Overview of Water Quality Assessment Biological Sampling Program

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Introduction

King County's researchers recently conducted extensive biological sampling in the Duwamish River estuary to evaluate risks to aquatic life, wildlife, and human health from combined sewer overflows (CSOs) and other discharges. This effort was undertaken between September 1996 and December 1997 using a number of specialized sampling and analytical approaches. Field sampling to measure chemical concentrations in water and sediments occurred over essentially the same time period. Upon completion of analyses, these data will be used to validate model-based estimates of chemical concentrations. These data also will add to our basic knowledge of the Duwamish River estuary and serve as a baseline for future monitoring. While some preliminary results are available and will be discussed in other sections of this conference, most of the resulting data are still to be analyzed and interpreted. This paper, then, focuses on the design of biological sampling and how the results will be used to predict risks.

The biological sampling program consisted of the following components:

- Chemical bioaccumulation studies in transplanted and wild mussels
- Chemical bioaccumulation studies in fish and shellfish
- Microbial uptake studies, and
- Benthic infaunal studies.

Chemical Bioaccumulation in Transplanted and Wild Mussels

Chemical bioaccumulation in transplanted and wild mussels was studied to learn which chemicals entering the Duwamish River estuary were bioavailable and bioaccumulated, and if bioaccumulation changed seasonally. Measured chemical concentrations (metals, organics, and tributyltin [TBT]) in the soft tissues of mussel transplants (*Mytilus galloprovincialis*) and wild mussels (*Mytilus trossulus*) was the basis of chemical monitoring. Following the general recommendations of Salazar and Salazar (1995), mussel transplants were deployed at two combined sewer overflow locations (Brandon Street CSO, Duwamish/Diagonal Way CSO/storm drain) and at two in-river reference sites (Slip #1, Kellogg Island) (Figure 1). Additionally, mussel transplants were deployed at a reference site in South Puget Sound (Totten Inlet). At each CSO location, the mussel transplants were deployed immediately in front of or just below (down river) of the discharge pipe. Distance from the outfall to the transplants was 25 m or less. Wild mussels were collected from the same CSO/storm drains and in-river reference sites as well as other locations in the Duwamish River (Slip #4, Hanford Avenue CSO, Terminal 105) and in Elliott Bay (Elliott Bay Pier). Wild mussels were collected within 50 m of each CSO location. These studies were undertaken in the dry season (September 1996) and repeated in the wet season (March 1997). Some preliminary results are presented by Strand et al. (this volume).

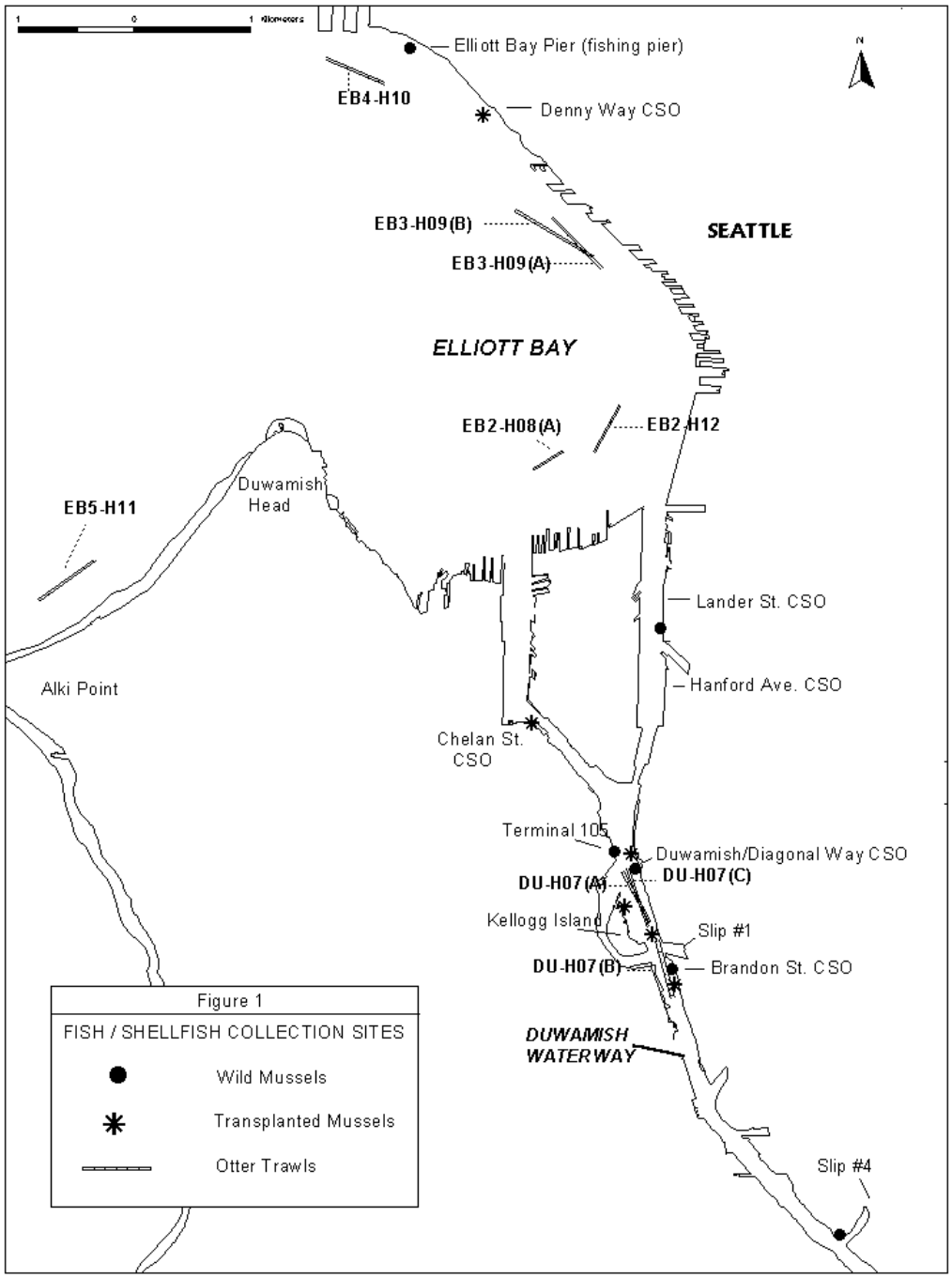

Figure 1. Site map of study area with sample locations.

Data on bioavailable organic chemicals were also collected in the wet season by employing semi-permeable membrane devices (SPMDs). Following the methods of Lefkovitz and Crecelius (1995), these devices were deployed in concert with mussel transplants at two of the CSO locations (Brandon Street CSO, Duwamish Diagonal Way CSO/storm drain) in the Duwamish River. Chemical concentrations in SPMDs and mussels can be used to calculate concentrations of organic chemicals in the water column

averaged over the period of exposure when the concentrations of organic chemicals are too low to detect using traditional grab sampling methods. Data from both the SPMDs and mussels, along with data from water and sediment monitoring, are being used to calibrate King County's computer model for simulating the transport and fate of organic chemicals from CSOs and other sources in the Duwamish estuary.

Chemical Bioaccumulation Studies in Fish and Shellfish

Concentrations of metals, organics, and TBT were also measured in fish, shellfish, and invertebrates (other than mussels). These measurements will be used in estimating chemical doses to wildlife and humans from ingesting chemically contaminated prey/seafood, sediment, and water from the study area. Estimated chemical doses from all sources in the Duwamish estuary will be used to calculate risks to wildlife and humans. Species monitored included English sole (*Pleuronectes vetulus*), quillback rockfish (*Sebastes maliger*), shiner perch (*Cymatogaster aggregata*), Dungeness crab (*Cancer magister*), spot prawn (*Pandalus platyceros*), market squid (*Loligo opalescens*), and intertidal invertebrates, mostly amphipods (*Traskorchestia traskiana*).

Fish, crabs, and prawns were collected by King County and the Washington Department of Fish and Wildlife employing a 400-mesh eastern otter trawl in April 1997. Trawl locations in the Duwamish River and Elliott Bay are shown in Figure 1. Reference collections were made in Port Susan and in Hood Canal. Intertidal invertebrates were screened from intertidal sediments in the Duwamish River at Kellogg Island and from a reference location at McAllister Creek on the Nisqually National Wildlife Refuge in July 1997. Squid were caught by rod and reel from the Elliott Bay Pier in December 1997.

Analytical measurements of chemicals in fish and shellfish tissues will contribute to estimates of exposure for wildlife receptors, in this case spotted sandpiper, blue heron, bald eagle, and river otter. Only tissue concentrations appropriate to the type of prey consumed by each receptor will be used in determining exposure. Chemical doses will be calculated using both measured and modeled chemical concentrations in prey weighted by ingestion rates for each prey item as well as doses received from ingesting sediment and drinking water. Chemical doses will be compared to toxicity reference values derived from the scientific literature for each of the target avian and mammalian receptors. Risks associated with chemicals from all sources will be distinguished from risks associated with CSO discharges. King County's chemical transport and fate model makes it possible to estimate the chemical contributions of CSOs relative to the total chemical background at various sites within the Duwamish estuary.

Human health risks (non-cancer and cancer) from consuming seafood will be estimated following EPA methodology (USEPA, 1989). Chemical doses will be calculated using measured and modeled fish and shellfish tissue concentrations and consumption rates for different types of seafood estimated for children, subsistence, and recreational fishers. The range of consumption rates used will encompass those experienced by minority group communities whose exposures may be influenced by their cultural or social activities. King County conducted a fish consumption survey of people collecting or gathering fish and shellfish from the study area in the summer of 1997. Other relevant consumption data will be obtained from the scientific literature as well as estimates of other types of exposure to chemicals in sediments and water that can take place during human use of the estuary. Chemical doses will be compared to EPA-derived chronic reference doses and cancer slope factors to determine human health risks. Again, risks from all sources of chemicals in the study area will be distinguished from chemicals discharged from CSOs.

Some preliminary results of analyses of chemical burdens in fish and shellfish from the Duwamish estuary are included in the Poster Session of this conference.

Microbial Uptake Studies

Transplanted and wild mussels were used to monitor microbial pathogens (bacteria and viruses) in the Duwamish River. In a study conducted at the beginning of the wet season in September 1997, uptake of

microorganisms in wild mussels was studied before and after a CSO overflow at the Brandon Street outfall. To gain better perspective on potential human exposure to the raw sewage component of combined sewer overflows, sewage treatment plant influent was also sampled and analyzed for the same microorganisms.

The pathogens analyzed in the treatment plant influent and in mussels included fecal coliforms, *Salmonella* spp., *Listeria* spp., and total enteric viruses. Fecal coliform concentrations were also measured in CSO discharges and in surface waters of the Duwamish River and Elliott Bay. Fecal coliform concentrations throughout the study area will be modeled using King County's water quality transport and fate model developed for this project.

Potential human health risks from pathogens in the Duwamish estuary from CSO discharges as well as from other sources will be estimated using two methods. First, modeled surface water concentrations of fecal coliforms will be compared to regulatory guidelines for shellfish harvesting and swimming for baseline conditions and for conditions which assume that no CSOs are discharging. Second, a qualitative assessment of the likelihood of risks from disease-causing bacteria and viruses in the estuary will be performed. This assessment will be based on data for pathogens present in sewage treatment plant influent, data from the scientific literature on the presence of pathogens in storm water and other sources, data from the scientific literature on survival rates of pathogens in estuarine waters, on uptake and depuration rates in shellfish, and on the doses of pathogens required to cause infection and illness in humans (ILSI, 1996; Rose and Gerba, 1991).

Benthic Infaunal Surveys

Benthic sampling was undertaken at a CSO/storm drain and a paired reference location in the Georgetown Reach of the Duwamish River. The CSO/storm drain selected for study was the Duwamish/Diagonal Way CSO/storm drain, located just upriver from Terminal 106 on the east shore. This particular CSO/storm drain was selected because it has been studied extensively by King County (1997) and clear gradients of organic enrichment (based on total organic carbon [TOC]) and sediment chemical contamination have been documented. A reference location on the opposite side of the river near the downstream tip of Kellogg Island was selected because Leon (1980) and Cordell et al. (1996) had studied the benthic community and shown that it was healthy and diverse. Sediments at the reference site were not found to violate the State of Washington Marine Sediment Quality Standards (Chapter 173-204-WAC) (R. Shuman, King County Department of Natural Resources, personal communication). The hydrodynamics, bathymetry, and conventional properties of sediments (grain size, total organic carbon [TOC]) at the reference location are similar to the hydrodynamics, bathymetry, and conventional properties of the sediments at the CSO/storm drain location.

Benthic infauna and sediment chemistry samples were collected in September 1997. Their sampling and analyses followed the Puget Sound Estuary Program protocols (PSEP, 1987; 1996a,b,c). A paired-station approach for statistical analysis will be adopted where stations within the influence of the CSO/storm drain will be compared to stations at the reference site. Station pairings will be based on similarities in distance from shore, depth, sediment grain size, and TOC. Characteristics (endpoints) of the benthic communities to be statistically analyzed will include the relative numbers and abundances of major taxonomic groups (polychaetes, molluscs, arthropods, echinoderms, and oligochaetes) as well as various diversity, evenness, trophic, and dominance indices. Additionally, these endpoints will be compared to the Puget Sound reference ranges currently being developed by the Washington Department of Ecology (Striplin, 1996).

Data from the CSO/storm drain will be compared to data from the reference site to determine whether statistically significant changes in the benthic community end points described above occurred in areas influenced by the CSO/storm drain. These data will be correlated with the concentrations of chemicals found in the sediments at these locations as well as the conventional properties (grain size and TOC) of the sediments. Any changes in the benthic community endpoints will be used to validate predictions of risk to aquatic life (benthos) based on model-derived sediment chemical concentrations. These data also will be compared to results of recent sediment bioassays conducted at this site and at other CSO sites.

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