Patuxent River Oil Spill

Proposal to Assess Oil Spill Impacts on Benthic Invertebrates

Prepared For

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INTRODUCTION

The state of Maryland has maintained an ecological monitoring program for Chesapeake Bay since 1984. The program includes a number of fixed and randomly selected sites in the Patuxent River. Many of the historical stations are located in the area affected by the recent oil spill. Benthic macro-invertebrates have been included in the Chesapeake Bay monitoring program because they are reliable and sensitive indicators of habitat quality in aquatic environments. Most benthic organisms have limited mobility and cannot avoid changes in environment conditions (Gray 1979). Benthos live in bottom sediments, where exposure to contaminants and low dissolved oxygen is highest. Benthic assemblages include diverse taxa representing a variety of physiological tolerances to environmental conditions. Benthic assemblages, therefore, respond to changes in environmental conditions, both natural and anthropogenic, in a variety of ways and are sensitive indicators and integrators of environmental change (Pearson and Rosenberg 1978, Warwick 1986, Dauer 1993, Wilson and Jeffrey 1994).

Benthic organisms are also important secondary producers, providing key linkages between primary producers and higher trophic levels (Virnstein 1977, Holland et al. 1980, 1989, Diaz and Schaffner 1990). Benthic invertebrates are among the most important components of estuarine ecosystems and may represent the largest standing stock of organic carbon in estuaries (Frithsen 1989). Many benthic organisms, such as oysters and clams, are economically important. Others, such as polychaete worms and crustaceans, significantly contribute to the diets of economically important bottom-feeding juvenile and adult fish such as spot and croaker (Homer and Boynton 1978, Homer at al. 1980)

Recent efforts by Maryland DNR have created a benthic index of biotic integrity (B-IBI) to help interpret these data (Weisberg et al. 1997). The B-IBI is an index that varies from 1 to 5 and is based on a number of summer time benthic invertebrate attributes such number of pollution tolerant species, number of opportunistic species, total numbers, total biomass, among others. The B-IBI is based on a set of benthic attributes that describe expected characteristics of benthic assemblages at site having environmental stress. B-IBI scores near 1 indicate sites where environmental stress has occurred, while sites with B-IBI scores near five indicate that the benthic community is healthy. DNR has been monitoring the benthic communities around Chalk Point for the last twenty years and the B-IBI has improved into the "good range" as a result of cleanup efforts and reductions in nutrient inputs. The long-term benthic database provides a unique opportunity to evaluate the effects of the oil spill on the ecological condition of Patuxent River benthic communities.

PROPOSED WORK

We propose to initiate an assessment to determine if the oil spill has impacted the benthic communities in Swanson Creek and the Patuxent River near Chalk Point. Benthic sampling around the area affected by the oil spill will be conducted in spring and summer 2000. The summer assessment will be conducted in conjunction with the next scheduled sampling event of the Maryland DNR Chesapeake Bay Benthic Monitoring Program (LTB), and will use common locations and platforms for the collection of data whenever possible. LTB has accumulated an extensive data base of benthic and water quality data in the region and these existing data will be used as much as possible. The integration of this study with on-going LTB efforts will result in a robust and scientifically-defensible impact assessment and will minimize the large costs typically associated with benthic sampling and processing. Furthermore, sample processing and organism identification will be done in-house, eliminating the need for subcontracts and substantially reducing the overall cost of the study.

The assessment will consist of river and creek subtidal benthic assessments. The river component will consist of revisiting sites in the mainstem of the Patuxent River that have been previously sampled as part of LTB. The creek component will allocate random samples to Swanson Creek in the immediate vicinity of the spill, and to another creek that has no impact or has been minimally impacted by the spill (to be determined with the guidance of trustees from existing data).

RATIONALE

The effects of oil spills on benthic organisms vary as a function of the severity and spatial extent of the event. The effects of oil spills and chronic hydrocarbon inputs on benthic organisms have been widely documented (e.g., Samiullah 1985, Gray et al. 1990, McGuinness 1990, Agard et al. 1993, Clarke 1993). Large hydrocarbon concentrations in sediment are toxic to many organisms and may cause widespread mortality. However, in systems that experience aperiodic disturbances such as those related to high summer temperatures and low dissolved oxygen, sensitive species are usually eliminated. This brings structural and organizational changes to the community and leads to pollution resistant communities. It is therefore critical to examine the condition of the benthic community before the oil spill in order to determine whether the impacted system differs significantly from what it would have been in the absence of the impact. It might be that the mortality resulting from the sediment toxicity after the oil spill is within the range of variability expected of communities associated with multiple environmental stresses. Use of the historical LTB database will therefore be very valuable to determining the status of benthic communities in the Patuxent River prior to the impact from the oil spill.

LTB has collected samples at fixed and random locations within the Patuxent River in the vicinity of Chalk Point both in the spring and summer seasons. Sampling in the spring (mid May to early June) will be important because the timing of a disturbance relative to the recruitment of species to the benthos is critical to survivorship. Larvae and

juveniles are the most sensitive stages of the life history of most species, and therefore, the coincidence of recruitment peaks with the oil spill may have devastating effects on the benthos. If a reduction or elimination of the benthos occurs, this may initially represent a significant reduction of food for demersal fishes. It is important therefore that we follow the recovery of the benthic community. This recovery may be hampered by additional stresses from near bottom summer low dissolved oxygen concentrations or high water temperatures. Sampling near the end of the summer season (early to mid September) will allow us to determine the cumulative effects of these stresses. Where no previous data are available (creek and beach/marsh components), we will assess the magnitude of the impact through comparison of sites near and distant from the spill source. This assumes that the baseline conditions between the near and distant areas studied are the same and that the only difference between them is proximity to the spill.

METHODS

River Component

Our approach will be based on the Before-After-Control-Impact design (BACI) (Stewart-Oaten et al. 1986, Underwood 1991) with modifications if necessary to take advantage of the large data set collected by the LTB program and available for this study: several dates (up to five years for random locations and up to 17 years for a fixed location at Chalk Point) before the perturbation at the impact site in the Patuxent River and at control sites in nearby rivers (for example, the Potomac and Rappahannock). The BACI design allows for natural differences between Control and Impact locations, and for changes from Before to the After period that influence the sites in a similar way. The approach will be to test whether the mean Impact-Control difference has changed Before and After the oil spill. We will use the data collected by LTB in spring (one fixed location) and summer 2000 (one fixed and several random locations). However, these data will need to be supplemented by additional data collected at the random sites sampled by LTB in previous years. Only by comparing data from the same sites before and after the impact can we assess changes to benthic populations that may be related to the oil spill.

In addition to the fixed site at Chalk Point, LTB sampled 13 sites in spring 1990-1993 as part of a historical random sampling design. We will revisit these sites and collect one sample per site. The BACI design can be applied to the fixed site and the summer random sites because we have the pre-spill and the post-spill condition at both the impacted area and controls elsewhere in Chesapeake Bay. The 13 spring sites, however, will not have comparable post-spill data outside the Patuxent River, and thus the design will be modified. Additionally, summer data can be analyzed in the context of measures of benthic community health using the B-IBI index. The B-IBI takes into account the natural range of variability within reference areas in Chesapeake Bay, and therefore it provides its own measure of stress without the necessity of a control.

Creek Component

No benthic data are available from Swanson Creek. Therefore, we propose to collect samples at Swanson Creek and compare these samples to a nearby undisturbed or minimally disturbed creek (e.g., Hunting Creek or Indian Creek). These samples will be paired in the sense that the near-field (Swanson Creek) and far-field (Hunting/Indian Creek) sites will be sampled simultaneously. We estimate that a minimum of 10 samples collected at each of these two creeks will be necessary to make valid statistical inferences related to impacts from the oil spill.

Field and Laboratory Procedures

Whenever possible, we will sample from vessels positioned in the area to conduct LTB sampling, thus saving time and minimizing additional field sampling costs. River and creek samples will be collected with the same gear used for historical samples so that the data are comparable. We will process the samples using the same procedures used for LTB analyses. Grab samples will be sieved through a 0.5-mm mesh screen, and the organisms retained on the screen will be preserved in a 10% formalin solution and stained. In the laboratory, organisms will be counted, identified, and their biomass measured. All sorting and identification will be done in-house to minimize costs.

We will record water depth, salinity, temperature, dissolved oxygen, particle size distribution (percent sand and silt-clay) and total organic carbon at every sampling site. Environmental factors will be used as covariats in the analysis of data. Sediment samples for analysis of PAH concentration will also be taken at each sampling site and will be archived for chemical analysis if desired.

Data Analysis

Data from the river component will be analyzed using the BACI design outlined above. In addition, summer data will be analyzed in the context of measures of benthic community health using the B-IBI index. If sediment chemistry data are available, we will look at variation in hydrocarbon concentrations that might explain differences in abundance or biomass. The proposed design will allow us to determine if significant differences exist within the benthic data. These data can be analyzed to determine the relationship, if any, between PAH contamination and benthic condition. If such a relationship is assessed (i.e., if the trustees determine that PAH assessment is necessary) and a relationship can be elucidated, the trustees will be able to utilize these data to evaluate the areal extent of the impact to the benthos. The statistical design of this study will not produce a stand-alone assessment of areal impacts to benthos, but can be used in accordance with other evaluations of the extent of PAH or oil impacts to determine the areal extent of impact to the benthos. Deliverables will include a short report presenting results and supporting data analyses.

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AMENDMENT TO JUNE 15 PROPOSAL
As per trustees' request
October 19, 2000

The creek component of the oil impact benthic assessment is modified as follows. The September field effort (summer) will be increased to 20 samples in Swanson Creek (10 more than originally proposed), 10 samples in Indian Creek, and 10 samples in Trent Hall Creek. Indian Creek and Trent Hall Creek are new additions to the sampling design. Sampling effort in Hunting Creek and the Patuxent River near Chalk Point will remain as originally proposed, i.e., 10 samples will be collected in each of Hunting Creek and the main Patuxent River near Chalk Point.

Swanson Creek will be divided into an upper and a lower stratum (separated at the spit). Ten sites will be randomly allocated to each of the two strata. Within the upper stratum we will revisit two of the three sites sampled in the spring and pick a new fresh set of eight random sites. Within the lower stratum, we will revisit five of the sites sampled in the spring and pick a new fresh set of five random sites. The sites to be revisited in the lower stratum will be selected at random. The sites to be revisited in the upper stratum are fixed because only three sites were sampled during the spring sampling effort and one of them is excluded from the selection process because it was associated with marsh vegetation. We believe that the presence of vegetation confounds the interpretation of oil impacts. To avoid the marsh fringe, extra sites will be randomly selected prior to sampling. The Field Crew Chief will then eliminate in the field any site that has vegetation and move to the next available site in each stratum (in the order determined by the random process). Samples from sites that are revisited will provide estimates of seasonal variability. Seasonal differences at the impacted location (Swanson Creek) will be compared with seasonal differences at the control location (Hunting Creek). The additional summer sites will provide increased spatial coverage.

As with Swanson Creek, five of the Hunting Creek spring sites will be revisited in summer, and these sites will be supplemented by a new fresh set of five additional random sites. The marsh fringe will be avoided as explained above.

Sampling sites at Indian Creek and Trent Hall Creek will be selected within upper strata that exclude the mouth of the creek. The marsh fringe will also be avoided.

The ten sampling sites in the main Patuxent River near Chalk Point will be supplemented by LTB sites sampled in 2000 as part of the LTB program. Twenty-five LTB sites are established annually throughout the Patuxent River to provide summer areal estimates of benthic community condition. As with the spring sampling, the ten summer sites proposed in the present study will be located in the vicinity of Chalk Point, defined as the portion of the mainstem of the Patuxent River between the Highway 231 bridge at Benedict and the Holland Cliff region upstream. The ten summer sites in the main Patuxent were previously sampled in 1998 or 1999 as part of LTB, so the present effort will consist of revisiting these sites, as discussed in the original proposal. LTB