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Recovery of interior brackish marshes seven years after the chalk point oil spill

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ABSTRACT

Seven years after the April 2000 spill of 140,000 gallons of a mixture of No. 6 and No. 2 fuel oils in the Patuxent River, Maryland, heavily oiled brackish marshes showed continuing effects. Stem density and stem height were significantly lower in oiled versus unoiled sites for *Spartina alterniflora* but not *Spartina cynosuroides* habitats. In contrast, belowground biomass was significantly lower in *S. cynosuroides* habitats but not *S. alterniflora* habitats. Total PAH concentrations were up to 453 mg/kg in surficial soils (0–10 cm) and 2921 mg/kg with depth (10–20 cm). The oil had lost 22–76% of its initial PAH content after seven years, although the oil in marsh soils has undergone little to no additional weathering since Fall 2000. Based on amphipod acute toxicity tests and sediment quality guidelines, 25% of the soils in the marsh are expected to be toxic (ESB-TU_{FCV} values > 3.0; P_{Max} > 0.65).

1. Introduction

On 7 April 2000, an estimated 140,000 gallons of a mixture of No. 6 and No. 2 fuel oils were released into Swanson Creek, the Patuxent River, and downstream tributaries from a ruptured pipeline to nearby Chalk Point Power Generating Station, Maryland. An estimated 76 acres of brackish marsh dominated by *Spartina alterniflora*, *Spartina cynosuroides*, and *Typha* spp. were affected. Cleanup methods varied widely. In the marsh adjacent to the leak site (Fig. 1), cleanup consisted of digging of trenches, low- to moderate-pressure and high-volume flushing, extensive manual removal using sorbents, filling of the trenches, and replanting (Gundlach et al., 2003). In the heavily oiled interior marsh areas at the head of Swanson Creek, boardwalk pathways were used to provide worker access for recovery of the pooled oil using sorbents. Nutrients were applied manually and by helicopter several times in the summer of 2000 in the interior areas of marshes east of the break site as part of a biostimulation program. Gundlach et al. (2003) reported that no cleanup was attempted in the interior marshes further to the west because of limited access.

In the Natural Resource Damage Assessment conducted by the resource trustees (Michel et al., 2002; NOAA et al., 2002), heavily oiled interior vegetation was estimated to recover in 5–10 years and soils were estimated to recover in 10–20 years (shorter for *S. alterniflora* and longer for *S. cynosuroides*). Because of these predicted long-term impacts, a study was conducted seven years after the initial spill to answer the following questions:

- What is the condition of the vegetation in the heavily oiled marsh seven years post spill compared to unoiled marshes?
- What is the degree of weathering of oil in the marsh soils?
- What are the sources of the PAHs in the marsh soils?
- Is the oil in the marsh soils toxic? If so, at what PAH concentrations?

2. Study methods

2.1. Study design

This study was conducted seven years after the Chalk Point oil spill, focusing on the most heavily oiled interior brackish marsh habitats of *S. alterniflora* and *S. cynosuroides*. The oil had pooled on the marsh surface, particularly in open, unvegetated areas created by muskrat grazing. We excluded the area immediately adjacent to the pipeline break where aggressive cleanup was conducted (Fig. 1). Sites were located in oiled marshes on either side of the release site where some cleanup efforts were conducted, using manual removal with sorbents by crews working from boardwalks. Sites were also located at the very head of Swanson Creek where it was reported that little or no cleanup was attempted. Therefore, the results of this study are representative of these conditions.

The study site is characterized as a brackish-water marsh, with mixed stands of *S. alterniflora*, *S. cynosuroides*, *Typha* spp.,

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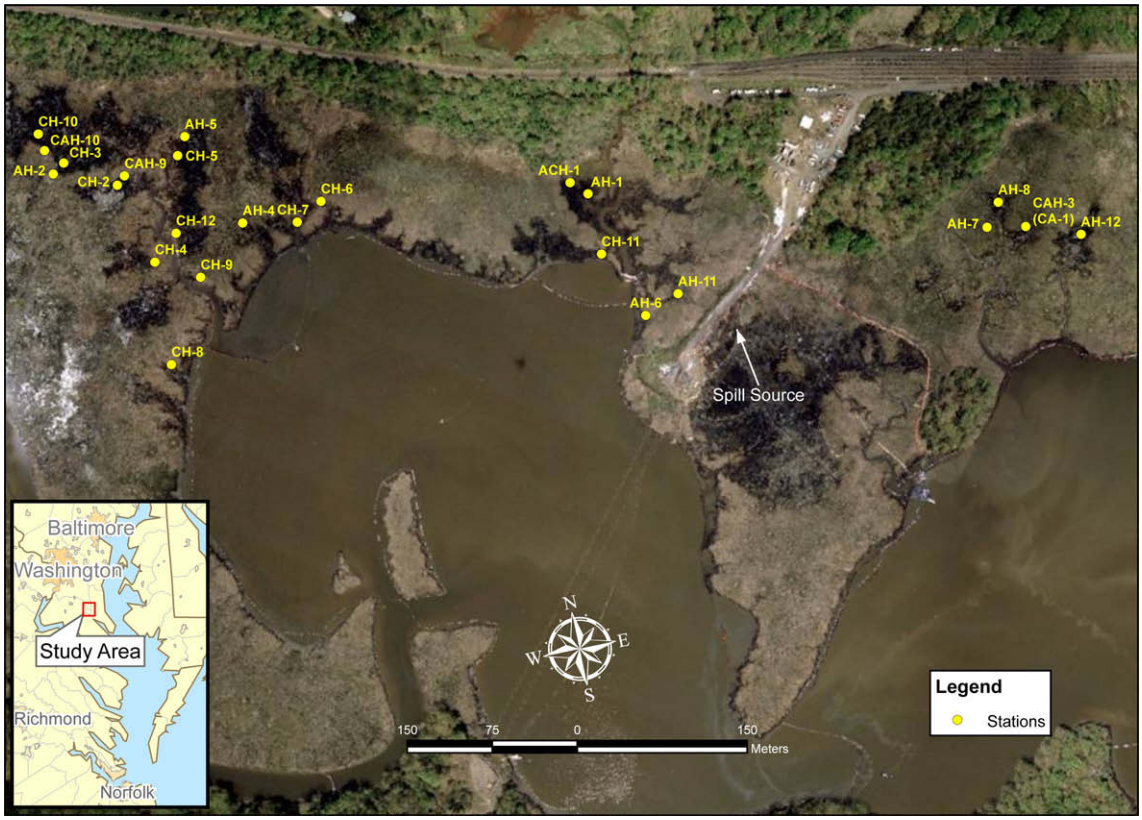

Fig. 1. Station locations and spill location plotted on aerial photography taken in April 2000 shortly after the spill to allow visualization of the sites relative to the oiling at the time of the spill. The four stations to the northeast were treated with nutrients in 2000. The four stations just to the northwest of the spill source were cleaned by workers on boardwalks using sorbents. The far western interior marshes were not cleaned.

and *Scirpus* spp., with minor occurrence of *Polygonum* spp. and *Amaranthus* spp. *S. cynosuroides* usually occurred as a continuous band of vegetation along creek banks and large zones throughout the marsh platform (comprising 49% of the marsh in Swanson Creek). *S. alterniflora* generally occurred as smaller patches interspersed in the marsh (comprising 23% of the marsh in Swanson Creek), and it was harder to find mono-specific stands. *Typha* occurred mostly along the marsh fringe in the oiled habitats (comprising 27% of the marsh in Swanson Creek), so was not included in our study, which focused only on the interior habitats.

The study design consisted of an oiled versus unoiled comparison of the following variables: vegetation health as indicated by stem density, stem height, and total (live and dead) belowground biomass; oil fate and effects as indicated by polynuclear aromatic hydrocarbon (PAH) concentration and weathering in soils; and toxicity as indicated by sediment bioassay tests. A statistical analysis of the power of proposed study variables was conducted to determine the minimum sample size to achieve 80% power given postulated effects sizes at the $\alpha = 0.2$ significance level. This level of significance was judged adequate given the uncertainty about effects sizes and the effort available. The final distribution of sites consisted of:

S. alterniflora: 12 unoiled sites (site name AR for *S. alterniflora* and reference)
10 oiled sites (site name AH for *S. alterniflora* and heavy oiling)
S. cynosuroides: 12 unoiled sites (site name CR for *S. cynosuroides* and reference)
14 oiled sites (site name CH for *S. cynosuroides* and heavy oiling)

2.2. Site selection

Color infrared digital aerial photographs were classified into three emergent marsh vegetation classes dominated by *S. alterniflora, S. cynosuroides*, and *Typha* spp. Oiled marsh areas were digitized from imagery acquired immediately after the spill. Nine random site locations were generated in oiled and unoiled interior areas for both marsh types. These nine new sites, plus three sites in each marsh type from previous investigations, were pooled together for each group. The area east of the break site, where intensive cleanup methods were used, was excluded from this study.

Some of the pre-selected unoiled sites were located more than several hundred meters from channels; in contrast, the oiled sites tended to be closer to marsh channels. Thus, some of the unoiled sites were located in the pre-selected areas but not as deep into the marsh. Distance to the nearest tidal channel was 17.9 meters (m) for the unoiled sites and 12.1 m for the oiled sites. A nonparametric test (Wilcoxon Oneway Analysis) was used to determine that the sites were not significantly different with respect to distance from the nearest tidal channel, with a Z value of 0.0650.

If the vegetation was dominated by either *S. alterniflora* or *S. cynosuroides*, the site was used for that marsh type. If the site had a mixed species assemblage, the site was moved to the nearest point with a homogenous plant community dominated by the species of interest. For two of the *S. alterniflora* pre-selected sites, all of the adjacent vegetation was dominated by *S. cynosuroides* so they were not moved, thus the final distribution of 14 oiled *S. cynosuroides* and 10 oiled *S. alterniflora*.

The oiled sampling sites are shown in Fig. 1, overlain onto the April 2000 (shortly post spill) vertical aerial photograph. Unoiled sites were in adjacent creeks both north and south of the oiled