet. In Virginia waters approximately 33 million cubic yards of sediment will be dredged and disposed of in two open water sites. The disposal plan and monitoring program were developed from interactions between the Baltimore and Norfolk District Corps of Engineers and the Commonwealth of Virginia. The monitoring plan while documenting the acute effects concentrates on the long-term impacts.

The basic management strategy in developing the disposal and monitoring plans were to minimize acute impacts and follow the resource value of the bottom for long-term changes that may be related to the disposal operation. With this in mind a baseline study was undertaken to assess existing conditions of the benthos and bottom sediments and estimate the magnitude of their spatial and seasonal variability (Diaz et al. 1985). The resource value of the benthos in trophic support of fisheries species was estimated using the Benthic Resources Assessment Technique developed by Lunz and Kendall (1982).

We found the composition of the benthic community and its final resource value to be controlled by sediment type, salinity, depth, and seasonal dissolved oxygen depression. For a given salinity the benthic resource value was higher in sediments having a mixture of sand and mud (silt-clay) relative to the sediments that are pure sand or clay or silt. In these areas of mixed sediments the biogenic structure of the sediment was well developed and the communities characteristic of mature successional stages. These areas supported a high biomass of benthos that was being utilized by fisheries species. Communities in pure sand or mud did have a resource value but it was lower than mixed sediments, with sand having a higher value than mud. Areas that were pure mud and stressed by low dissolved oxygen had the lowest resource value.

The total area of the Bay can be broken down into sand, mixed, and silt-clay habitats, as follows:

	Sand	Mixed	Silt-Clay
VA+MD	57%	25	18
VA	67	20	13

For the purpose of long-term management of the bottoms resource value it would then be most prudent to protect the areas of mixed sediments. The possibility also arises that resource value of silt-clay areas may be increased by the addition of sandy sediments, assuming other important factors such as dissolved oxygen or sediment stability are not problems.

The Virginia disposal sites identified for use in the Baltimore channel project involve 2% of the Virginia bottom with higher benthic resource value near Wolf Trap and 0.3% of the lower resource bottom near Rappahannock Shoals (Figure 2). One disposal site in each area will be used. At Wolf Trap the sites were very similar being mostly mixed sediments of high resource value. Neither site is significantly higher in value. At Rappahannock Shoals the primary site varied from pure mud to sand and also had low and high resource value habitats. The alternate site was uniformly muddy and had overall a moderate to low resource value. It would then seem, in the long run, most appropriate to use the alternate site for disposal. The possibility also exists that the sandier channel sediments will raise the value of the alternate site.

To minimize any of the long-term impacts of the channel deepening it would seem that at Wolf Trap the key is the rate of spread of the sediment after disposal. The communities present are not adapted to high rates of sediment accumulation. If the hydrodynamic regime spreads the material "slowly" then it is likely that the high resource value of the region will be preserved. On the other hand rapid movement of the dredged material out of the disposal area will likely cause depression in resource value.

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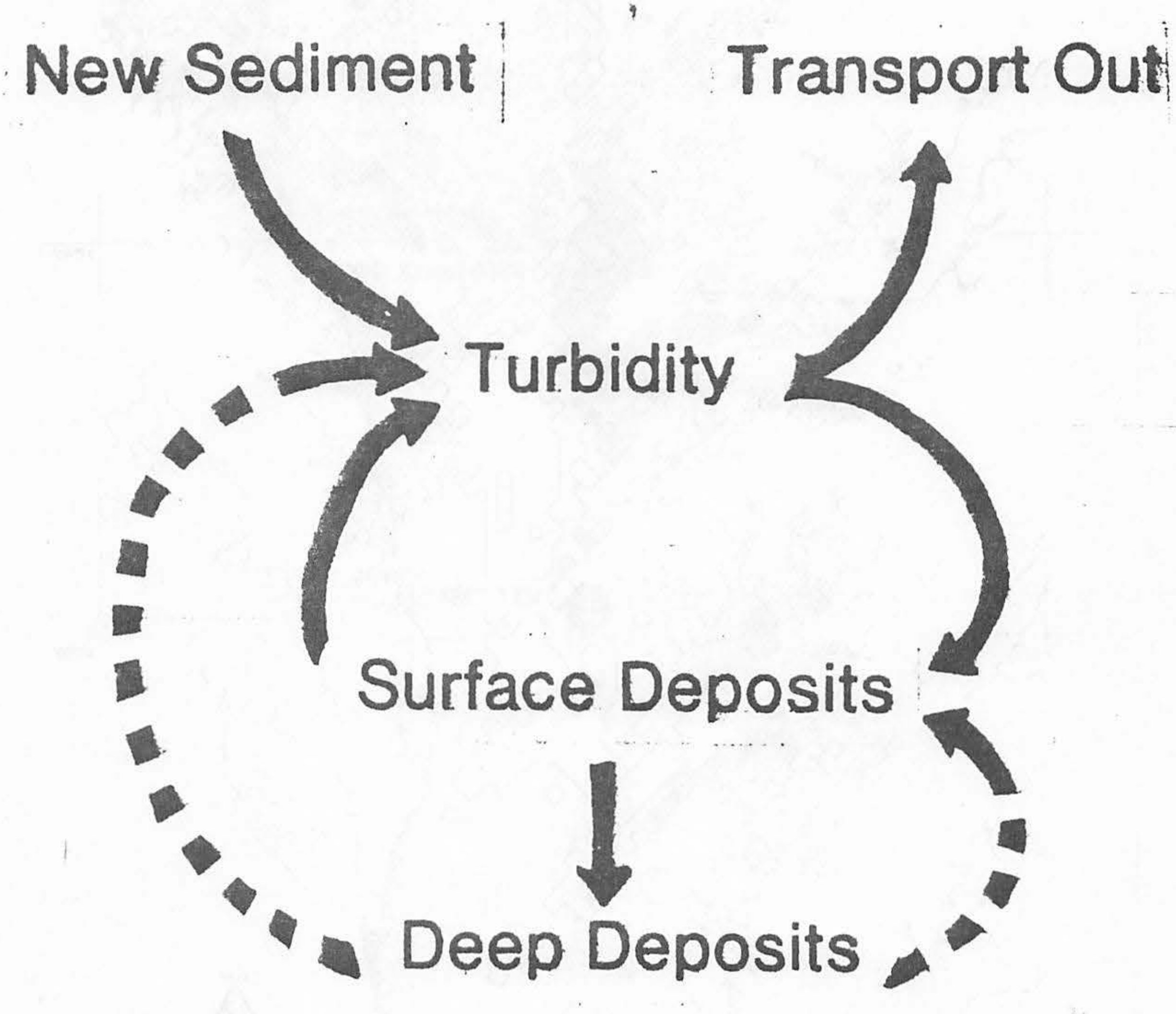

Figure 1. Schematic representation of natural sediment dynamics and how dredging and open water disposal affect these dynamics. Dredging affects are depicted by broken lines. Surface deposits are considered to be on the order of 15 cm in thickness.

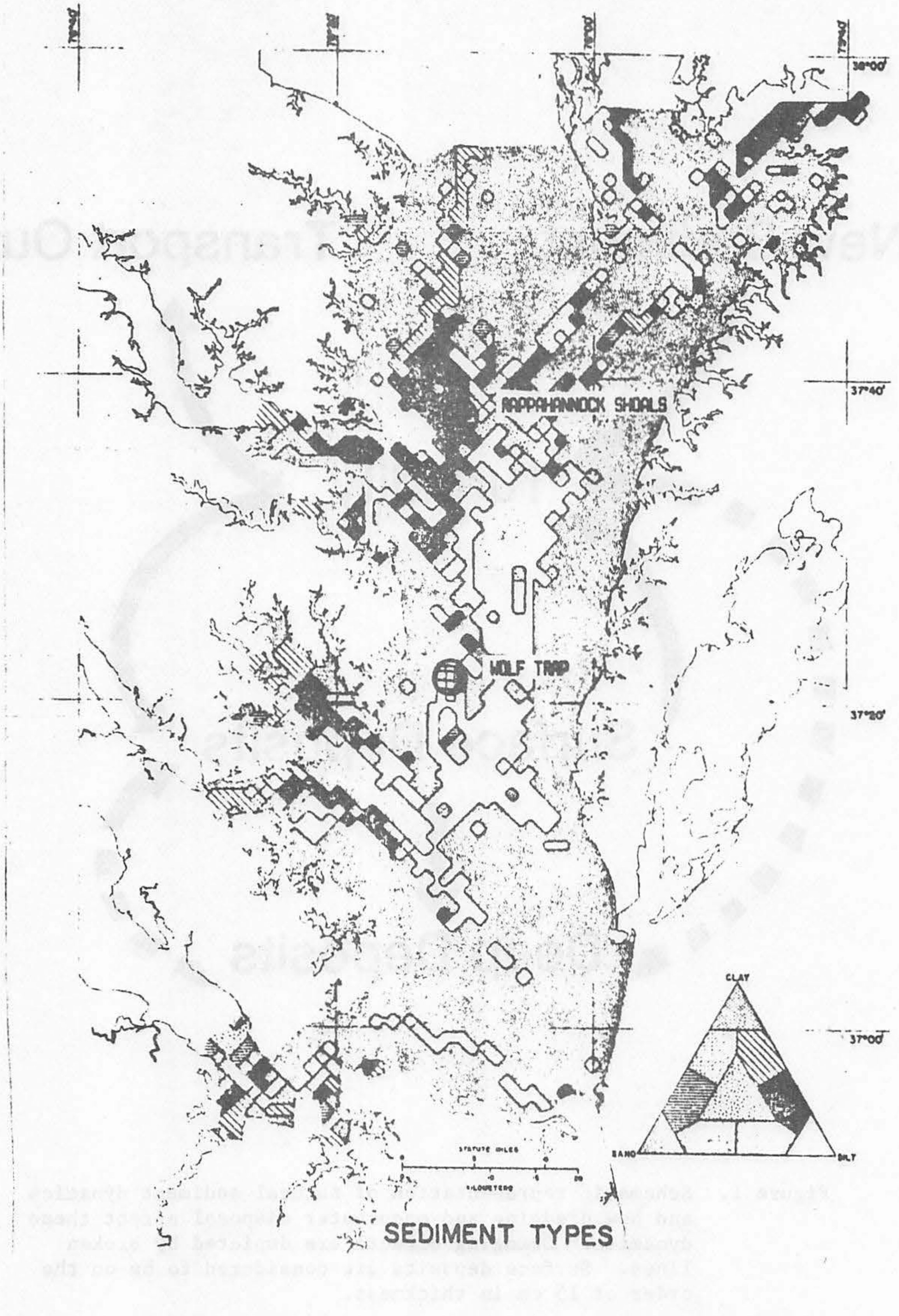

Figure 2. Map of sediment types in the lower Chesapeake Bay with approximate location of the Wolf Trap and Rappahannock Shoals disposal areas.