Elliott Bay/Duwamish Restoration Program: Intertidal Habitat Projects Monitoring Report

2001-2003 Final Report

Prepared for the Elliott Bay/Duwamish Restoration Program Panel

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Final Report

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The Intertidal Habitat Projects Monitoring Final Report 2001-2003 is produced through the contributions of personnel at the Western Washington Fish and Wildlife Office, U.S. Fish and Wildlife Service, Lacey, Washington. This report incorporates the 2001 and 2002 Intertidal Habitat Projects Monitoring Reports and findings from the 2003 field season. Lead authors for this report were Shirley Burgdorf and Howard Gearns. Authors for the 2002 Report were Karen Myers, Joe Polos, Shirley Burgdorf, and Carrie Cook-Tabor. The 2001 Report was written by David Low and Karen Myers.

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INTRODUCTION

This report contains monitoring data collected in 2003, and summary comparisons to data collected in 2001 and 2002, for three intertidal habitat restoration projects and their reference sites in the lower Duwamish River Estuary. These data were collected as part of the Elliott Bay/Duwamish Restoration Program (EBDRP). The EBDRP Panel was established as part of a 1991 consent decree between the City of Seattle, Metro (now King County Department of Natural Resources) (DNR), and natural resource trustees[1]. The projects' construction and monitoring have been under the sponsorship and guidance of the EBDRP Panel of Managers, comprised of the City of Seattle, King County DNR, and the natural resource trustees, and follow the Intertidal Habitat Projects Monitoring Program monitoring plan (EBDRP 2000). Physical success and biological success criteria were identified in the monitoring plan to determine if project restoration goals are being met. Five specific criteria were identified to be monitored under the physical success criteria and eight under the biological success criteria (Table 1). Data collection methods and post-construction, site monitoring schedules were followed as described in the monitoring plan unless otherwise stated.

Table 1. Physical and biological success criteria monitored at the Elliott Bay/Duwamish Restoration Program Sites (from EBDRP 2000).

Physical Success Criteria	Biological Success Criteria
1. Intertidal Area 2. Tidal Regime 3. Slope Erosion 4. Sediment Structure 5. Sediment Quality *(Herring's House only)*	1. Marsh Vegetation Establishment - *Marsh vegetation area* 2. Marsh Vegetation Establishment - *Species composition* 3. Marsh Vegetation Establishment - *Plant vigor* 4. Riparian Vegetation Establishment - *Areal extent & invasive plant coverage* 5. Riparian Vegetation Establishment - *Survival* 6. Bird Use 7. Fish Access/Presence 8. Invertebrate Prey Resource Production

Restoration Sites

Monitoring efforts in 2003 for the EBDRP were limited to three of the four restoration sites described in the monitoring plan (EBDRP 2000). Hamm Creek Estuary, Herring's House (formerly Seaboard Lumber), and North Wind's Weir (also called Cecil B. Moses Park) restoration sites and their reference sites, are shown in Figure 1. Construction at the fourth site, Kenco Marine, has not been initiated so monitoring at this site will not begin before 2005. The Hamm Creek Estuary and Herring's House restoration sites were constructed in 2000 and monitoring began in 2001. Construction on the North Wind's Weir restoration site began in December 2002, and monitoring commenced in early 2003.

[1] National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, Washington State Department of Ecology, the Muckleshoot Indian Tribe, and the Suquamish Tribe.

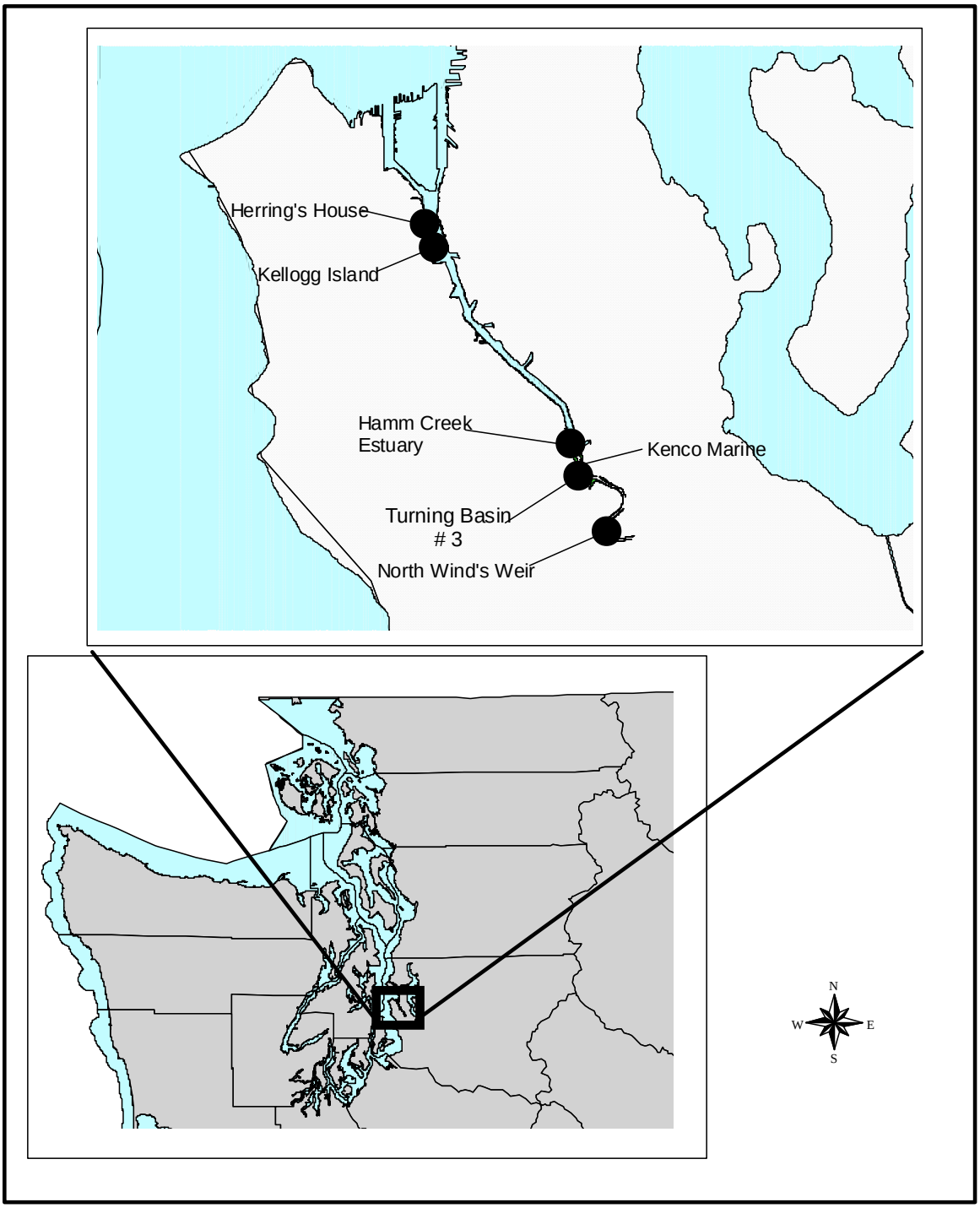


Figure 1. Location of Duwamish River Estuary restoration and reference sites monitored in 2001, 2002, and 2003.

Reference Sites

To gauge the success of some of the biological criteria monitored at each restoration site, reference sites were selected for comparison. Due to the scarcity of 'natural' intertidal habitat remaining in the lower Duwamish Estuary, it was not possible to select reference areas containing all biological criteria to be measured. The location and number of reference areas vary for each restoration site, based on the availability of similar sites and requirements for each monitoring criteria.

Hamm Creek Estuary and North Wind's Weir

The Hamm Creek Estuary and North Wind's Weir restoration sites are located close together and share two of the same reference sites. The first reference site, a natural area forming a peninsula (near a small creek adjacent to the Turning Basin #3), was used as the reference site for both fish and bird surveys (Figure 2). Fish were surveyed at a point just north of this site, while birds were surveyed in the estuary in the northern part of the peninsula. The second reference site, a small marsh on the eastern bank of the Duwamish River across from North Wind's Weir, was used as a reference site for marsh vegetation. This same site also served as the sediments and macroinvertebrates reference site for North Wind's Weir. The Hamm Creek Estuary reference site for sediments and macroinvertebrates, was a small fringe marsh located along the shoreline adjacent to the study area, just up- and downstream of the restoration site.

Herring's House

Three reference sites were used for Herring's House (Figure 3). The reference site for fish sampling was a beach on the eastern shore of Kellogg Island, near the bend at the midpoint of the Island. The second site, used as the reference site for bird surveys, was the northwest edge of Kellogg Island (directly across from the mouth of Puget Creek). The third reference site, for marsh vegetation, sediments, and macroinvertebrates, was a small area of naturally occurring stands of Lyngby's sedge (*Carex lyngbyei*) and bulrush (*Scirpus validus*) located just upstream of the Herring's House restoration site.

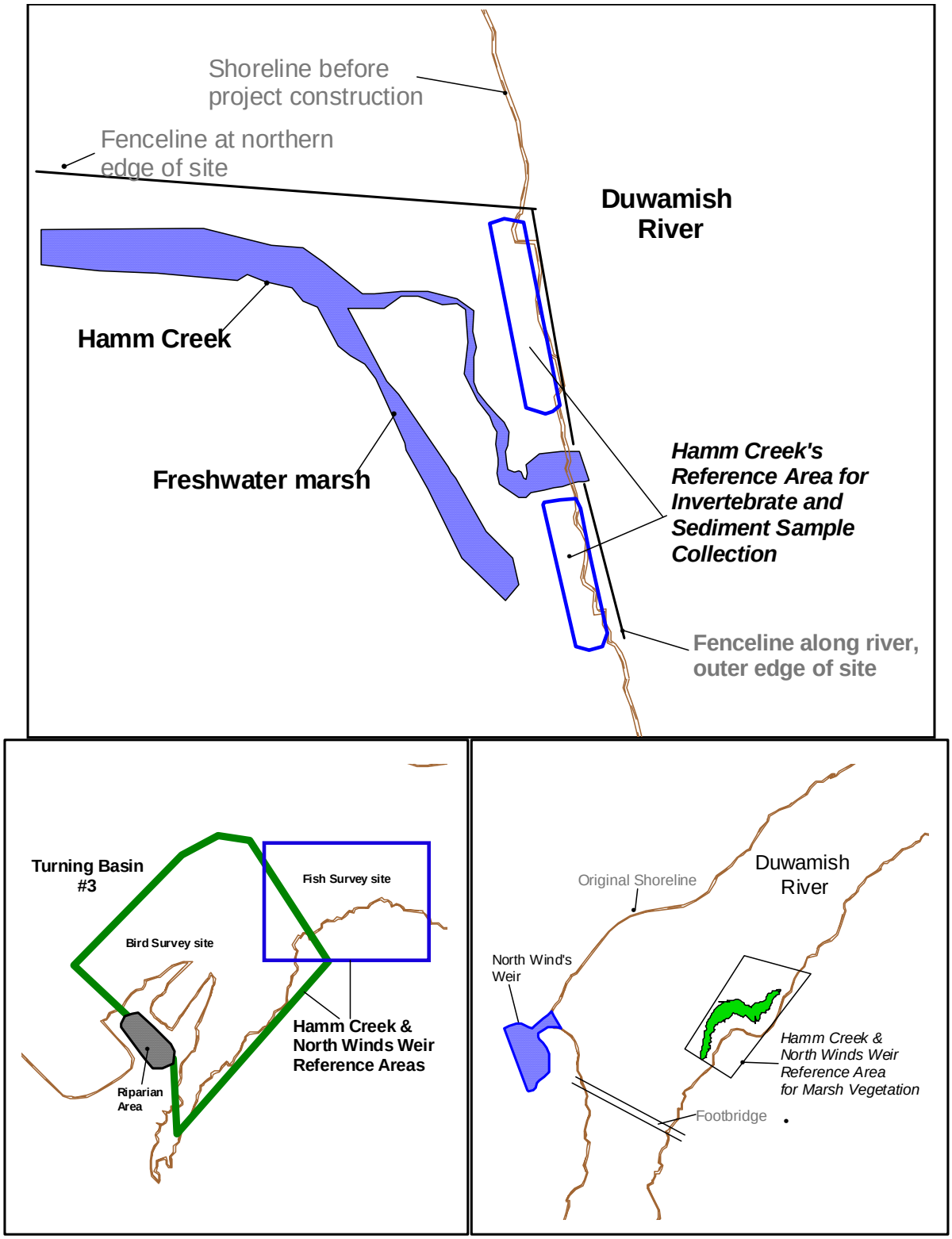


Figure 2. Location of reference sites for Hamm Creek Estuary and North Wind's Weir restoration sites in 2001, 2002, and 2003.

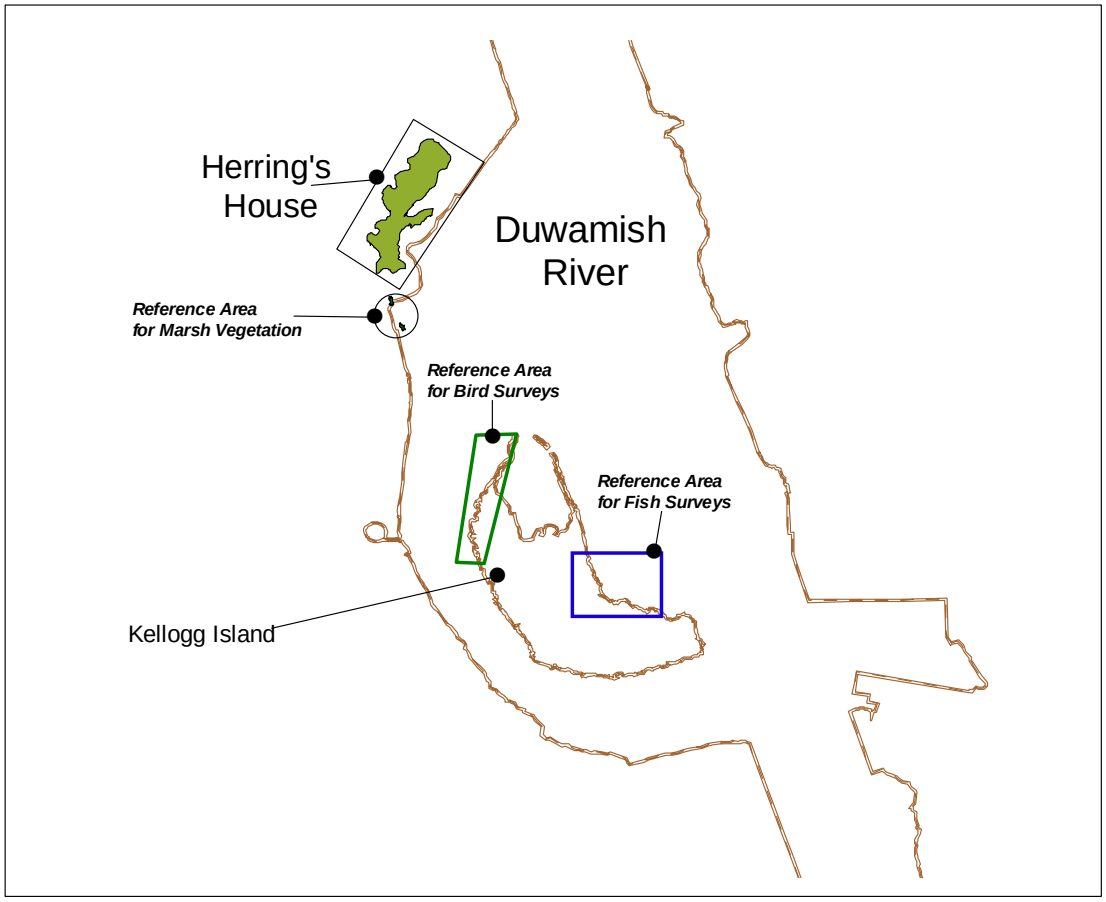


Figure 3. Location of reference sites for Herring's House restoration site in 2001, 2002, and 2003.

PHYSICAL CHARACTERISTICS

Intertidal Area (Physical Success Criterion 1). *Total restored area between an elevation of +12.0 ft Mean Low Low Water (MLLW) and -2.0 ft MLLW will be at least 90% of the target intertidal elevation for each site. Target intertidal area for the Hamm Creek Estuary is 4,047 m^2 (1.0 acre), Herring's House is 8,094 m^2 (2.0 acres), and North Wind's Weir is 4,047 m^2 (1.0 acre) (EBDRP 2000).*

Methods

As in 2002, the Hamm Creek Estuary, Herring's House, and North Wind's Weir sites were surveyed in fall and winter 2003 using a Nikon[1] Total Station and standard surveying techniques

[1]For informational purposes only. In all instances, use of brand names in this report does not constitute endorsement by the U.S. Government.

(Harrelson *et al*. 1994). The techniques included surveying enough points along the perimeter of the intertidal areas, at the 12 ft MLLW level, to characterize the shape of the area being measured. The survey at Hamm Creek Estuary included the intertidal area of the creek from a point approximately 5 meters (m) downstream of the confluence of Hamm Creek and the freshwater marsh to the fence forming the lower boundary of the site at the confluence of the Duwamish River. At Herring's House and North Wind's Weir, the survey areas included the basin and outlet channel to the Duwamish River. Field surveys included mapping the +12.0 ft MLLW contour and the lowest extent of each site; lower elevations did not reach -2.0 ft MLLW at any of the restoration sites. Points taken along the perimeter of the intertidal area were later connected using Nikon TransIt software, and the intertidal area between +12 ft MLLW and the lowest point at the site was calculated with this same software.

In 2001, the intertidal area at each restoration site was mapped using the Trimble GeoExplorer 3 Global Positioning System (GPS) ($\pm$1-5 m precision for each point with differential correction), by walking a continuous line along the perimeter of the intertidal area, outlined by flags placed at 12 ft MLLW based on tide. Due to the different survey techniques employed in 2001 versus 2002 and 2003, accuracy and precision of the intertidal area estimates are likely inconsistent from year to year. In order to minimize measurement error influence in determining if a change occurred in the intertidal area from 2001, Hamm Creek Estuary and Herring's House restoration sites were also mapped using GPS in winter 2002 and 2003. The data points were downloaded, differentially corrected, and stored in Geographical Information System (GIS)/ArcView software. The results from GPS were compared to the area values calculated by Total Station in 2002 and 2003.

Results

The intertidal area of the Hamm Creek Estuary restoration site, as measured with Total Station, in 2003 was 2,964 m^2 (0.7 acres), an estimated decline of 41 m^2 from 2002 (Table 2). The fence line at the lower boundary of the site was the lowest point and was approximately 7 ft (2.1 m) in elevation. The intertidal area measured with GPS in 2003 was 2,967 m^2. The GPS measurements for the intertidal area were 3,278 m^2 (0.8 acres) and 2,833 m^2 (0.7 acres) in 2002 and 2001 respectively.

The Herring's House restoration site intertidal area was 8,484 m^2 (2.1 acres) using Total Station, a decline of 99 m^2 from 2002 (Table 2). The survey included the intertidal basin and part of the estuarine channel that connects the basin to the Duwamish River. The lowest point surveyed at the site was 5.0 feet (1.52 m) in elevation, and was located within the intertidal basin, $\leq$16.40 feet (5 m) north of the channel's opening. With GPS the intertidal area of the site was 8,359 m^2 (2.1 acres) in 2003. This is less than the intertidal area of 8,737 m^2 in 2002 and 8,449 m^2 (2.1 acres) estimated using GPS in 2001.

The North Wind's Weir intertidal area was estimated to be 1,211 m^2 (0.3 acres) using the Total Station and 1,278 m^2 (0.3 acres) using GPS.

Table 2. Comparison of Total Station and GPS intertidal area measurements for three restoration sites on the Duwamish River Estuary.

Site	Total Station area (m^2)		GPS area (m^2)		
	2002	2003	2001	2002	2003
Hamm Creek Estuary	3,005	2,964	2,833	3,278	2,967
Herring's House	8,583	8,484	8,449	8,737	8,504
North Wind's Weir	-	1,211	-	-	1,278

Discussion

Based on Total Station measurements at the Hamm Creek restoration site, the difference in area between 2002 and 2003 was an estimated decline of 41 m^2. This difference is probably due to the error associated with having taken fewer points with which to construct the outline of the polygon in 2003 than in 2002, and not due to a substantial change in the site. The 2003 intertidal area of 0.7 acres does not meet the physical success criterion of 1.0 acres for the site. Total station intertidal area estimates at the Herring's House restoration site in 2002 and 2003 differed by 99 m^2. When converted to acres, both estimates exceed the success criterion of 2.0 acres for the site. The intertidal area (0.3 acres) estimated at North Wind's Weir does not meet the physical success criterion of 1 acre for the site.

Comparing the Total Station and GPS measurements for each restoration site by year, the intertidal area measured with the Total Station was less than the respective site's GPS intertidal area measurement. The observed differences between the Total Station and GPS estimates, ranging from 273 m^2 to 3 m^2, are small enough to be within the random error of the GPS measurements. Based on GPS measurements at Hamm Creek and Herring's House, there were decreases in intertidal area at both sites since 2002, but increases compared to values from 2001. These fluctuations may be due in part to random error, differences in survey techniques, equipment error, or to small changes in the sites as they equilibrate.

Tidal Regime (Physical Success Criterion 2). *Tidal amplitude, as determined by both timing and elevation of high and low tide events, is equivalent inside and outside of the project area (EBDRP 2000).*

Methods

The Hamm Creek and Herring's House restoration sites were not scheduled for tidal regime monitoring in 2003. This was the first sampling year for the North Wind's Weir restoration site and the site required tidal regime monitoring. A continuously-recording tide gage (Global Water Level Loggers) was installed at the North Wind's Weir restoration site to monitor tidal timing and magnitude (precision: 0.2% overall, 0.1% linearity). A tide gage was also placed in the Duwamish River, adjacent to the restoration site, to record tidal stage simultaneously for comparison. The tide gage recorded data for two complete tidal cycles, over a 24-hour period.

Tidal-stage data were collected on June 3-5 (average tide), September 10-11 (spring tide), and December 9-10, 2003 (spring tide).

Results

All data collected from North Wind's Weir indicate that tidal exchange between the restoration site and Duwamish Estuary continues to remain unimpeded. Data from the three sampling events were nearly identical. The graph of the September spring tide (Figure 4) illustrates the simultaneous changes inside and outside of the site.

Discussion

The timing and magnitude of the tidal cycles recorded thus far have been virtually the same. Adequate tidal exchange between the restoration site and the Duwamish River allows flushing of the site, which facilitates the movement of nutrients and sediments between the site and the main river channel. Increased colonization of the site by aquatic invertebrates and desirable marsh vegetation species may also occur more easily with sufficient tidal exchange, and salmonids and other fish can continue to access and utilize the restored estuarine habitat. The North Wind's Weir site is different than the Hamm Creek and Herring's House restoration sites because the water basin does not completely drain with low tide.

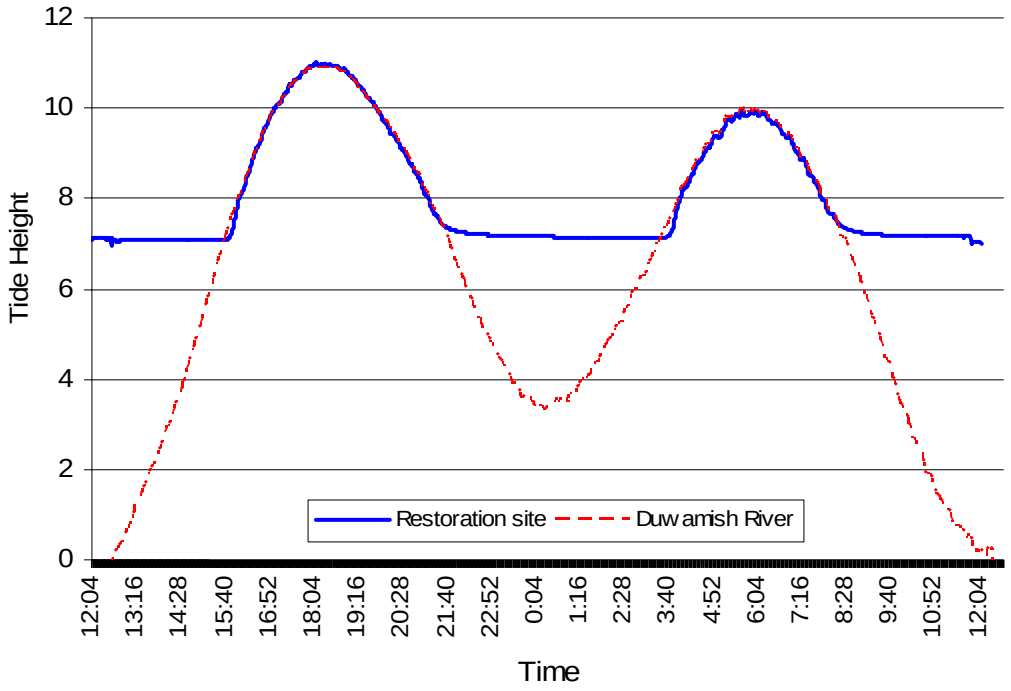


Figure 4. Tide regime at North Wind's Weir restoration site and the mainstem Duwamish River site on September 9-10, 2003.

Slope Erosion (Physical Success Criterion 3). *No evidence of erosion that threatens property, infrastructure, or is otherwise unacceptable, is observed after a period of initial site stabilization (EBDRP 2000).*

Methods

During site visits, visual inspections were made to determine any obvious bank erosion. Areas with noticeable erosion were identified and additional contour data was collected during Total Station surveys. These preliminary surveys were performed to serve as a basis for any future efforts to map loss of sediments in problem areas. Photographs of the sites were also taken periodically during the year to compare erosion over time. Photographs and Total Station surveys were also taken before and after the repair construction conducted by King County in late September 2003.

Results

The Hamm Creek Estuary restoration site had erosion occurring at the site in 2001- 2002, and further significant erosion of the instream channel occurred in 2003. Sediments at the Hamm Creek Estuary have continued to erode, most noticeably along the north bank of the creek near its confluence with the Duwamish River (Figures 5a & 5b). King County constructed interim erosion control measures in early spring of 2003 by securing coir logs (coconut fiber or other fiber filled mesh rolls) along the north bank (Figure 5c). In September 2003, King County strategically placed large boulders, cobble, and rootwads along the north bank to protect the eroding peninsula, which seems to have slowed the rate of erosion at the site (Figure 5d).

No obvious bank erosion is evident at the Herring's House and North Wind's Weir sites and they have remained stable since construction was completed.

Discussion

While Herring's House and North Wind's Weir appear to be stable, erosion continues to be a concern at the Hamm Creek Estuary. Most of the erosion appears to be occurring in the intertidal area on the northern side of the creek, downstream of where it begins to flow parallel to the mainstem Duwamish River. The most noticeable movement of sediments is located on the northern bank of the lower mouth of Hamm Creek, where subsurface wood and other materials have become exposed. Efforts to stabilize the area, including placement of cobble, boulders, and large woody debris, were made in 2001 by U.S. Army Corps of Engineers. These attempts to prevent further erosion did not correct the situation. By fall 2002, continued erosion of sediments had dislodged one of the fence posts along the northern shore of the mouth of Hamm Creek. Further erosion on the north bank in 2003 dislodged more of the goose exclusion barrier and washed out much of the lower peninsula where Hamm Creek turns perpendicular to the mainstem of Duwamish River. More bank repair work was constructed in September 2003, in which large boulders, cobble, and rootwads were strategically placed along the north bank to protect the eroding peninsula. Small changes in topography have taken place over the last few months as the site settles and stabilizes after construction. No large obvious erosion has occurred since the repair work was completed.

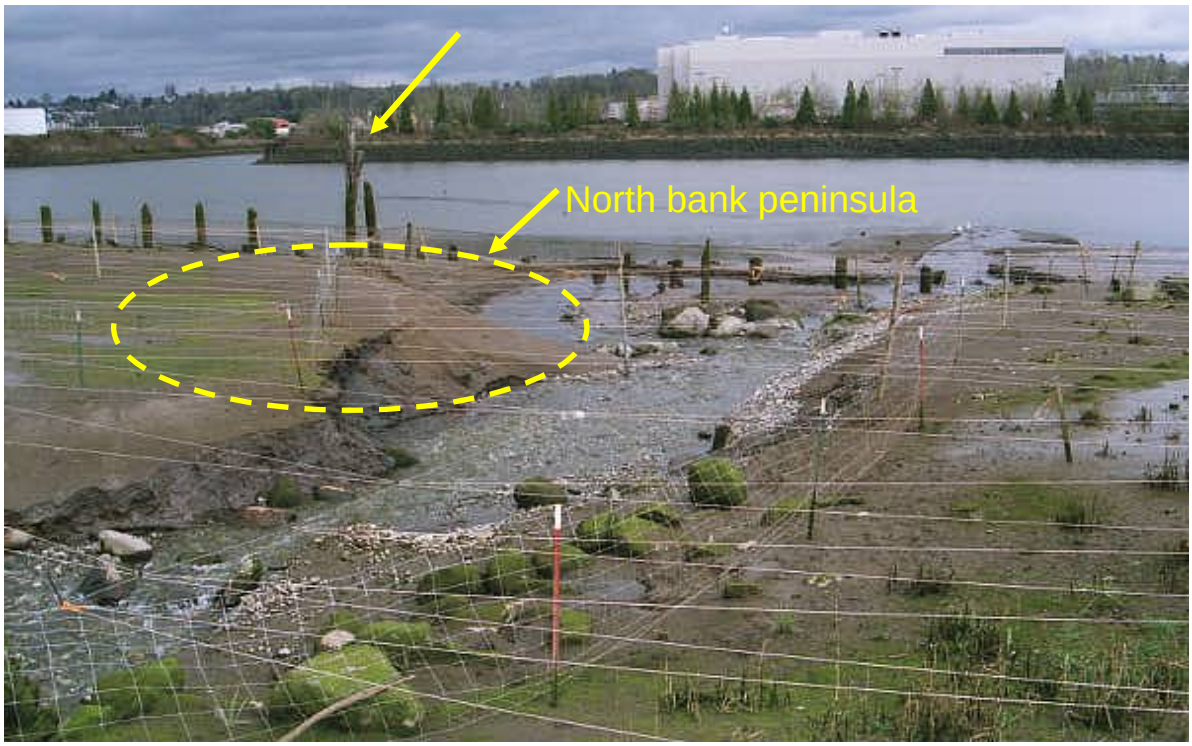


Figure 5a. Confluence of Hamm Creek and the Duwamish River in 2001.

Figure 5b. Confluence of Hamm Creek and the Duwamish River with effects of erosion in 2003.

Figure 5c. Interim erosion repair work at Hamm Creek restoration site, spring 2003.

Figure 5d. Bank erosion repair work at Hamm Creek restoration site in September 2003.

Sediment Structure (Physical Success Criterion 4). *Over time, sites will accumulate fine-grained material and organic matter. This would be evidenced by a decrease in mean grain size, and an increase in organic carbon in surface sediments (EBDRP 2000).*

Methods

Sediment structure was monitored by collecting sediment core samples and analyzing these for grain-size composition and total organic carbon (TOC). Sediment core samples were taken using a 3-inch diameter PVC plastic pipe, driven with a rubber mallet to a depth of 10 cm. Ten cores, increased from six cores in previous years, were collected in the intertidal area of each site in 2003. Because of the importance of grain size and organic content to benthic invertebrate colonization (Cordell *et al*. 1999), the sample locations corresponded to the same habitat strata as invertebrate core sampling (Biological Success Criterion 8). Ten sediment samples were collected at the Hamm Creek Estuary in the lower intertidal zone on September 19, 2003. These samples were collected earlier than in previous years due to erosion repair work scheduled for the following week. As with the invertebrate surveys, samples were not stratified by vegetation and elevation at this site, due to the influence of the freshwater creek present in the lower intertidal zone.

Herring's House and North Wind's Weir restoration and reference sites were sampled on October 7, 2003, to correspond with the time schedule of the previous years. Core sampling was stratified by vegetated (5 samples/ site, +10 ft MLLW and above) and unvegetated (5 samples/site, +9 ft MLLW and below) areas, corresponding to habitat strata of invertebrate core sampling. Sample areas without vegetation in the +9 ft MLLW zone were difficult to find at the Herring's House restoration site due to the presence of brass buttons (*Cotula coronopifolias*), a nonnative plant species that colonized much of the lower intertidal basin at Herring's House.

Sediment sample analyses were performed by a contracted laboratory. Results were evaluated to determine whether grain size and organic matter increased or decreased at each site from previous years. A decrease in grain size is indicated by decreasing percentages of sand and increasing percentages of silt and clay (both were considered fine grained sediments). An increase in organic matter is indicated by increasing TOC percentages.

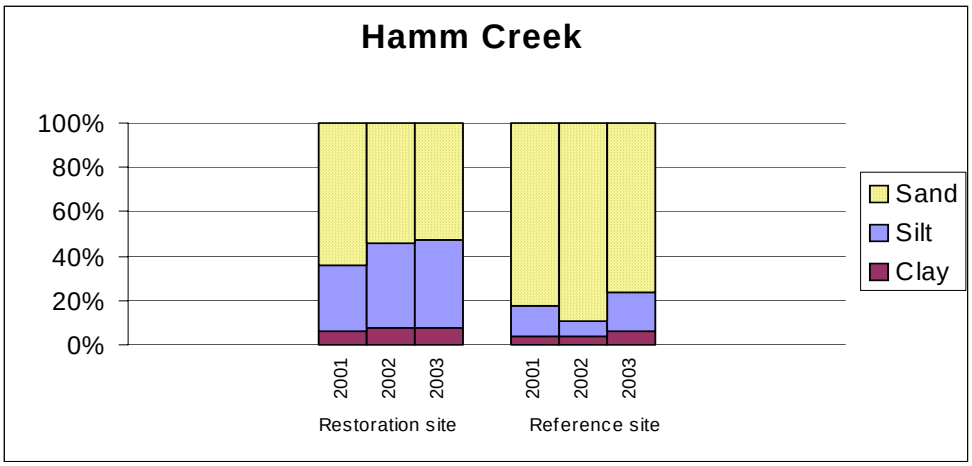
Results

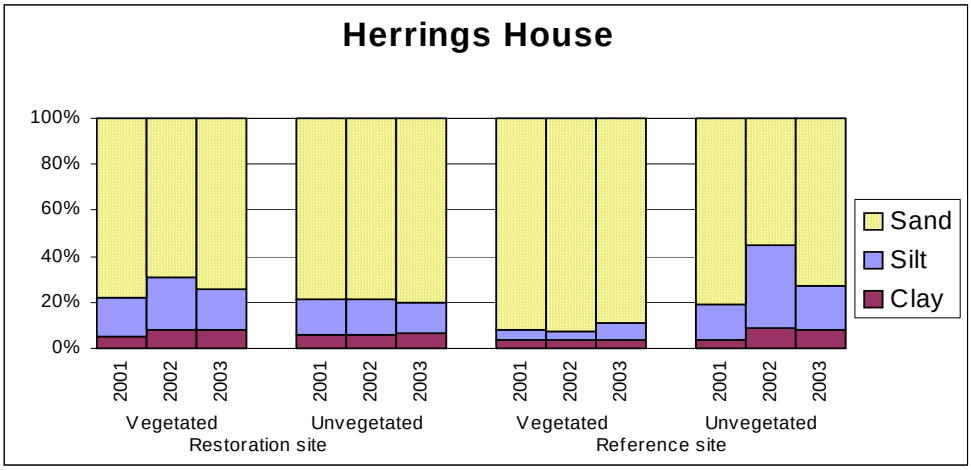
Grain size remained virtually unchanged from 2002 to 2003 at the Hamm Creek Estuary restoration site, and decreased at the reference site (Figure 6). Mean percent TOC values increased slightly at both the restoration and reference sites in 2003 (Table 3). From 2001 to 2003, mean percent TOC values were similar between the restoration and reference sites.

In 2003, grain size increased slightly in the vegetated and unvegetated areas of the Herring's House restoration site. At the reference site, grain size decreased slightly in the vegetated areas, but increased in the unvegetated areas. At the Herring's House restoration site, mean percent TOC values for the vegetated areas decreased slightly, but increased in the unvegetated areas. At the reference site, mean percent TOC increased substantially in both the vegetated and unvegetated areas. Over the 3-year period, 2001 to 2003, TOC values in the vegetated areas varied from year to year but remained greater at the Herring's House restoration site than at the reference site. TOC values in the unvegetated areas at the Herring's House restoration and reference sites also varied, and in 2003, mean TOC became greater at the reference site than the restoration site.

Table 3. Mean percent total organic carbon (TOC) for Hamm Creek Estuary, Herring's House and North Wind's Weir restoration sites and corresponding reference sites, in 2001, 2002, and 2003.

Site	TOC (%) 2001	2002	2003
Hamm Creek	0.9	0.7	1.0
Hamm Creek Reference	0.8	0.6	1.1
Herring's House			
Vegetated	5.9	6.7	5.4
Unvegetated	4.1	1.7	3.0
Herring's House Reference			
Vegetated	2.5	0.9	3.6
Unvegetated	2.3	1.3	3.3
North Wind's Weir			
Vegetated	-	-	1.4
Unvegetated	-	-	1.7
North Wind's Weir Reference			
Vegetated	-	-	4.9
Unvegetated	-	-	1.4





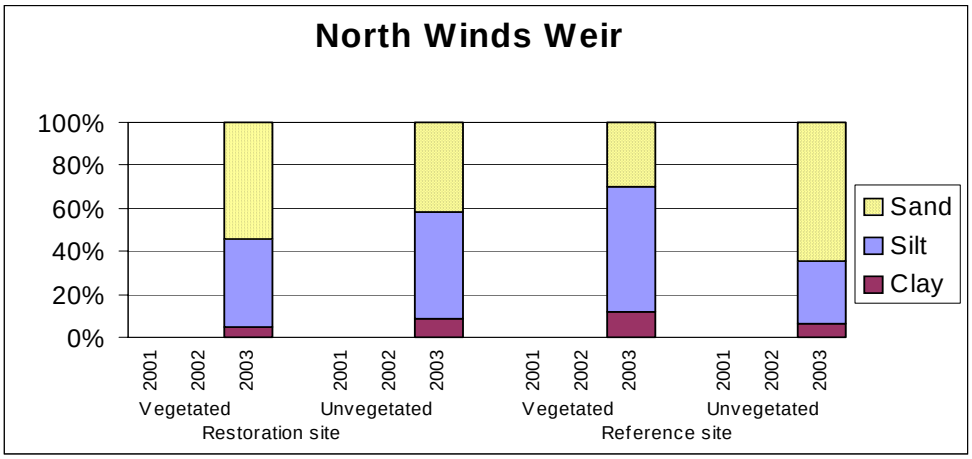


Figure 6. Mean percent composition by grain size for Hamm Creek Estuary, Herring's House, and North Wind's Weir restoration sites and corresponding reference sites, in 2001, 2002, and 2003.

The first year that North Wind's Weir restoration and reference sites were sampled was in 2003. Grain size and mean percent TOC values in the vegetated and unvegetated areas of the restoration site were similar. At the reference site, grain size in the vegetated areas were substantially less and mean percent TOC values were substantially greater than in the unvegetated areas. Detailed results from analysis of TOC and sediment grain size distribution are included in Appendix 1.

Discussion

According to this criterion, successful restoration is demonstrated by an accumulation of fine-grained material and organic matter, indicated by decreasing grain size and increasing total organic carbon, respectively. Estuarine habitats with fine-grained sediments and organic matter support the formation of a detritus-based food web necessary for benthic invertebrates, fish, and wildlife of special interest to this project (EBDRP 2000). In part, grain size influences the assemblage of benthic invertebrates, and organic matter influences the quality and quantity of food available for invertebrates (Cordell *et al*. 1999).

The Hamm Creek Estuary restoration site did not experience a substantial change in grain size from 2002 to 2003, and only a slight increase in TOC. At the reference site over the last year, 2002 to 2003, grain size decreased and TOC increased slightly. The 3-year trend for the restoration site showed a decline in grain size between the first 2 years of sampling and then leveled off from Year 2 to Year 3. This trend showed the expected results following sediment disturbance from restoration construction. The trend for mean percent TOC at a restoration site is expected to increase over time. Because of a decrease in 2002, the mean percent TOC values did not seem to follow the expected trend. Determining if this drop was statistically significant is hampered due to small sample sizes. At the Hamm Creek reference site, the grain size increased in Year 2 and decreased in Year 3, but TOC values dropped in Year 2 and increased in Year 3. Grain size increase and TOC decrease at the reference site may have been due to heavy erosion at the restoration site in 2002 (three of the six sediment samples were collected downstream of the mouth of Hamm Creek). Erosion in 2003 was minimal in comparison to 2002 because of the erosion control measures undertaken in early spring of 2003. These changes in grain size and TOC values cannot be viewed as statistically significant due to the small sample size and variability among the samples.

Sediment data collected during a March 1995 pre-restoration study near Herring's House had a TOC value of 2.79% (U.S. Army Corps of Engineers 1995). According to the report, this value was sufficient to support benthic organisms. Although the values at the Hamm Creek Estuary restoration and reference sites are below 2.79%, benthic invertebrates are present at the sites. To date, we have not located any further information on favorable TOC levels for benthic organism establishment or its effects on food availability in the Duwamish River. Trends and changes will continue to be monitored within the limits of the survey protocol.

Sediment structure analysis at the Herring's House restoration site indicated a slight increase in mean grain size in the vegetated and unvegetated areas from 2002. In the reference area, grain size decreased slightly from the previous year's surveys in the vegetated areas, but increased in the unvegetated areas. The 3-year trend for TOC at the restoration and reference sites is highly variable year to year, but is sufficient to support benthic organisms. Most of the mean TOC values at Herring's House restoration site were greater than or similar to the results of the March 1995 study mentioned above (U.S. Army Corps of Engineers 1995). Although the results from

the sediment structure analysis provide some indication of the degree of accumulation of fine-grained material and organic matter at the site, the sample size is small (5 samples/site), and may not adequately characterize the site. This potential limitation is illustrated by the variability of the grain size and TOC samples within a stratum at each site (see Appendix 1). Another factor at the Herring's House restoration site which may cause some difficulty in site characterization in the future is the presence of a nonnative plant, brass buttons, which has begun to colonize most of the mudflat area at the site, making it difficult to randomly select sample collection locations in unvegetated mudflat areas.

Since this was the first year of sampling at the North Wind's Weir restoration site, yearly comparisons could not be made. This year's data will be used as the baseline for future monitoring. Grain size and TOC values follow the anticipated values when comparing a newly disturbed restoration site to an undisturbed reference site. At the restoration site, small differences in grain size and TOC values are expected in vegetated versus unvegetated strata, and large differences expected between vegetated and unvegetated strata at the reference site.

Sediment Quality (Physical Success Criterion 5*). No evidence of contamination due to sediment transport or on-site migration of upland contaminants to groundwater or aquatic areas.* (Herring's House only) *(EBDRP 2000).*

Methods

Visual inspections were made at the Herring's House restoration site during most field surveys to assess if riprap and/or soils remained stable as compared to the as-built surveys. Photo points were used to compare any yearly changes.

Results

No noticeable migration of riprap or soils occurred at the Herring's House site.

The Washington State Department of Ecology has issued a voluntary cleanup order for this site, requiring installation of three groundwater monitoring wells for compliance with the order. As of December 2003, groundwater monitoring wells have not been installed at the Herring's House restoration site.

Discussion

Soils and riprap at the Herring's House restoration site appear to have remained stable this year, when compared to the as-built map for the site. No movement of sediments has been observed. Following discussions with cooperators this year, the EB/DRP Panel decided not to install monitoring wells at the Herring's House site.

BIOLOGICAL CHARACTERISTICS

Marsh Vegetation Establishment (Biological Success Criteria 1-3). *The areal extent of vegetation should be stable or increasing (Criterion 1), species composition of native wetland plants should be comparable to appropriate reference sites (Criterion 2) and plant vigor should be comparable to appropriate reference sites (Criterion 3) (EBDRP 2000).*

Methods

Total Areal Extent

Marsh vegetation was surveyed at the Hamm Creek Estuary, Herring's House, and North Wind's Weir restoration and reference sites in summer 2003. The extent of marsh vegetation was mapped using GPS, and an area estimate was calculated for each site using GIS/ArcView software. The GPS method consisted of walking a line along the marsh vegetation boundary, continuously recording positions to form the perimeter of a polygon, then calculating the resulting area ($\leq$3 m per position with differential correction), using GIS/ArcView software.

Marsh Vegetation Patches

Individual marsh vegetation patches (Lyngby's sedge and bulrush) were measured to the nearest 0.1 m using a measuring tape, and total area of the patches were calculated for each site. This method differed from 2001, in which GPS was used to estimate the area of individual marsh vegetation patches. Because the areas of some of the vegetation patches were too small to be effectively measured with the resolution of the GPS equipment, the direct measurement was deemed to be a better method for this parameter. The difference in sampling methodology does not allow for a direct comparison of marsh vegetation areas from 2001 to areas estimated for 2002 and 2003, but overall trends may be detectable.

Species Composition

Vegetation surveys for species composition occurred along previously established transects at the Hamm Creek Estuary and Herring's House restoration and references sites and at two new transects established at the North Wind's Weir restoration site (Figures 7a and 7b). Species composition was determined by identifying and estimating the percent coverages of all plant species within a 0.25 m^2 quadrat placed at several points along each transect. Each quadrat was placed in the same approximate location ($\leq$1 m) as in previous years. This repetition of placement from 2001 was important, particularly in transects 1 and 3 at the Hamm Creek Estuary restoration site, due to the presence of relatively large expanses of bare mudflat with small, scattered patches of vegetation. Plots in the same locations as the previous year would better characterize vegetation growth from year to year, due to the large amount of bare ground present along much of the shoreline in this area[1].

Plant Vigor

Shoot height and density of the target species, Lyngby's sedge and bulrush, were measured within the quadrats (0.25 m^2) to estimate the plant vigor criteria. The heights of the three tallest shoots of each species were measured to the nearest centimeter (cm). Differences in mean maximum shoot height between the restoration sites and their respective reference sites were determined using a t-test (Zar 1999). Shoot density was determined by counting the number of shoots for each species. Differences between restoration sites and their respective reference sites were examined by using a Mann-Whitney U test (Zar 1999) for comparing two means with non-normal distribution.

[1]In 2001, plots were randomly placed along transects, and quadrats were located on both bare ground and in vegetated areas.

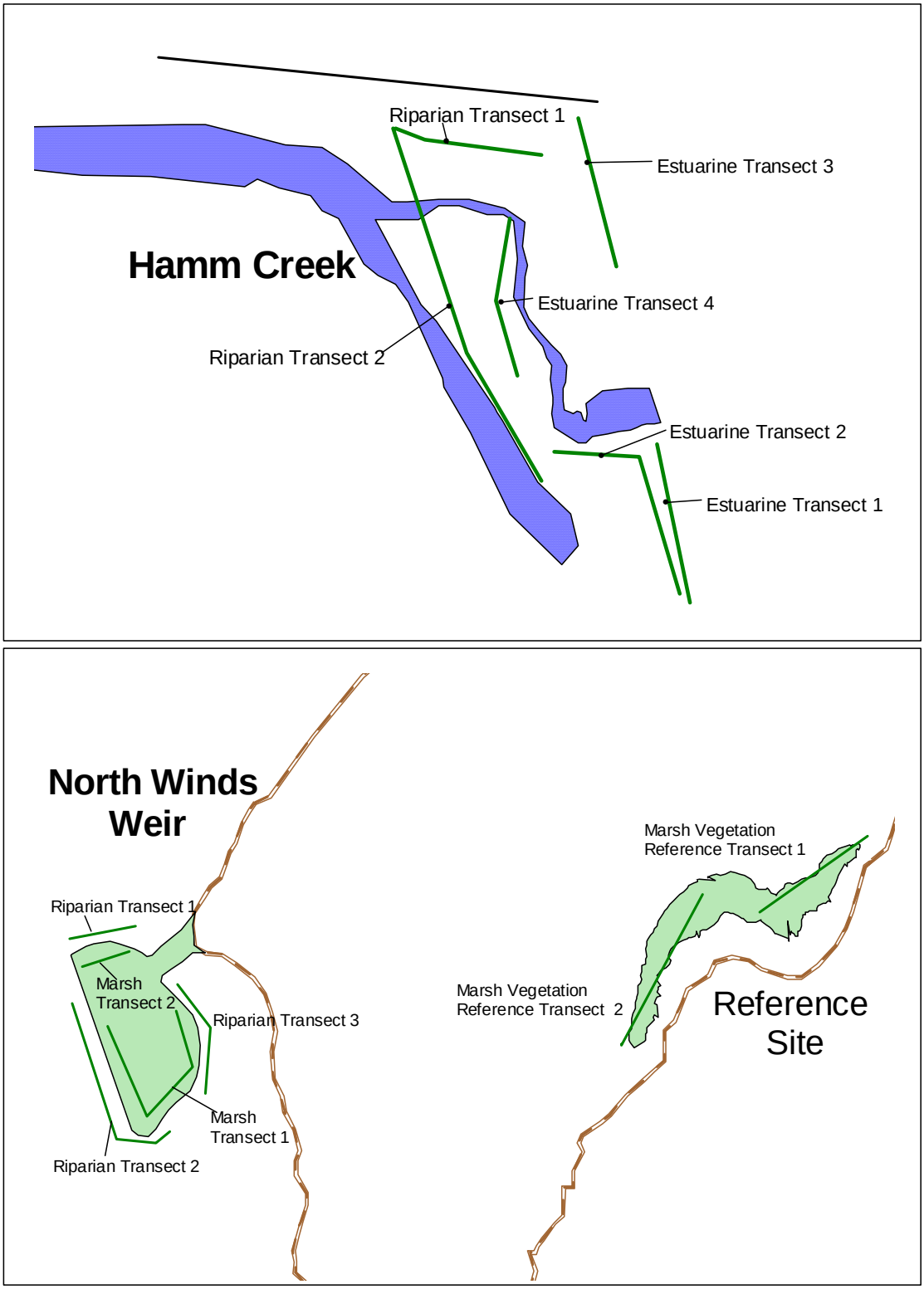


Figure 7a. Placement of vegetation transects at the Hamm Creek Estuary (top) and North Wind's Weir restoration and reference (bottom) sites.

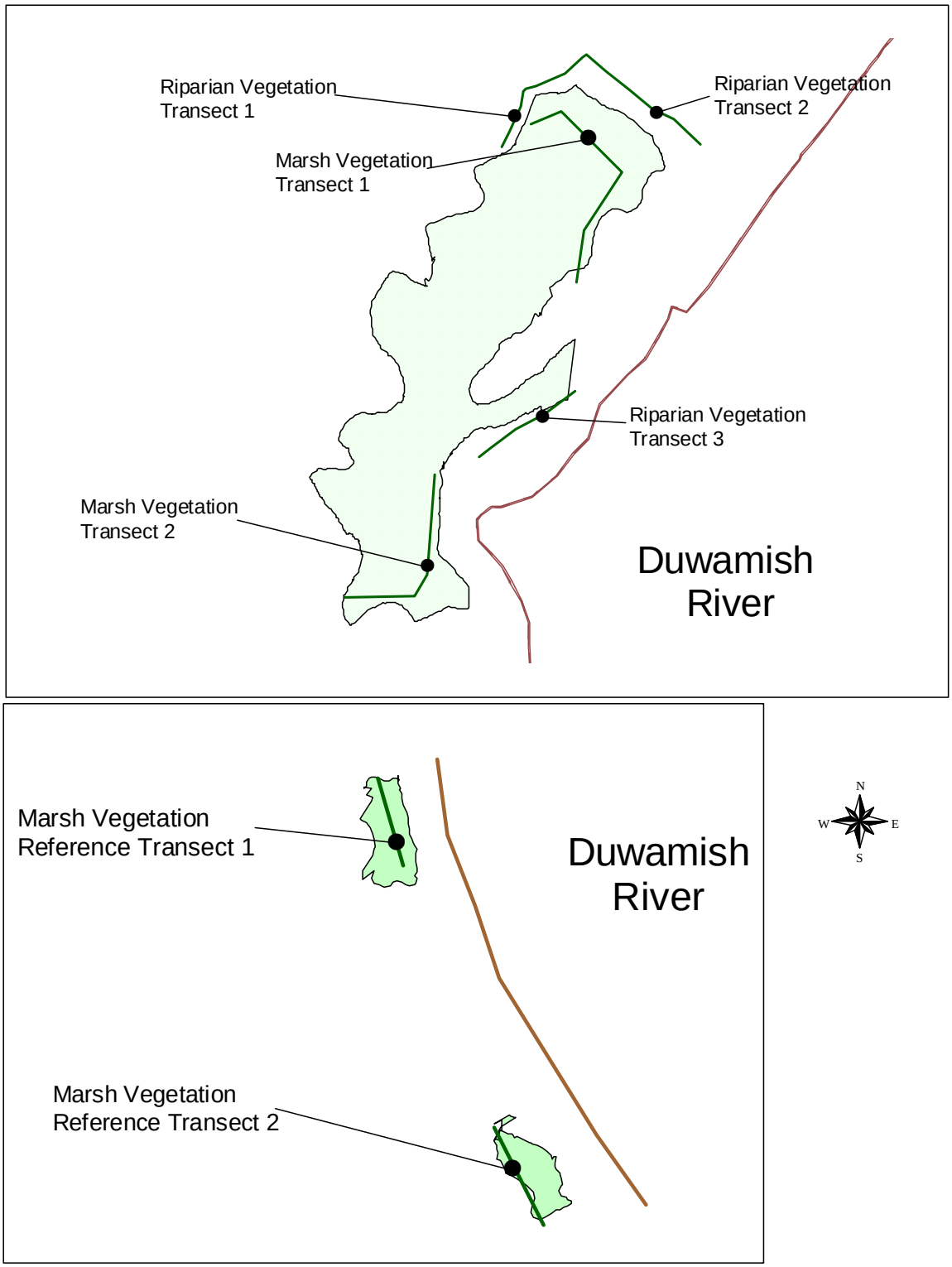


Figure 7b. Placement of vegetation transects at the Herring's House restoration (top) and reference (bottom) sites in 2001, 2002, and 2003.

Results

Total Areal Extent

The total areal extent of marsh vegetation (using the GPS) for the Hamm Creek Estuary restoration site in 2003 was 1,683 m^2 (0.4 acres). For the Herring's House restoration site, the total areal extent of marsh vegetation was 8,504 m^2 (2.1 acres), and for North Wind's Weir the areal extent was 364 m^2 (0.09 acres). Marsh vegetation areal extent data from 2002 is available for the Hamm Creek Estuary and Herring's House restoration sites, but only patches of Lyngby's sedge and bulrush were mapped with GPS in 2001.

Marsh Vegetation Patches

The total area of marsh vegetation patches (Lyngby's sedge and bulrush) at the Hamm Creek Estuary restoration site in 2003 was 1,014 m^2. At the reference site, the area of marsh vegetation patches was 535 m^2. The respective vegetation areas at each site in 2003 are less than the areas measured in 2002 (1,051 m^2 restoration site; 622 m^2 reference site). At the Herring's House site, total area of marsh vegetation patches (Lyngby's sedge and bulrush) was 395 m^2 in 2003. The total area of marsh vegetation patches at the reference site was 109 m^2 in 2003. Marsh vegetation areas in 2002 were 279 m^2 at the restoration site, and 65.3 m^2 at the reference site. In 2003 the total area of marsh vegetation patches (Lyngby's sedge and bulrush) at the North Wind's Weir restoration site was 182 m^2. The reference site is the same site as the Hamm Creek reference site.

Species Composition

The number and percent cover of understory vegetation species at the Hamm Creek Estuary restoration site was greater than at the reference site in 2003 (Table 4). The estimated percent cover at the Hamm Creek Estuary restoration site was smaller than at the Hamm Creek Estuary (and North Wind's Weir) reference site (Table 4).

The number of understory vegetation species and the estimated percent cover of understory species at the North Wind's Weir restoration site were similar to the values for the North Wind's Weir (and Hamm Creek) reference site. The estimated percent cover of target species, at the North Wind's Weir restoration site, was much less than at the reference site.

Although the number of understory species increased at the Herring's House restoration site, the estimated percent cover of understory species at the Herring's House restoration site decreased from 2002 to 2003. At the reference site, the number of understory species and the percent cover decreased. For the target species, the estimated percent cover decreased at the restoration and the reference site.

Table 4. Estimated mean percent cover of target species, Lyngby's sedge (*Carex lyngbyei*) and bulrush (*Scirpus* spp.), and the understory vegetation species present in marsh transects at Hamm Creek Estuary (HC), North Wind's Weir (NWW), and Herring's House (HH) restoration and reference sites.

Site	Number of understory species			Estimated % cover of marsh vegetation[1]					
				Understory species			Target species		
	2001	2002	2003	2001	2002	2003	2001	2002	2003
HC Restoration	20	19	18	47	51	41	17	28	21
HC & NWW Reference	5	7	5	26	16	3	78	82	70
NWW Restoration	-	-	3	-	-	2	-	-	6
HH Restoration	6	4	8	35	80	75	7	7	5
HH Reference	6	10	7	52	55	32	31	19	7

[1]Each site's percent cover was estimated by averaging the percent cover values in each plot surveyed at the Site. Understory and target vegetation species' percent cover were estimated separately.

Plant Vigor

Hamm Creek Estuary (shoot height and density): Mean shoot height of the target species was significantly greater at the Hamm Creek Estuary reference site ($t = -5.0$, $df = 70$, $P < 0.05$, Lyngby's sedge; $t = -6.5$, $df = 16$, $P < 0.05$, bulrush) than at the restoration site in 2003 (Table 5). Mean shoot height of Lyngby's sedge differed from 2002 to 2003 at the restoration site (decrease of 5 cm) and reference site (decrease of 15 cm). Mean shoot height of bulrush increased at the restoration site (by 16 cm) but decreased at the reference site (by 11 cm).
In 2003, mean shoot densities of Lyngby's sedge were significantly greater ($U = 188$, $CV = 188$, $P = 0.05$) at the Hamm Creek Estuary reference site than at the restoration site (Table 6). Mean shoot densities increased from 2002 to 2003 in both the restoration and reference site sample plots. Mean shoot densities of bulrush at the restoration and reference sites were similar in 2003 and were similar to those at the respective sites in 2002 surveys.

North Wind's Weir (shoot height and density): Mean shoot height of Lyngby's sedge was significantly greater ($t = -8.3$, $df = 55$, $P < 0.05$) at the North Wind's Weir (and Hamm Creek) reference site than at the restoration site in 2003 (Table 5). The mean shoot height of bulrush could not be calculated due to the absence of the bulrush in transect plots.

The mean shoot densities of Lyngby's sedge was significantly greater ($U = 161$, $CV = 136$, $P = 0.05$) at the North Wind's Weir (and Hamm Creek) reference site than at the restoration site in 2003 (Table 6). The mean shoot density comparison for bulrush between the North Wind's Weir restoration and reference sites was not statistically significant even though bulrush was not present in any sample plots at the restoration sites (Table 6).

Herring's House (shoot height and density): In 2003, mean shoot height of Lyngby's sedge could not be calculated at the Herring's House restoration site, due to the absence of the species in transect plots. The mean shoot height of bulrush was significantly greater ($t = -18.2$, $df = 15$, $P < 0.05$) at the Herring's House reference site than at the restoration site in 2003 (Table 5).

Mean shoot height at the restoration site did not change from 2002 to 2003 but decreased at the reference site from 153 cm (2002) to 142 cm (2003).

The mean shoot density comparison for Lyngby's sedge between the Herring's House restoration and reference sites was not statistically significant even though Lyngby's sedge was not present in any sample plots at the restoration sites (Table 6). Although mean shoot density comparison for Lyngby's sedge could not be made between years at the restoration site, the mean density at the reference site was less in 2003 than in 2002 (Table 6). Mean shoot densities of bulrush were similar (U=103.5, CV=145, $P<0.05$) at the restoration and reference sites in 2003. At the restoration and reference site, mean shoot density of bulrush was similar between 2002 and 2003.

Table 5. Comparison of mean shoot heights of target marsh vegetation species, Lyngby's sedge (*Carex lyngbyei*) and bulrush (*Scirpus* spp.), during vegetation sampling at Hamm Creek Estuary, North Wind's Weir, and Herring's House restoration and reference sites, in 2001, 2002, and 2003. An asterisk indicates a statistically significant difference (Mann-Whitney test, P<0.05).

			Shoot height				
	Year	**Site**	**Mean (cm)**	**Min (cm)**	**Max (cm)**	**Std. dev.**	**n (shoots)**
Lyngby's sedge							
Hamm Creek Estuary	2001	Restoration	96	45	177	38	18
		Reference	129*	48	190	40	30
	2002	Restoration	90	26	169	40	39
		Reference	143*	85	205	37	30
	2003	Restoration	85	12	155	35	43
		Reference	128*	65	194	36	29
North Wind's Weir	2003	Restoration	57*	12	119	28	28
		Reference	Same reference site as Hamm Creek reference (see above)				
Herring's House	2001	Restoration	26	5	50	13	29
		Reference	76*	65	90	8	12
	2002	Restoration	No analysis performed (*Carex* absent from plots)				
		Reference	87	45	104	17	12
	2003	Restoration	No analysis performed (*Carex* absent from plots)				
		Reference	72	64	80	9	4
Bulrush							
Hamm Creek Estuary	2001	Restoration	72	20	118	30	18
		Reference	148*	56	200	47	8
	2002	Restoration	64	49	87	10	11
		Reference	185*	152	215	27	6
	2003	Restoration	80	28	118	27	9
		Reference	164*	132	200	27	9
North Wind's Weir	2003	Restoration	No analysis performed (*Scirpus* absent from plots)				
		Reference	Same reference site as Hamm Creek reference (see above)				
Herring's House	2001	Restoration	61	55	65	6	3
		Reference	143*	70	215	50	14
	2002	Restoration	48	20	113	24	27
		Reference	153*	111	193	28	15
	2003	Restoration	48	17	66	10	25
		Reference	142*	117	169	16	12

Table 6. Mean shoot densities of Lyngby's sedge (*Carex lyngbyei*) and bulrush (*Scirpus* spp.) and statistical analyses for Hamm Creek Estuary, Herring's House, and North Wind's Weir restoration and reference sites during marsh vegetation sampling, in 2001, 2002, and 2003. An asterisk indicates a statistically significant difference (Mann-Whitney test, P<0.05).

			n		Shoot Density		
	Year	**Site**	**Shoots**	**Plots**	**Mean**	**Min**	**Max**
Lyngby's sedge							
Hamm Creek Estuary	2001	Restoration	130	24	5	0	39
		Reference	155	11	14*	0	30
	2002	Restoration	218	24	9	0	57
		Reference	251	11	23*	0	42
	2003	Restoration	267	24	11	0	51
		Reference	281	11	26*	0	56
North Wind's Weir	2003	Restoration	38	17	2*	0	7
		Reference	Same reference site as Hamm Creek reference (see above)				
Herring's House	2001	Restoration	70	20	4	0	19
		Reference	57	10	6	0	17
	2002	Restoration	0	20	0	0	0
		Reference	61	10	6*	0	51
	2003	Restoration	0	20	0	0	0
		Reference	12	10	1	0	11
Bulrush							
Hamm Creek Estuary	2001	Restoration	28	24	1	0	10
		Reference	23	11	2	0	18
	2002	Restoration	29	24	1	0	11
		Reference	27	11	2	0	15
	2003	Restoration	51	24	2	0	30
		Reference	39	11	5	0	19
North Wind's Weir	2003	Restoration	0	17	0	0	0
		Reference	Same reference site as Hamm Creek reference (see above)				
Herring's House	2001	Restoration	7	20	0.4	0	7
		Reference	56	10	6*	0	17
	2002	Restoration	70	20	4	0	25
		Reference	46	10	5	0	12
	2003	Restoration	52	20	3	0	22
		Reference	52	10	5	0	20

[1]Number of shoots/0.25m^2

Discussion

Total Areal Extent

The areal extent of marsh vegetation at Hamm Creek Estuary and Herring's House restoration sites often extend into the riparian zone. At North Wind's Weir the marsh vegetation is still distinctly separate from the riparian zone and has some riparian species that were planted below the 12 ft MLLW elevation.

The Biological Success Criterion 1 (areal extent of marsh vegetation) is not yet met at the Hamm Creek Estuary restoration site. From 2002 to 2003, the areal extent of marsh vegetation at the Hamm Creek Estuary restoration site decreased by 528 m^2. Some of this decline is from the loss of soils due to the erosion along the north bank of Hamm Creek, just upstream of where the creek enters the Duwamish River. A 180 m^2, previously vegetated area along the north bank had changed to bare ground by August of 2003.

The areal extent of marsh vegetation at the North Wind's Weir site was measured at the outermost line surrounding the marsh vegetation plantings, but the Lyngby's sedge itself was very sparse, having been recently planted in the spring of 2003. This year's baseline data will be used in the future to gauge the success of the areal extent criterion (Biological Success Criterion 1) at North Wind's Weir.

The entire intertidal basin of the Herring's House restoration site was included in the marsh vegetation areal extent estimate due to the presence of a low-growing cover of scattered vegetation, primarily a nonnative colonizing species (brass buttons). The value for the areal extent of marsh vegetation is overestimated, due to the absence of brass buttons in the channel and in small patches of mudflat which were too small to measure using GPS (because of the resolution of the equipment). The areal extent of marsh vegetation at the Herring's House site was smaller in 2002 than in 2003 by 283 m^2. It is difficult to determine if the decline is significant or within the error of the estimate. It is not yet possible to determine if the Biological Success Criterion 1 has been met.

Marsh Vegetation Patches

From 2002-2003 at the Hamm Creek Estuary restoration and reference sites, the total area of marsh vegetation decreased. The decrease of marsh plant species at the restoration site may be due to the erosion of soils at the site. At the reference site the decline in area covered by target species was 37 m^2 from 2002 to 2003. The cause of the decline is unknown, but the possibility of over-grazing by Canada geese or other herbivores cannot be eliminated.

Marsh vegetation patches at North Wind's Weir were only in their first year of growth since planting. This year's data will be the baseline for future measurements of vegetation patches at the site.

The Herring's House restoration and reference sites showed an increase in the total area of marsh vegetation patches from 2002 to 2003. The patches of Lyngby's sedge and bulrush are increasing in size even though the goose exclusion fencing was removed at the restoration site and a new goose exclusion fence installed at the reference site. The goose exclusion fence encloses one patch of the naturally remaining vegetation and the new plantings of sedge and bulrush at the reference site. Future use of the site as a reference site will need to be considered.

Species Composition
The restoration site has not yet reached comparable levels of species composition as stated in the goal of Biological Success Criterion 2 for species composition. From 2001 to 2003, the number of understory species decreased by two species overall at the Hamm Creek Estuary restoration site. At the reference site, the number of species decreased by two species from 2002 to 2003, returning to the same number of species counted in 2001. At the Hamm Creek Estuary restoration and reference sites, the percent of understory species decreased by 6% and 23%, respectively, from 2001 to 2003. Percent cover of target species at the Hamm Creek Estuary restoration site increased by 4% from 2001 to 2003, but decreased by 8% at the reference site. With only 1 year of data for the North Wind's Weir restoration site, yearly comparisons were not possible. Comparisons to the reference site show the number and percent cover of understory species to be similar, but as expected, the percent cover of targets species was substantially lower (64%) at the restoration site.

The percent cover of target species decreased at the restoration and reference sites from 2001 to 2003. This decline may reverse itself in the future since many of the vegetation transect plots contained large percentages (ranging from 35%-95%) of dead, target species plants. Visual observations of large driftwood logs in the area suggest that the plants died due to flattening by the logs during low tides. At the Herring's House restoration site in 2003, the number of understory species and the percent cover of target species was similar to the reference site, but the percent cover of understory species differed by 43%. The species composition at Herring's House restoration site appears to be moving closer to meeting Biological Success Criterion 2.

Plant Vigor
Plant vigor, as defined by shoot height and density of the target species (Lyngby's sedge and bulrush), was generally better at the reference sites than at their respective restoration sites. At the Hamm Creek Estuary restoration site, mean shoot height of Lyngby's sedge continued to decline from 2001 counts, but mean shoot height of bulrush increased by 8 cm over mean heights recorded in 2001. At the corresponding reference site, the mean shoot heights for both target species peaked in 2002 then fell back in 2003 to values similar to 2001 values. The mean shoot density of both target species increased, but the increases were only 6 shoots/0.25m^2 for Lyngby's sedge and 1 shoot/0.25m^2 for bulrush. Overall, the mean shoot height and mean shoot density of target species are less at the restoration site than at the reference site.

This was the first year of data sampling for the North Wind's Weir restoration site so yearly comparisons were not possible. As would be expected for the first year, comparisons to the reference site show the mean shoot height and mean shoot density of Lyngby's sedge to be significantly less. Bulrush was absent from the vegetation plots.

A noticeable difference at the Herring's House restoration site in 2002 and 2003, compared to 2001, was the absence of Lyngby's sedge shoots in the plots. Mean shoot height of bulrush at the restoration site remained the same as the 2002 value but was lower than the value recorded in 2001. Mean shoot density of bulrush was similar to 2002 values and higher than 2001 values. Comparing the restoration and reference site, bulrush mean shoot height remained significantly higher at the reference site, but mean shoot density was not significant.

All three restoration sites still show an overall difference in plant vigor compared to the reference sites, and do not yet meet the Biological Success Criterion 3 as stated in the monitoring plan (EBDRP 2000).

Riparian Vegetation (Biological Success Criteria 4 and 5). *The areal extent of vegetation should be stable or increasing over time, and cover not less than 90% of the upland vegetated area of each project site at the end of 10 years, and invasive plant coverage should be minimal (Criterion 4). Survival of riparian plantings in each cover class (herb, shrub, and tree) should be at least 75% at the end of 3 years (Criterion 5) (EBDRP 2000).*

Methods

Areal Extent
To estimate the areal extent of riparian vegetation, the perimeters of riparian vegetation at each site were mapped using the Trimble GeoExplorer 3 GPS in a similar manner as for areal extent of marsh vegetation. During the construction of the restoration sites, most of the area upslope of the marsh was planted with riparian vegetation (shrubs and trees) in a somewhat uniform fashion, with herbaceous plants colonizing the disturbed areas between the plantings. The riparian and marsh vegetation zones overlapped occasionally at the sites. For purposes of the estimate, the riparian vegetation zone included all upland plantings and small, but substantial, patches of riparian vegetation (or individual trees) that extended into the marsh vegetation zone.

Percent Cover of Vegetation Layers
To assess the percent cover of herbaceous, shrub, and tree layers, surveys were conducted in the riparian vegetation zone along transects established in 2001 for Hamm Creek Estuary and Herring's House restoration sites. In 2003, three riparian transects were established at the new North Wind's Weir restoration site. Plots were placed along transects, at random intervals for each transect. The first plot of each transect was located a random distance from the starting point. The herbaceous layer was sampled using a 0.25 m^2 quadrat, and the shrub and tree layers were sampled using a 3-m radius circular plot. Percent cover was visually estimated to the nearest 5% for each layer. For each site, mean percent cover values were calculated for all layers. Since each layer's estimate was independent of the other vegetation layers, and the size of herbaceous plots was smaller than the other layers, the sum of the percentages does not equal 100%.

Nonnative species
Nonnative species were sampled as a layer, at the same time as shrub and tree layers, using a 3-m radius circular plot. Percent cover was visually estimated to the nearest 5 percent for each layer, and means were calculated as with the other vegetation layers.

The monitoring plan (EBDRP 2000) identified three nonnative species of special concern which could become established at the site: Himalayan blackberry (*Rubus discolor*), Scot's broom (*Cytisus scoparius*), and Japanese knotweed (*Polygonum cuspidatum*). While two of these species (Himalayan blackberry and Scot's broom) were encountered at the sites, there were also other invasive, nonnative species present which were included in the layer's percent cover estimates in each plot.

Survival
Survival of shrubs and trees was determined by comparing the number of dead or stressed individuals to the total number of individuals (shrubs and trees) in the percent cover survey plots at each site.

Results

Areal Extent
The total areal extent of riparian vegetation at Hamm Creek Estuary in 2003 was 3,049 m^2 (0.75 acres). At the North Wind's Weir restoration site, the areal extent of the riparian vegetation was 1,285 m^2 (0.32 acres). At Herring's House, the areal extent of riparian vegetation in 2003 was 9,705 m^2 (2.4 acres).

Percent Cover of Vegetation Layers
At Hamm Creek Estuary, percent cover of the herbaceous and tree layers increased from the previous year's surveys, but the percent cover of the shrub layer decreased (Table 7). Yearly comparisons could not be made for the North Wind's Weir restoration site since this was the first year of sampling following completion of the site. At Herring's House, percent cover for herbaceous and tree layers in 2003 increased from 2002, but the percent cover for the shrub layer remained unchanged (Table 7). Riparian vegetation species observed at Hamm Creek Estuary, North Wind's Weir, and Herring's House restoration sites during 2001, 2002, and 2003 surveys are included in Appendix 2.

Table 7. Percent cover of herbaceous, shrub, tree, and nonnative riparian vegetation layers, estimated independently, at Hamm Creek Estuary, North Wind's Weir, and Herring's House during 2001, 2002, and 2003.

		Percent Cover of Riparian Vegetation Layers			
Site	**Year**	**Herbaceous** (0.25m^2 quadrat)	**Shrub** (3m radius plot)	**Tree** (3m radius plot)	**Nonnative** (3m radius plot)
Hamm Creek Estuary	2001	28	7	11	4
	2002	71	15	25	18
	2003	76	8	30	21
North Wind's Weir	2003	36	30	38	21
Herring's House	2001	44	27	26	5
	2002	50	16	35	17
	2003	56	16	57	18

Nonnative Species
There was an increase in the percent cover of nonnative species at Hamm Creek Estuary from 2002 (18%) to 2003 (21%) (Table 7). Nonnative species present included: butterfly bush (*Buddleja* sp.), bull thistle (*Cirsium vulgare*), Scot's broom, hairy cat's ear (*Hypochaeris radicata*), prickly lettuce (*Lactuca serriola*), ryegrass (*Lolium perenne* ssp. *multiflorum*, likely planted as a soil stabilizer), birdsfoot trefoil (*Lotus corniculatus*), reed canarygrass (*Phalaris*

arundinacae), creeping buttercup (*Ranunculus repens*), Himalayan blackberry, common tansy (*Tanacetum vulgare*), red clover (*Trifolium pretense*), and white clover (*T. repens*).

This was the first year of sampling since construction of the North Wind's Weir restoration site, and the percent cover of nonnative vegetation was 21%. Nonnative plant species present included: dog fennel (*Anthemis cotula*), bromegrass (*Bromus* sp.), lambsquarters (*Chenopodia album*), Canada thistle (*Cirsium arvense*), bull thistle, strawberry (*Fragaria* sp., planted as ground cover), velvetgrass (*Holcus lanatus*), hairy cat's ear, white sweet clover (*Melilotus alba*), prickly lettuce, plantain (*Plantago* sp.), bluegrass (*Poa* sp.), smartweed (*Polygonum* sp.), buttercup (*Ranunculus* sp.), Himalayan blackberry, common tansy, and white clover.

The percent cover of nonnative vegetation at Herring's House restoration site increased from 17% in 2002 to 18% in 2003 (Table 7). Nonnative species present included: dog fennel, common mustard, bromegrass, butterfly bush, Canada thistle, bull thistle, orchardgrass (*Dactylis glomerata*), quackgrass (*Elytrigia repens*), tall fescue (*Festuca arundinacea*), strawberry, St. John's wort (*Hypericum* sp.), hairy cat's ear, prickly lettuce, birdsfoot trefoil, white sweet clover, reed canarygrass, plantain, Himalayan blackberry, common tansy, dandelion (*Taraxacum officinale*), and red clover.

Survival

Survival of shrubs and trees at Hamm Creek Estuary was high (≥91%). The total number of shrubs counted decreased from 2002 to 2003, but the total number of trees observed increased (Table 8). At North Wind's Weir, the survival of shrubs and trees was 95% and 92%, respectively. At Herring's House, survival was high (99%) for both shrub and tree layers, although the number of shrubs and trees counted decreased in 2003 (Table 8).

Table 8. Survival of riparian vegetation shrubs and trees at the Hamm Creek Estuary, North Wind's Weir, and Herring's House restoration sites during 2001, 2002, and 2003.

Site	Layer	# Plants			# Dead			# Stressed			% Survival		
		2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
Hamm Creek Estuary	Shrub	63	100	87	0	1	0	0	0	0	100	99	100
	Tree	74	101	133	2	1	8	5	4	4	91	95	91
North Wind's Weir	Shrub			128			4			3			95
	Tree			211			3			14			92
Herring's House	Shrub	205	231	166	0	1	0	0	0	1	100	100	99
	Tree	130	273	239	0	19	1	0	5	1	100	91	99

Discussion

Areal Extent

During construction, shrubs and trees were planted in a fairly uniform fashion throughout the riparian zones of Hamm Creek Estuary, North Wind's Weir, and Herring's House restoration sites. The total areal extent of riparian vegetation in 2003 was different than in 2002 at the Hamm Creek Estuary and Herring's House restoration sites. Hamm Creek Estuary experienced

an increase of 15% (544 m^2) in riparian areal extent. At Herring's House, the total areal extent of riparian vegetation increased by 11% (999 m^2) during the same time period. The upland boundaries surveyed at each site's riparian zone were the same in 2002 and 2003, but as riparian vegetation spread into the edges of the intertidal area (below 12.0 ft MLLW), the lower boundary of the riparian zone varied. The areal extent of riparian vegetation appeared stable and increasing at the end of 3 years since construction of the restoration site. Areal extent of riparian vegetation is expected to continue to fluctuate over time, as the boundaries of the riparian and marsh vegetation zones merge.

This was the first year of sampling at the North Wind's Weir restoration site. The estimated areal extent of riparian vegetation in 2003 will serve as the baseline for future comparisons. One key observation at the site was that a number of riparian species were planted outside the goose exclusion fence, but below the high tide (12 ft MLLW) elevation, and many of these plants were showing signs of stress.

Percent Cover of Vegetation Layers

At Hamm Creek Estuary, the percent cover of herbaceous and tree vegetation layers increased by 5% from 2002 to 2003, but the percent cover of shrubs decreased by 7%. The herbaceous and tree layers attained the projected goal for Year 3 coverage estimates (>70% herbaceous, >25% tree) as stated in the monitoring plan (EBDRP 2000). The shrub layer did not reach the projected goal of >30% coverage. The first year of sampling at North Wind's Weir showed the percent coverage of the shrub and tree layers to range between 30% and 38%. These percentages should be a good base for continued growth of all layers. At Herring's House, percent cover of the herbaceous and tree layers increased in 2003 from the previous year, and the percent cover for the shrub layer remained unchanged. Only the tree layer reached the projected goal for Year 3 coverage estimates (>25%). The herbaceous and shrub layers were 14% below the Year 3 projected goals (>70% herbaceous, >30% shrub).

Nonnative Species

There was an increase in percent cover of nonnative vegetation species at Hamm Creek Estuary in 2003. Two of the three nonnative species identified as especially problematic, Himalayan blackberry and Scot's broom, were present at the site. There were many other nonnative species present which appeared to be colonizing the site. When all nonnative species present in the surveys are included, the estimated percent cover of nonnative species at the site is 21%, a value above the target goal for Year 3 (<10%). There have been observed attempts to remove some of the nonnative species (especially Scot's broom) present at the site. However, many plants are still present and spreading, and may soon begin to compete with preferred, native vegetation for space and other resources.

This was the first year of sampling after construction of the North Wind's Weir restoration site, and the percent cover of nonnative species was higher (21%) than at the Hamm Creek and Herring's House restoration sites in their first year (4% and 5%, respectively, in 2001) after construction. One reason for the high percent of nonnative species at North Wind's Weir was due to the fact that strawberry was planted as a ground cover. Himalayan blackberry and Scot's broom are also present at the site.

At Herring's House, percent cover of nonnative species increased in 2003. Nonnative species at the site comprised 18% of the cover at the site, which is above the maximum percent cover goal

(<10%) for the restoration sites in 2003 (EBDRP 2000). Many of these nonnative plant species are likely to become problematic at the sites in the next several years.

One species which was observed in 2002 and 2003 at both the Hamm Creek Estuary and Herring's House sites (but not in transects) was perennial pepperweed (*Lepidium latifolium*), a Class B noxious weed in the State of Washington and a designate in King County. This category of noxious weed requires control of seed production (Lantz and Simon 1998).

Survival
At the Hamm Creek Estuary and Herring's House sites, the survival of riparian plantings in each cover class category (shrubs and trees) met the Biological Success Criterion 5 of at least 75% survival at the end of 3 years. Survival of shrubs and trees was high at the Hamm Creek Estuary site (100% shrubs, 91% trees). The survival estimate in relation to site development could be misleading at this stage of monitoring, due to the subsequent plantings of trees at the site by other entities (e.g., People for Puget Sound). While these actions are beneficial to the site in the long term, the planting of additional vegetation (e.g., trees) biases survival estimates of this monitoring project. Overall, survival of trees and shrubs was high for Herring's House, due to volunteer seedlings and vegetation enhancement and/or replacement by Seattle City Park staff. Maintenance by Seattle City Park staff has been observed, such as plantings and removal of dead plants, although most of the plantings observed by Service personnel occurred in the park-like section of the site, outside of the riparian perimeter used for this project.

The survival of trees and shrubs at the North Wind's Weir site was high as estimated from transect plots. Visual observations of the riparian vegetation planted near the goose exclusion fence showed higher stress and mortality.

In addition to plantings during construction, People for Puget Sound has since been involved in adaptive management at the Hamm Creek Estuary restoration site, enhancing vegetation establishment through plantings (e.g., willow stakes planted along the freshwater marsh shoreline) (Tom Dean, People for Puget Sound, personal communication 2002). Although this management will be beneficial to the site in the future, the addition of plants between vegetation surveys may make it difficult to correctly interpret changes in percent cover and survival of riparian vegetation from year to year. While these data have been included in this report, interpretation of the data provided by these surveys must be considered carefully under the present conditions.

Bird Use (Biological Success Criterion 6). *Use of the restoration sites and the area within 50 meters of the site by indigenous/native bird species should be comparable to that of the appropriate reference sites (EBDRP 2000).*

Methods
Bird surveys designed to detect bird presence/absence were conducted quarterly at the Hamm Creek Estuary, Herring's House, and North Wind's Weir restoration sites, with surveys at each restoration site performed concurrently with the respective reference site's survey. Because North Wind's Weir and Hamm Creek share the same reference site, the restoration sites were alternately paired with the reference site for concurrent sampling. As an example, if Hamm Creek was surveyed concurrently with the reference site, then the North Wind's Weir restoration

site was surveyed immediately thereafter to minimize the time between restoration and reference site surveys for North Wind's Weir. Three 15-minute surveys were performed on the same day at each of the site pairs on March 20, June 30, September 11, and December 9, 2003, with the first survey beginning at sunrise, and at or near high tide. When the initial 15-minute survey was completed for the first concurrent sites, observers then traveled to the next concurrent sites for a survey at high tide. The two remaining surveys for the sites were conducted in an alternating pattern, at mid- and low tides (i.e., when the restoration sites were dewatered), respectively.

During the quarterly surveys for presence/absence of birds, additional information was collected for use in detecting trends or changes over time. At each site, observers recorded all birds present, their gender (if known), and their primary behavior. Primary behavior was defined as the behavior exhibited by each bird during most of the observation period. Recorded behaviors included transit (swimming or flying), foraging, breeding/mating, resting/loafing, perching, and other. Birds flying over the site, but not obviously associated with the site, were noted, but were not included in analyses.

Results

At both the Hamm Creek Estuary and Herring's House sites, fewer bird species were observed in 2003 than in 2002 (Table 9). This was the first year for conducting bird surveys at North Wind's Weir so a yearly comparison can not be made. When the restoration and reference sites are compared, the Hamm Creek Estuary sites had similar numbers of bird species (difference of ≤4 species) in all 3 years. At Herring's House restoration and reference sites, numbers of bird species showed more yearly variation. Restoration to reference site comparisons show a difference of 7 species in 2001, 2 species in 2002, and 3 species in 2003. North Wind's Weir restoration site had fewer bird species than the reference site (difference of 7 species).

Table 9. Numbers of bird species observed in quarterly surveys at the Hamm Creek Estuary, Herring's House, and North Wind's Weir restoration and reference sites in 2001, 2002, and 2003.

		# Bird species observed									
		Restoration					**Reference**				
Site	**Year**	**Mar**	**Jun**	**Sep**	**Dec**	**Site total**	**Mar**	**Jun**	**Sep**	**Dec**	**Site total**
Hamm Creek Estuary	2001	8	15	14	12	29	13	15	10	8	32
	2002	12	19	15	13	36	9	12	30	15	40
	2003	16	20	15	12	31	20	14	17	10	33
Herring's House	2001	6	11	13	13	27	9	12	9	8	20
	2002	13	16	14	14	34	9	16	15	16	32
	2003	13	21	13	13	32	15	21	16	9	35
North Wind's Weir	2003	9	16	7	12	26	20	14	17	10	33

Numbers of species present varied by quarter during surveys at the Hamm Creek Estuary, Herring's House, and North Wind's Weir restoration sites and their respective reference sites. In 2003, the greatest quarterly difference occurred at the North Wind's Weir sites during the March and September surveys. Observations during the March and September quarters noted twice as many bird species at the reference site (20 and 17 species) than were found at the restoration site (9 and 7 species, respectively) (Table 9). A complete list of birds present at the Hamm Creek Estuary, Herring's House, and North Wind's Weir sites appears in Appendix 3.1.

Native bird species observed during surveys at Hamm Creek Estuary restoration site, but not at the reference site, included hooded merganser (*Lophodytes cucullatus*), red-tailed hawk (*Buteo jamaicensis*), osprey (*Pandion haliaetus*), tree swallow (*Tachycineta bicolor*), violet-green swallow (*T. thalassina*), Northern rough-winged swallow (*Stelgidopteryx serripennis*), barn swallow (*Hirundo rustica*), and savanna sparrow (*Passerculus sandwichensis*) (Appendix 3.2). Species seen at the Hamm Creek Estuary reference site in 2003, but not at the restoration site, included pied-billed grebe (*Podilymbus podiceps*), bufflehead (*Bucephala albeola*), mew gull (*Larus canus*), ring-billed gull (*Larus delawarensis*), bushtit (*Psaltriparus minimus*), Bewick's wren (*Thryomanes bewickii*), cedar waxwing (*Bombycilla cedrorum*), common yellowthroat (*Geothlypis trichas*), and pine siskin (*Carduelis pinus*).

Native bird species seen during surveys at the Herring's House restoration site, but not at the reference site, included Cooper's hawk (*Accipiter cooperii*), spotted sandpiper (*Actitis macularia*), rock dove (*Columba livia*), tree swallow, black-capped chickadee (*Poecile atricapilla*), bushtit, American robin (*Turdus migratorius*), yellow-rumped warbler (*Dendroica coronata*), white-crowned sparrow (*Zonotrichia leucophrys*), and pine siskin (Appendix 3.3). Species observed at the reference site, but not the restoration site, included western grebe (*Aechmophorus occidentalis*), double-crested cormorant (*Phalacrocorax auritus*), common goldeneye (*Bucephala clangula*), bufflehead, common merganser (*Mergus merganser*), red-breasted merganser (*Mergus serrator*), western sandpiper (*Calidris mauri*), mew gull, ring-billed gull, glaucous-winged gull (*Larus glaucenscens*), tern (*Sterna spp.*), belted kingfisher (*Megaceryle alcyon*), cliff swallow (*Petrochelidon pyrrhonota*), and an oriole (*Icterus spp*) .

Native bird species observed during surveys at North Wind's Weir restoration site, but not at the reference site, include a sandpiper species (Scolopacidae), northern flicker (*Colaptes auratus*), downy woodpecker (*Picoides pubescens*), barn swallow, ruby-crowned kinglet (*Regulus calendula*), and yellow-rumped warbler (Appendix 3.4). Species seen at the reference site in 2003, but not at the restoration site, included pied-billed grebe, Canada goose (*Branta Canadensis*), gadwall (*Anas strepera*), green-winged teal (*Anas crecca*), bufflehead, common snipe (*Capella gallinago*), mew gull, rock dove, cedar waxwing, common yellowthroat, white-crowned sparrow, red-winged blackbird (*Agelaius phoeniceus*), pine siskin, and American goldfinch (*Carduelis tristis*).

The influence of tidal stage on numbers and species of birds was unclear. No obvious trends were evident from analysis of these data.

Discussion

Hamm Creek Estuary

In 2003, the number of bird species at Hamm Creek Estuary was similar to the reference site. Hamm Creek had more swallow species present than the reference site and the reference site had more gull and passerine species present. Numbers of passerines were observed at both sites, especially groups of sparrows and finches. They appeared to be using the restoration and reference sites in a similar manner, but at different times. In fall, the largest numbers of sparrows and finches were seen at the restoration site; in spring, more were seen at the reference site than at the restoration site. The reference site has a more developed riparian area than the restoration site, which may account for the wider variety of passerines observed there.

Many waterfowl (swans, geese, and ducks) winter in the Puget Sound area, using the rivers and estuaries and other areas nearby as feeding and resting areas from fall through spring (Puget Sound Water Quality Authority 1991). Although Canada geese and diving ducks were often seen at the Hamm Creek Estuary restoration and reference sites, the majority of waterfowl using the areas were dabbling ducks (mallard, gadwall, and green-winged teal).

Herring's House Restoration Site

During quarterly surveys at Herring's House in 2003, the total numbers of species present at the restoration and reference sites were similar or identical. Two raptor species (osprey and red-tailed hawk) were seen at the restoration site, but not at the reference site, probably due to the osprey nesting platform and grassy field present at the restoration site and not at the reference site. More passerine species were seen at the restoration site than the reference site. The difference was the large numbers of sparrows, finches, and other passerines at the restoration site's extensive riparian area which were not observed at the reference site. Passerines may not have been observed at the reference site because of its distance from the viewing point.

The reference site tended to have more diving duck, gull, and shorebird species than the restoration site. Although gulls were occasionally observed foraging successfully in the restoration site, the deeper channel near the reference site may offer more foraging opportunities for gulls and terns. Diving ducks were often observed in the deeper habitat. The reference site also contains several pilings and log booms which are often used by gulls for resting. Shorebirds may be drawn to the extensive mudflats at the north end of Kellogg Island. Large numbers of Canada geese were observed at the Herring's House reference site, but not at the restoration site. On the other hand, more dabbling ducks were seen at the restoration site than at the reference site. There may be several reasons this separation of ducks and geese occurs at the sites. One important reason may be that the topography of the restoration site may not be attractive to geese for foraging or resting purposes.

North Wind's Weir

The differences in number of bird species at North Wind's Weir restoration and reference sites could be due to the project site construction being finished just prior to the beginning of the surveys. The upland riparian area at North Wind's Weir restoration site also contains larger, remaining overstory trees (used by the woodpecker species) that the reference site does not have. The passerines and ducks, present at the reference site and not the restoration site, may be using the abundant midstory and herbaceous plant species available at the reference site. As the riparian habitat grows at the restoration site, the number of species present may increase and become more similar to that of the reference site.

Fish Presence/Access (Biological Success Criterion 7). *Estuarine fishes will access the project sites. Juvenile salmonid presence within the project sites should be comparable to that of appropriate reference sites at the end of ten years (EBDRP 2000).*

Methods

Sampling methods and sites used for monitoring fish in 2003 were the same as those used in 2001 and 2002 (Low and Myers 2002). Reference sites with tidal channels similar to the three restoration sites (Hamm Creek Estuary, Herring's House, and North Wind's Weir) were not available in the lower Duwamish waterway. Instead, reference sites were selected with intertidal/nearshore habitats that were similar to those provided by the restoration sites at high tide. The Turning Basin was used as a reference site for Hamm Creek Estuary and North Wind's Weir, and Kellogg Island was used as a reference site for Herring's House. Because of the lack of tidal channels at the reference sites, it was necessary to use two different fish sampling techniques.

A fyke-net with an attached live box was set across the outlet at high tide at the three restoration sites. Fish were trapped in the net as they migrated from the sites during the ebb tide. Beach seines were used to sample fish at the reference sites during high tide. A small outboard motor boat was used to deploy a 37-m beach seine parallel to shore and the seine was retrieved by a 2-3 person crew. No direct numerical comparisons can be made between the reference and restoration sites due to the different sampling techniques used. Eight bi-weekly fish surveys were conducted at Hamm Creek Estuary, Herring's House, North Wind's Weir, Turning Basin, and Kellogg Island from March 2 through July 10. The sampling period this year was from April to July instead of from March to June as in 2001 and 2002. This time period was changed from last year to capture the tail-end of the juvenile salmonid outmigration and to capture more of the non-salmonids that reside in the estuary.

Captured fish were identified (to species for salmonids and at least to family for non-salmonids), counted, examined for fin-clips or marks, and released. Forklength measurements, to the nearest millimeter, were collected on up to 30 individuals of each salmonid species except for Chinook salmon (*Oncorhynchus tshawytscha*) that were counted and immediately released. Natural Resources Consultants, Inc. (NRC) and the Seattle District of the U.S. Army Corps of Engineers (Corps), conducted fish surveys as part of a separate study in the lower Duwamish Estuary at the Hamm Creek, Herring's House, and the Turning Basin sites using the same fish capture methods. When possible, we shared sampling duties and data at these sites.

Results

Hamm Creek Estuary Restoration Site

Seven different fish species/groups were captured at Hamm Creek Estuary during 2003 sampling efforts (Table 10). A total of 4,040 salmonids consisting of Chinook salmon, chum salmon (*O. keta)*, and coho salmon (*O. kisutch*) was captured. The most common was chum salmon, comprising 96% of all salmonids captured. Unidentified sculpin (*Cottidae*), three spine stickleback (*Gasterosteus aculeatus*), unidentified flatfish (*Pleuronectiformes*), and shiner perch (*Cymatogaster aggregata*) were the most common non-salmonid species captured.

The peak catch of chum salmon occurred on April 16, which accounted for 32% of the chum salmon caught during the sampling season. The majority of Chinook salmon (77%) was caught on May 29. A total of 29 adipose fin-clipped (AD-clipped) Chinook salmon were captured: seven on May 28, eighteen on June 11, and four on June 25. Fin clips were not observed on any other salmonid captured. Length measurements and catch summaries for salmonids captured at the Hamm Creek Estuary site are presented in Appendix 4.1.

Hamm Creek Estuary and North Wind's Weir Reference Site
Twelve different fish species/groups were captured at the Hamm Creek Estuary and North Wind's Weir reference site in 2003 (Table 10). A total of 216 salmonids representing five species (Chinook salmon, chum salmon, coho salmon, cutthroat trout (*O. clarki clarki*) and steelhead trout (*O. mykiss*)) were captured. Chum salmon comprised 56% of the total salmonids captured. Chinook salmon comprised 38%. A total of six steelhead trout were caught on June 12. Two cutthroat trout were caught, one on April 3, and the other on June 12. Unidentified flatfish, starry flounder (*Platichthys stellatus*), surf smelt (*Hypomesus pretiosus*), snake prickleback (*Lumpenus sagitta*), unidentified sculpin, shiner perch, stickleback, and Pacific sardine (*Sardinops sagax*) were the non-salmonid fishes captured.

The peak catch of chum salmon occurred on May 14, which accounted for 39% of the chum salmon caught during the sampling season. The largest Chinook salmon catch (51%) were caught, occurred on May 28. A total of 18 AD-clipped Chinook salmon were captured at Hamm Creek Estuary reference site, 3 on April 3, 9 on May 28, 3 on June 12, and 3 on July 10. Fin clips were not observed on any other salmonid captured. Length measurements and catch summaries for salmonids captured at the Hamm Creek Estuary reference site (Turning Basin) are presented in Appendix 4.2.

North Wind's Weir Restoration Site
Nine different fish species/groups were captured at North Wind's Weir restoration site during 2003 (Table 11). A total of 216 salmonids representing four species (Chinook salmon, chum salmon, coho salmon, and cutthroat trout) were captured. The most common (74%) were chum salmon. Chinook salmon made up 18%, while coho salmon made up 8%, of all salmonids caught during the 2003 sampling season. The non-salmonid species caught at this site were unidentified sculpin, shiner perch, three spine stickleback, flatfish, and lamprey (*Lampetra spp*).

The peak catch of chum salmon and coho salmon occurred on May 14, which accounted for 90% of the chum salmon and 94% of the coho salmon caught during the 2003 sampling season. The majority (41%) of the Chinook salmon were captured on June 11. A total of 28 AD-clipped Chinook salmon were captured at North Wind's Weir restoration site, with the majority (50%) caught on May 28. Fin clips were not observed on any other salmonid captured. Length measurements and catch summaries for salmonids captured at North Wind's Weir restoration site are presented in Appendix 4.5.

North Wind's Weir Reference Site
The North Wind's Weir reference site is the same as the Hamm Creek reference site (see above).

Table 10. Number and species of fish captured during 2003 monitoring of the Hamm Creek Estuary restoration and reference site of the Elliott Bay/Duwamish Restoration Program.

Site	Date	Fish Species											
		Chinook	Chum	Coho	Steel-head	Cutthroat	Sculpin	Threespine stickleback	Flatfish	Shiner perch	Snake Prickleback	Sardine	Surf smelt
Restoration Site (Hamm Creek Estuary)	1-Apr	2	1078				2	3					
	15-Apr	10	1258				47						
	29-Apr		1023				27	2					
	13-May		518				42	6					
	27-May	123	2				8	7	3	2			
	10-Jun	19	2										
	24-Jun	4					6	155	9	9			
	July 9	1					5	276	3	1239			
	Total	**159**	**3881**				**137**	**449**	**15**	**1250**			
Reference Site (Turning Basin)	2-Apr	18	11	3		1			4				
	April17		32		6								1
	30-Apr	5	2				3		5				
	14-May	4	48	1			2		71				
	28-May	41	28				13	2	96	7			
	11-Jun	7		2		1	43	1	108	348	3		
	26-Jun						8		70	11			
	9-Jul	6					34	5	130	2776		1	
	Total	**81**	**121**	**6**	**6**	**2**	**103**	**8**	**484**	**3142**	**3**	**1**	**1**

Table 11. Number and species of fish captured during 2003 monitoring of the North Wind's Weir restoration and reference sites of the Elliott Bay/Duwamish Restoration Program.

Site	Date	Fish Species												
		Chinook	Chum	Coho	Steelhead	Cutthroat	Sculpin	Threespine stickleback	Flatfish	Lamprey	Sardine	Snake prickleback	Shiner perch	Surf smelt
Restoration Site (North Wind's Weir)	15-Apr		4											
	29-Apr		8											
	13-May	9	143	17									1	
	27-May	14	4				9						3	
	10-Jun	16		1		1	83	3		2			21	
	24-Jun						30	2	1				2	
	8-Jul						13	2	1				2	
	Total	**39**	**159**	**18**		**1**	**135**	**7**	**2**	**2**			**29**	
Reference Site (Turning Basin) *same as for Hamm Creek reference*	2-Apr	18	11	3		1			4					
	16-Apr		32		6									1
	30-Apr	5	2				3		5					
	14-May	4	48	1			2		71					
	28-May	41	28				13	2	96				7	
	11-Jun	7		2		1	43	1	108			3	348	
	26-Jun						8		70				11	
	9-Jul	6					34	5	130		1		2776	
	Total	**81**	**121**	**6**	**6**	**2**	**103**	**8**	**484**		**1**	**3**	**3142**	**1**

Herring's House Restoration Site
Twelve different fish species/groups were captured at the Herring's House restoration site in 2003 (Table 12). A total of 1,045 salmonids representing five species (Chinook salmon, chum salmon, coho salmon, pink salmon, and steelhead trout) were captured with the most common (75% of the total salmonids caught) being chum salmon. Chinook salmon comprised 23% and coho salmon comprised 2% of the total salmonids caught during the 2003 sampling season. Sculpin, shiner perch, stickleback, flatfish, and starry flounder were the common non-salmonids captured. Snake prickleback and gunnel (*Pholidae spp*.) were also found in lower abundances.

The peak catch of chum salmon occurred on April 16, which accounted for 37% of all chum caught at Herring's House. The majority of Chinook salmon (40%) was caught on May 29 and the peak catch for coho salmon (43%) was on May 15. Two steelhead trout were caught on May 15, and a single pink salmon was captured on April 3. A total of 212 AD-clipped Chinook salmon were caught at the Herring's House restoration site. The majority of the AD-clipped Chinook salmon (51%) was caught on May 28. Fin clips were not observed on any other salmonid captured. Length measurements and catch summaries for salmonids captured at the Herring's House restoration site are presented in Appendix 4.3.

Herring's House Reference Site
Nine different fish species/groups were captured at the Herring's House reference site during 2003 (Table 12). A total of 190 salmonids representing three species (Chinook, chum, and coho) were captured with the most common (71% total salmonids) being chum salmon. Chinook salmon made up 29% of the total salmonids. Unidentified sculpin, three spine stickleback, flatfish, starry flounder, and shiner perch, were the common non-salmonids captured at this site. A single greenling (*Hexagrammidae spp*.) was caught on June 26, and a single bay pipefish (*Syngnathus leptorhynchus*) was caught on July 10.

The majority of the chum salmon (92%) were captured on April 17, and 40% of the Chinook salmon were caught on July 10. A single coho salmon was caught on May 15. A total of 33 AD-clipped Chinook salmon were captured at Herring's House reference site, with the majority (42%) caught on July 10. Fin clips were not observed on any other salmonid captured. Length measurements and catch summaries for salmonids captured at the Herring's House reference site are presented in Appendix 4.4.

Discussion
Intertidal habitats, such as those restored under the Elliott Bay/Duwamish Restoration Program and monitored by this project, are utilized by a wide variety of important salmonid and non-salmonid fish species for rearing and foraging. Both ocean-type Chinook salmon (Healey 1991) and chum salmon (Emmett *et al*. 1991, Salo 1991) utilize estuarine areas for prolonged rearing. Both of these species, but particularly young chum salmon fry, utilize shallow intertidal habitats for rearing. While steelhead trout spend little time in estuarine waters (Emmett *et al*. 1991), coho salmon (Emmett *et al.* 1991, Sandercock 1991) and cutthroat trout (Emmett *et al*. 1991) may spend extended periods rearing in estuarine areas, although they more typically migrate quickly through these areas to neretic waters. Estuarine intertidal habitats are also very important to non-salmonid species such as Pacific sanddab (*Citharichthys sordidus*), starry flounder, shiner perch, three spine stickleback, and Pacific Staghorn sculpin (*Leptocottus armatus*) (Hart 1973, Emmett *et al*. 1991) which utilize these areas as nursery grounds as well as adult rearing areas.

Table 12. Number and species of fish captured during 2003 monitoring of the Herring's House restoration and reference site of the Elliott Bay/Duwamish Restoration Program.

Site	Date	Fish Species													
		Chinook	Chum	Coho	Pink	Steelhead	Sculpin	Threespine stickleback	Flatfish	Gunnel	Striped perch	Snake prickleback	Shiner perch	Bay pipefish	Greenling
Restoration Site (Herring's House)	1-Apr	3	101	2											
	2-Apr	4	104		1			10							
	15-Apr	4	202				24	11					241		
	16-Apr	7	293				23	8					812		
	29-Apr	5	20	1			29	10					2658		
	30-Apr	3	9	6			53	3				1	1795		
	12-May	1	4	3			288	4					28		
	14-May	33	45	10									203		
	16-May	17		1		2	16	8				2	8500		
	27-May	1	1				121	1	4	2	5		4722		
	27-May	95					132		1				2280		
	10-Jun	19	1				1	21	1	2			197		
	11-Jun	35					55	8	3	1			4450		
	24-Jun	3	2				135	1	3	1			3650		
	25-Jun	2	2				188	6	3	1			1147		
	8-Jul	2					445	115	4	15			8850		
	9-Jul	1					107	55	1				1265		
	Total	**235**	**784**	**23**	**1**	**2**	**1617**	**261**	**20**	**22**	**5**	**3**	**40798**		
Reference Site (Kellogg Island)	2-Apr		1				1	2							
	16-Apr	3	123				5								
	30-Apr	7	4				35	2	3						
	14-May	1		1			22		8						
	28-May	15	4				36		18				91		
	11-Jun	12	1				41	20	55				12		
	25-Jun	1					8		4						1
	9-Jul	16	1				22	6	22				78	1	
	Total	**55**	**134**	**1**			**170**	**30**	**110**				**181**	**1**	**1**

While quantitative fish abundance comparisons are not warranted because of the two different sampling techniques used at the restoration and reference sites and the infrequent sampling effort (biweekly), the catches of different species allow for evaluation of the use of the restoration sites. Sampling for fish presence/absence at the Hamm Creek Estuary, Herring's House, and North Wind's Weir restoration sites, indicates that salmonids and other estuarine fish species were able to access the sites and utilize them for rearing. Chum salmon were the predominant salmonid captured at all sites (restoration and reference), while Chinook salmon were captured in large numbers at some sites. Generally the relatively low catches of coho salmon and steelhead trout are to be expected because theses species are the least dependent of the salmonids captured on estuarine habitats for rearing (Emmett *et al*. 1991). Extending the sampling season into July allowed more of the non-salmonids that resided in the estuary to be captured. A total of 1,115 flatfish, 2,265 sculpins, 48,542 shiner perch and 763 three spine sticklebacks were the common non-salmonids that were captured during the sampling season. Compared to previous years when the sampling season was earlier, there was a dramatic difference in abundance and species captured.

Large numbers of Chinook salmon, coho salmon, chum salmon, and steelhead trout are reared at hatchery facilities within the Green/Duwamish Basin and released into the system (Table 13). Marked hatchery fish (Chinook salmon and coho salmon) were captured at all sites with large numbers of Chinook salmon occurring at Herring's House restoration site. It is likely that some of the captured chum salmon were from hatchery production, but these fish are not marked so their origin cannot be visually determined. Determining the level of use of the intertidal habitat at the restoration sites by hatchery produced fish is not possible due to the low level of sampling effort but these fish are utilizing the sites for rearing to some degree.

While different fish species/groups have been captured at the restoration and reference sites during 2001 through 2003 sampling efforts (Table 14), the capture of salmonids (primarily Chinook salmon and chum salmon) and non-salmonids (primarily flatfish, sculpin, three spine stickleback, and shiner perch) in all years indicates that the restoration sites are accessible to these fishes. Due to the frequency of sampling (bi-weekly), the chances of catching fish representing the variety of species/groups that utilize the lower Duwamish River is greatly influenced by their abundance, life history stage at the time of sampling, and, in the case of salmonids, releases of hatchery production. Over the past 3 years of fish sampling, captures of individuals or small numbers of fishes such as dace (*Rhinichthys sp*.), eulachon (*Thaleicthys pacificus*), gunnel (*Pholis sp*.), herring (*Clupea sp*.), Pacific lamprey (*Lampetra tridentata*), snake prickleback, sandlance (*Ammodytes hexapterus*), and sucker (*Catostomidae*) indicates that these intertidal habitats are utilized by a wide variety of fishes.

Table 13. Releases of hatchery fish into the Green/Duwamish River system in 2003 (data provided by NRC, Inc.).

Species	Age	Location	Release Date	Number	Agency [1]	Comments
Chinook	subyearling	Soos Cr	May 15-June 1	400,000	WDFW	200000 with ad/cwt
		Above HH	March 20-25	402,000	MIT	No CWT, no yearlings released
	yearling	Icy Cr	April 30	300,000	WDFW	ad-clip, no cwt
Coho	subyearling	Above HH	April 14-15	548,000	MIT	No marks
	yearling	Soos Cr	April 19	475,000	WDFW	ad-clip, no cwt
		Crisp Cr	April 30-May 7	240,000	MIT	checking clip
		Crisp Cr	April 30-May 7	11,000	MIT	Ad/CWT
		Crisp Cr	April 30-May 7	39,000	MIT	CWT Only
		Myrtle Edwards net pens	~June 1	402,000	MIT	
Chum	subyearling	Keta Cr	March 7-April 7	1,200,000	MIT	No marks
Steelhead	yearling	Soos Cr, Palmer, Icy Cr, & Flaming Geyser	April 30	300,000	WDFW	ad-clip, no cwt
		Keta Cr	April 30-May 7	34,000	MIT	Green R Native spawn hatchery

[1]WDFW= Washington Department of Fish and Wildlife, MIT=Muckleshoot Indian Tribe

Table 14. Fishes captured at restoration and reference sites from 2001-2003 sampling for the Elliott Bay/Duwamish Restoration Program.

	Hamm Creek Estuary		Herring's House		North Wind's Weir	
Year	**Restoration site**	**Reference site**	**Restoration site**	**Reference site**	**Restoration site**	**Reference site**
Salmonids						
2001	Chinook	Chinook	Chinook	Chinook		
	Chum	Chum	Chum	Chum		
	Coho	Coho		Coho		
		Steelhead				
		Cutthroat				
2002	Chinook	Chinook	Chinook	Chinook		
	Chum	Chum	Chum	Chum		
	Coho	Coho	Coho	Coho		
	Cutthroat	Cutthroat	Cutthroat			
2003	Chinook	Chinook	Chinook	Chinook	Chinook	Chinook
	Chum	Chum	Chum	Chum	Chum	Chum
	Coho	Coho	Coho	Coho	Coho	Coho
		Cutthroat	Pink		Cutthroat	Cutthroat
		Steelhead	Trout			Steelhead
Non Salmonids						
2001	Sculpin	Sculpin	Sculpin	Sculpin		
	Threespine stickleback	Threespine stickleback	Threespine stickleback	Threespine stickleback		
	Flatfish	Flatfish	Flatfish	Flatfish		
	Shiner perch	Pacific lamprey	Shiner perch	Shiner perch		
	Dace	Herring	Gunnel	Snake prickleback		
	Sand lance	Sand lance		Eulachon		
	Sucker					
2002	Sculpin	Sculpin	Sculpin	Sculpin		
	Threespine stickelback	Threespine stickelback	Threespine stickleback	Threespine stickleback		
	Flatfish	Flatfish	Flatfish	Flatfish		
	Sucker	Shiner perch		Shiner perch		
2003	Sculpin	Sculpin	Sculpin	Sculpin	Sculpin	Sculpin
	Threespine stickleback	Threespine stickleback	Threespine stickleback	Threespine stickleback	Threespine stickleback	Threespine stickleback
	Flatfish	Flatfish	Flatfish	Flatfish	Flatfish	Flatfish
	Shiner perch	Shiner perch	Shiner perch	Shiner perch	Shiner perch	Shiner perch
		Sardine	Snake prickleback	Greenling	Pacific lamprey	Sardine
		Snake prickleback	Gunnel	Bay pipefish		Snake prickleback
		Surf smelt				Surf smelt

Invertebrate Prey Resource Production (Biological Success Criteria 8). *Production of invertebrate prey taxa known to be important to juvenile salmonids should be comparable to that of appropriate reference sites at the end of ten years (EBDRP 2000).*

Methods

Sampling for fallout insects from riparian areas and benthic invertebrates from intertidal areas, collectively described as invertebrate prey resources produced, was conducted using the protocols described by Cordell *et al*. (1994, 1999). Invertebrate sampling occurred once a month in March, April, May, and June. Two types of invertebrate samples were collected: (1) fallout insect traps for terrestrial insects, and (2) core samples for aquatic invertebrates. The numbers of traps deployed varied by site and habitat strata present at each site (Table 15).

At the Hamm Creek Estuary restoration and reference sites, monthly invertebrate sampling included the placement of fallout insect traps in the estuary (five traps in the restoration site and five in the reference site). Ten additional insect traps were placed along the creek to examine upstream sources of invertebrate food resources for the estuary. Ten core samples for macroinvertebrates were taken in the intertidal area at the site, but the samples were not stratified in vegetated and unvegetated areas. At Hamm Creek Estuary, the creek runs through the lower intertidal area, significantly affecting the estuarine invertebrate community of the mudflat. With the freshwater creek flowing over this area during low tide, the invertebrate community is substantially different from the brackish community of the reference area. For this reason, no samples were taken in the mudflat stratum of Hamm Creek Estuary restoration and reference sites. At the Herring's House and North Wind's Weir restoration and reference sites, five fallout insect traps were placed in the estuary at each site. In addition to the fallout insect traps, 10 invertebrate core samples were taken from each of the following habitats: (1) macrofauna in the vegetated region of the higher intertidal zone, (2) macrofauna in the mudflat area of the lower intertidal zone, and (3) meiofauna in the mudflat area of the lower intertidal zone. All samples were preserved, labeled, and delivered to Jeff Cordell of the University of Washington School of Aquatic and Fisheries Sciences, who has been contracted to analyze the samples.

Table 15. Numbers of invertebrate samples collected by site in 2003.

Sample Type	Hamm Creek Estuary			North Winds Weir		Herring's House		Total
	Creek	Estuary	Ref. site	Rest. Site	Ref. Site	Rest. Site	Ref. Site	
Fallout insect traps	40	20	20	20	20	20	20	80
Core Samples								
Vegetated macrofauna	-	40	40	40	40	40	40	160
Mudflat macrofauna	-	-	-	40	40	40	40	80
Mudflat meiofauna	-	-	-	20*	20*	40	40	80
Total core samples	-	40	40	110	110	120	120	320
Total invertebrate samples	40	60	60	130	130	140	140	400

* Mudflat meiofauna samples were not collected in March and April at North Wind's Weir.

Results

Samples have been sorted and identified. Results of the invertebrate prey resource production surveys are not yet available, pending release of the draft/final report by Cordell.

Discussion

The draft report from UW is pending.

SUMMARY

Physical Characteristics

Intertidal Area
From 2002 to 2003, there were small decreases in intertidal area at both the Hamm Creek Estuary and Herring's House sites. Hamm Creek Estuary and North Wind's Weir currently do not meet the target intertidal area (90% of 4,047 m^2 (1.0 acre) for both sites) of Physical Success Criterion 1. Herring's House exceeds the specified target intertidal area (90% of 8,094 m^2 (2.0 acres)) of Physical Success Criterion 1.

Tidal Regime
The Hamm Creek and Herring's House restoration sites were not scheduled for tidal regime monitoring in 2003. Tidal exchange between the North Wind's Weir restoration site and the Duwamish River is unimpeded, and currently meets Physical Success Criterion 2.

Slope Erosion
Visual inspections and photographic documentation at Hamm Creek Estuary indicate significant erosion occurred along the north bank of Hamm Creek (does not meet Physical Success Criterion 3). Several corrective actions have been employed by other entities to control this erosion, and erosion at the site appears to have slowed. Herring's House has remained stable since construction, with no obvious movement of sediments detected (meets Physical Success Criterion 3). The North Wind's Weir site showed no signs of erosion during the first year since construction.

Sediment Structure
Surveys and analyses of sediment structure at the Hamm Creek Estuary restoration and reference sites showed a decrease in grain size and an increase in total organic carbon, meeting Physical Success Criterion 4. Since the Herring's House restoration and reference sites showed an increase in grain size and a decrease in total organic carbon, the site does not meet Physical Success Criterion 4. The success or failure of North Wind's Weir restoration site to meet Physical Success Criterion 4 cannot be determined because this was the first year after construction.

Sediment Quality (Herring's House only)
No noticeable migration of riprap or soils occurred at the Herring's House restoration site (meets part of Physical Success Criterion 5). Following discussions with cooperators this year, the EB/DRP Panel decided not to install monitoring wells at the Herring's House site, therefore it is not possible to determine the status of Physical Success Criterion 5.

Biological Characteristics

Marsh Vegetation
Total areal extent of marsh vegetation at the Hamm Creek Estuary restoration site decreased since 2002 and does not meet part of Biological Success Criterion 1. Herring's House restoration site also had a decrease in areal extent of marsh vegetation, but the 3% decline seems to be within the range of the measurement error. Changes in marsh vegetation patch areas indicate that the area of target vegetation species (Lyngby's sedge and bulrush) increased at Hamm Creek Estuary and Herring's House restoration sites since construction of the sites and meet part of Biological Success Criterion 1. Species composition of native wetland plants is not comparable to appropriate reference sites (does not

meet Biological Success Criterion 2). Plant vigor is better at the reference sites than at the respective restoration sites (does not meet Biological Success Criterion 3).

Riparian Vegetation Establishment

None of the sites currently meet all of Biological Success Criteria 4 and 5.

Areal Extent

From 2002 to 2003, the total areal extent of riparian vegetation increased at the Hamm Creek Estuary and Herring's House restoration sites and meet Biological Success Criterion 4. Criterion 4 cannot yet be assessed for the North Wind's Weir site.

Percent Cover of Vegetation Layers

At the Hamm Creek Estuary restoration site, percent cover of herbaceous and tree layers met the goals of Biological Success Criterion 4, but the shrub layer did not. At the Herring's House restoration site, the percent cover of the tree layer meets Biological Success Criterion 4, but the herbaceous and shrub layers did not meet the criterion. Criterion 4 cannot yet be assessed for the North Wind's Weir site.

Nonnative Species

Scot's broom and Himalayan blackberry were present at the Hamm Creek Estuary, North Wind's Weir, and Herring's House restoration sites. From 2002 to 2003, the percent cover of all nonnative species at the restoration sites increased and currently comprise 21% (Hamm Creek Estuary), 21% (North Wind's Weir), and 18% (Herring's House) of the sites, well above the maximum 10% goal specified by the monitoring plan.

Survival

While recorded survival was high for the restoration sites, these numbers may be misleading, due to enhancement and vegetation control at the sites. Currently all sites meet Biological Success Criterion 5.

Bird Use

Numbers of bird species are similar between the Hamm Creek Estuary, Herring's House, and North Wind's Weir restoration sites and their respective reference sites (meets Biological Criterion Success 6).

Fish Presence/Access

Sampling for fish presence/access of the Hamm Creek Estuary, Herring's House, and North Wind's Weir restoration sites indicates that salmonids and other estuarine fish species were able to access the sites and that Biological Success Criterion 7 is currently being met.

Invertebrate Prey Resource Production

The draft report from J. Cordell (University of Washington) is pending.

RECOMMENDATIONS

- **General recommendations for cooperative action at the sites:** In addition to the monitoring activities being conducted as part of the Elliott Bay/Duwamish Restoration Program (EBDRP), other monitoring, restoration, and construction activities are being conducted near or on the restoration and reference sites. These activities are being conducted by a variety of different entities in the Duwamish River Estuary and include volunteer monitoring, research, and management of the sites. We recommend that the EBDRP Panel include a discussion in one of their meetings on ways to ensure more effective coordination with the various entities working in the area. A process should be identified a minimum of 3 months prior to the start of the 2005 monitoring activities for the EBDRP.

- **Loss of vegetation reference sites:** The EBDRP Panel needs to discuss the continued monitoring of the reference sites a minimum of 3 months prior to the start of the 2005 monitoring activities. The Herring's House vegetation reference site was planted and fenced this year by another entity. The additional plantings of *Carex* and *Scirpus* species will impede our ability to distinguish future expansion of the original vegetation patches from the new plantings. The Hamm Creek and North Wind's Weir vegetation reference site is scheduled for construction activity from the restoration of the adjoining uplands of the site by the U.S. Army Corps of Engineers. Because of these alterations to the reference site, the EBDRP Panel needs to decide if they want to continue the monitoring of these sites or identify new reference sites.

- **Immediate action needed:** A focused, coordinated effort to control nonnative vegetation is needed at the restoration sites. Of particular concern is the presence of perennial pepperweed, which has been observed at two sites. Control of seed production of this Class B noxious weed is required in King County, and may be a recurring problem due to the presence of this plant on adjacent property. Himalayan blackberry and Scot's broom have also been identified as problematic because of their spread.

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APPENDICES

Appendix 1.1. Total organic content and grain size of sediment cores taken at the Hamm Creek estuary and reference site.

					Grain Size								
		TOC (%)			Sand (%)			Silt (%)			Clay (%)		
Site	**Sample #**	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Hamm Creek Estuary	**1**	0.3	0.4	0.5	85	40	55	12	55	38	3	5	7
	2	2	0.4	0.4	60	92	73	35	5	23	5	3	4
	3	0.9	0.5	0.5	58	57	53	34	38	40	8	5	7
	4	0.8	0.9	1	60	65	35	32	30	51	8	5	14
	5	0.4	0.4	2.2	53	50	19	39	42	63	8	8	18
	6	1.1	1.5	1.4	68	20	45	27	60	48	5	20	7
	7			0.5			63			33			4
	8			1.2			68			26			6
	9			1			57			34			9
	10			0.8			60			35			5
	mean	0.9	0.7	1.0	64	54	53	30	38	39	6	8	8
Hamm Creek Reference	**1**	1	0.8	3.4	73	77	51	24	18	37	3	5	12
	2	0.4	0.5	1.3	98	95	68	2	2	25	2	3	7
	3	0.3	0.4	0.8	95	97	81	2	1	15	3	3	4
	4	0.2	0.4	1.6	90	95	51	5	2	36	5	3	13
	5	0.6	0.4	2.1	80	97	57	15	1	31	5	3	12
	6	2.1	0.9	0.9	60	77	79	35	18	16	5	5	5
	7			0.3			93			5			2
	8			0.4			92			6			2
	9			0.2			97			2			2
	10			0.3			96			3			2
	mean	0.8	0.6	1.1	83	90	77	14	7	18	4	4	6

Appendix 1.2. Total organic content and grain size of sediment cores taken at the Herring's House restoration and reference site.

					Grain Size								
		TOC (%)			Sand (%)			Silt (%)			Clay (%)		
Site	**Sample #**	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
	Vegetated												
Herring's House	1	5.4	3.0	0.7	75	70	92	20	22	6	5	8	2
	2	6.8	14.8	1.8	78	62	91	17	28	7	5	10	2
	3	5.4	2.4	11.5	80	77	78	15	18	12	5	5	10
	4	-	-	4.9	-	-	58	-	-	30	-	-	12
	5	-	-	7.9	-	-	51	-	-	35	-	-	14
	mean	**5.9**	**6.7**	**5.4**	**78**	**70**	**74**	**17**	**23**	**18**	**5**	**8**	**8**
	Unvegetated												
	1	1.9	2.4	2	83	65	87	12	25	8	5	10	5
	2	4.2	1.4	2.3	80	91	90	15	5	6	5	4	4
	3	6.3	1.4	4.5	75	80	83	17	15	10	8	5	7
	4	-	-	3.2	-	-	67	-	-	22	-	-	11
	5	-	-	2.8	-	-	76	-	-	18	-	-	6
	mean	**4.1**	**1.7**	**3.0**	**79**	**79**	**81**	**15**	**15**	**13**	**6**	**6**	**7**
	Vegetated												
Herring's House Reference	1	2.2	1.0	2.0	93	95	92	4	1	4	3	5	4
	2	2.4	1.3	8.8	93	90	79	4	7	13	3	3	8
	3	2.9	0.5	1.4	90	95	94	5	2	5	5	3	2
	4	-	-	3	-	-	88	-	-	8	-	-	4
	5	-	-	2.6	-	-	90	-	-	7	-	-	3
	mean	**2.5**	**0.9**	**3.6**	**92**	**93**	**89**	**4**	**3**	**7**	**4**	**4**	**4**
	Unvegetated												
	1	1.2	1.9	2.2	83	72	80	12	23	13	5	5	6
	2	2.4	0.7	1.3	75	22	84	20	65	11	5	13	5
	3	3.2	1.3	4.5	83	72	70	14	20	20	3	8	10
	4	-	-	7.1	-	-	67	-	-	20	-	-	13
	5	-	-	1.5	-	-	60	-	-	32	-	-	8
	mean	**2.3**	**1.3**	**3.3**	**80**	**55**	**72**	**15**	**36**	**19**	**4**	**9**	**8**

Appendix 1.3. Total organic content and grain size of sediment cores taken at the North Wind's Weir restoration and reference site.

					Grain Size								
	Sample	TOC (%)			Sand (%)			Silt (%)			Clay (%)		
Site	#	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
North Wind's Weir	**Vegetated**												
	1	-	-	0.8	-	-	57	-	-	39	-	-	4
	2	-	-	2.9	-	-	44	-	-	48	-	-	8
	3	-	-	1.2	-	-	78	-	-	20	-	-	2
	4	-	-	0.7	-	-	57	-	-	38	-	-	5
	5	-	-	1.4	-	-	33	-	-	60	-	-	7
	mean			**1.4**			**54**			**41**			**5**
	Unvegetated												
	1	-	-	1	-	-	52	-	-	41	-	-	7
	2	-	-	2.5	-	-	34	-	-	56	-	-	10
	3	-	-	2	-	-	38	-	-	52	-	-	10
	4	-	-	2.2	-	-	28	-	-	61	-	-	11
	5	-	-	0.8	-	-	59	-	-	36	-	-	5
	mean			**1.7**			**42**			**49**			**9**
North Wind's Weir Reference	**Vegetated**												
	1	-	-	6.7	-	-	11	-	-	75	-	-	14
	2	-	-	6.6	-	-	11	-	-	73	-	-	16
	3	-	-	3.3	-	-	45	-	-	46	-	-	9
	4	-	-	4.2	-	-	39	-	-	49	-	-	12
	5	-	-	3.9	-	-	45	-	-	45	-	-	10
	mean			**4.9**			**30**			**58**			**12**
	Unvegetated												
	1	-	-	1.6	-	-	51	-	-	40	-	-	9
	2	-	-	1.5	-	-	58	-	-	34	-	-	8
	3	-	-	1.8	-	-	61	-	-	32	-	-	7
	4	-	-	1.3	-	-	74	-	-	22	-	-	4
	5	-	-	0.9	-	-	78	-	-	18	-	-	4
	mean			**1.4**			**64**			**29**			**6**

Appendix 2. Riparian plant species observed in transect plots at the Hamm Creek Estuary, Herring's House, and North Wind's Weir restoration sites in 2001, 2002, and 2003. An asterisk ("*") denotes species included in nonnative vegetation percent cover estimates.

Scientific name	Common name	Scientific name	Common name
Abies grandis	Grand fir	*Mahonia sp.*	Oregon-grape
Acer circinatum	Vine maple	*Malus fusca*	Pacific crab apple
Acer macrophyllum	Big leaf maple	*Medicago hispida*	Japanese clover (=bur clover)*
Agrostis sp.	Bentgrass	*Melilotus alba*	White sweet clover*
Alnus rubra	Red alder	*Oemleria cerasiformis*	Indian-plum
Amelanchier alnifolia	Serviceberry	*Oxalis sp.*	Oxalis
Ammophila arenaria	Beach grass	*Phalaris arundinacea*	Reed canarygrass*
Anthemis cotula	Dog fennel*	*Philadelphus lewisii*	Mock orange
Arbutus menziesii	Pacific madrone	*Physocarpus capitatus*	Pacific ninebark
Arctostaphylos uva-ursi	Kinnikinnick	*Picea sitchensis*	Sitka spruce
Asclepias sp.	Milkweed*	*Pinus contorta*	Lodge pole pine
Betula sp.	Birch	*Plantago sp.*	Plantain*
Bromus sp.	Bromegrass*	*Poa sp.*	Bluegrass
Buddleja sp.	Butterfly bush*	*Polygonum* sp.	Smartweed*
Chenopodium album	Lambsquarter*	*Polystichum munitum*	Western swordfern
Cirsium arvense	Canada thistle*	*Populus balsamifera ssp. trichocarpa*	Black cottonwood
Cirsium vulgare	Bull thistle*	*Pseudotsuga menziesii*	Douglas-fir
Conium inaculatum	Poison hemlock*	*Quercus sp.*	Oak
Convolvulus arvenis	morning glory*	*Rabinia sp.*	Black locust
Cornus stolonifera	Red-osier dogwood	*Ranunculus repens*	Creeping buttercup*
Crataegus douglasii	Black hawthorne	*Rhamnus purshiana*	Cascara
Cytisus scoparius	Scot's broom*	*Ribes sanguineum*	Red-flowering currant
Dactylis glomerata	Orchardgrass	*Rosa nutkana*	Nootka rose
Daucus carota	Queen Anne's lace*	*Rubus discolor*	Himalayan blackberry*
Elytrigia repens	Quackgrass	*Rubus laciniatus*	Evergreen blackberry*
Epilobium angustifolium	Fireweed	*Rubus parviflorus*	Thimbleberry
Epilobium sp.	Willowherb	*Salix hookeriana*	Hooker's willow
Equisetum sp.	Horsetail	*Salix lucida ssp. lasiandra*	Pacific willow
Festuca arundinacea	Tall fescue	*Salix sitchensis*	Sitka willow
Festuca rubra	Red fescue	*Senecio vulgaris*	Common groundsel
Fragaria sp.	Strawberry*	*Spiraea douglasii ssp. douglasii*	Hardhack
Holcus lanatus	Common velvetgrass	*Symphoricarpos albus*	Common snowberry
Holodiscus discolor	Ocean spray	*Tanacetum vulgare*	Common tansy*
Hypericum sp.	St. John's wort*	*Taraxacum officinale*	Dandelion
Hypochaeris radicata	Hairy cat's-ear*	*Thuja plicata*	Western redcedar
Juncus bufonius	Toad rush	*Trifolium pratense*	Red clover
Lactuca serriola	Prickly lettuce*	*Trifolium repens*	White clover
Lolium perenne	Ryegrass*	*Trifolium sp.*	Clover
Lonicera involucrata	Black twinberry	*Vixia sp.*	Vetch
Lotus corniculatus	Birdsfoot trefoil*		

Appendix 3.1. List of birds observed at the Hamm Creek Estuary, Herring's House, and North Wind's Weir restoration and reference sites in 2001, 2002, and 2003.

Common Name	Scientific Name
Geese	
Canada goose	*Branta canadensis*
Dabbling Ducks	
Gadwall	*Anas strepera*
Mallard	*Anas platyrhynchos*
Green-winged teal	*Anas crecca*
Diving Ducks	
Bufflehead	*Bucephala albeola*
Barrows goldeneye	*Bucephala islandica*
Common goldeneye	*Bucephala clangula*
Common merganser	*Mergus merganser*
Red-breasted merganser	*Mergus serrator*
Hooded merganser	*Lophodytes cucullatus*
Waterbirds/Seabirds	
Double-crested cormorant	*Phalacrocorax auritus*
Pied-billed grebe	*Podilymbus podiceps*
Western grebe	*Aechmophorus occidentalis*
Waders	
Great blue heron	*Ardea herodias*
Green heron	*Butorides virescens*
Shorebirds	
Killdeer	*Charadrius vociferous*
Spotted sandpiper	*Actitis macularia*
Western sandpiper	*Calidris mauri*
Greater yellowlegs	*Tringa melanoleuca*
Common snipe	*Capella gallinago*
Gulls/Terns	
California gull	***Larus californicus***
Glaucous-winged gull	***Larus glaucescens***
Mew gull	***Larus canus***
Ring-billed gull	***Larus delawarensis***
Caspian tern	*Sterna caspia*
Raptors	
Osprey	*Pandion haliaetus*
Red-tailed hawk	*Buteo jamaicensis*
Cooper's hawk	*Accipiter cooperii*
Bald eagle	*Haliaeetus luecocephalus*
Other piscivores	
Belted kingfisher	*Ceryle alcyon*

Common Name	Scientific Name
Woodpeckers	
Northern flicker	*Colaptes auratus*
Downy Woodpecker	*Picoides pubescens*
Swallows	
Purple martin	*Progne subis*
Barn swallow	*Hirundo rustica*
Cliff swallow	*Petrochelidon pyrrhonota*
Northern rough-winged swallow	*Stelgidopteryx serripennis*
Violet green swallow	*Tachycineta thalassina*
Tree swallow	*Tachycineta bicolor*
Sparrows/Finches	
Song sparrow	*Melospiza melodia*
White-crowned sparrow	*Zonotrichia leucophrys*
Savannah sparrow	*Passerculus sandwichensis*
American goldfinch	*Carduelis tristis*
Pine Siskin	*Carduelis pinus*
Purple finch	*Carpodacus purpureus*
House finch	*Carpodacus mexicanus*
Other Passerines	
Cedar waxwing	*Bombycilla cedrorum*
Black-capped chickadee	*Poecile atricapilla*
Bushtit	*Psaltriparus minimus*
Marsh wren	*Cistothorus palustris*
Bewick's wren	*Thryomanes bewickii*
Ruby-crowned kinglet	*Regulus calendula*
Golden-crowned kinglet	*Regulus satrapa*
Orange-crowned warbler	*Vermivora celata*
Yellow-rumped warbler	*Dendroica coronata*
Yellow warbler	*Dendroica petechia*
Common yellowthroat	*Geothlypis trichas*
Unidentified oriole	*Icterus sp.*
Red-winged blackbird	***Agelaius phoeniceus***
Brown-headed cowbird	***Molothrus ater***
Human associated species	
American robin	*Turdus migratorius*
Crow	*Corvus* sp.
Nonnative Species	
Domestic goose	*Anser* sp.
Rock dove/Pigeon	*Columba livia*
European starling	*Sturnus vulgaris*
House sparrow	*Passer domesticus*

Appendix 3.2 Numbers of birds at Hamm Creek Estuary restoration site and associated reference site during quarterly surveys in 2001, 2002, and 2003.

	2001 survey								2002 survey								2003 survey							
	Hamm Cr				Turning Basin				Hamm Cr				Turning Basin				Hamm Cr				Turning Basin			
	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec
Waterfowl																								
Canada goose	-	18	29	10	44	1	16	-	44	-	-	-	4	-	12	-	13	8	-	-	4	-	13	5
Gadwall	4	4	1	31	8	-	8	4	9	1	-	34	12	-	-	10	14	-	-	18	4	-	-	-
Mallard	4	13	15	20	23	4	53	14	3	9	5	47	4	2	38	16	5	9	9	50	-	5	34	-
Green-winged teal	-	-	-	4	11	-	-	-	10	-	-	-	-	-	-	-	10	-	-	-	2	-	-	-
Bufflehead	-	-	-	-	60	-	-	-	-	-	-	7	8	-	-	-	-	-	-	-	-	-	-	2
Barrow's goldeneye	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common goldeneye	-	-	-	-	-	-	-	11	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Goldeneye spp.	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
Red-breasted merganser	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common merganser	4	16	-	-	2	-	-	-	-	10	-	-	-	-	2	-	-	-	-	4	1	-	-	-
Hooded merganser	-	-	-	2	-	-	-	-	1	-	-	6	-	-	-	-	2	-	-	-	-	-	-	-
Merganser spp.	-	-	-	-	6	1	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	15	-
Gull/Terns/Waterbirds																								
California gull	-	-	-	-	-	-	4	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Glaucous-winged gull	-	-	-	-	-	-	2	-	-	-	-	2	-	-	1	-	3	-	-	10	6	-	5	1
Mew gull	-	-	-	-	-	1	-	-	-	-	-	-	-	-	5	-	-	-	-	-	39	-	6	-
Ring-billed gull	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2	-
Herring gull	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
Gull spp	-	-	-	5	56	-	-	4	-	-	-	-	4	-	1	-	-	3	-	2	-	2	1	-
Caspian tern	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tern spp	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piped bill grebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Western grebe	4	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Double-crested cormorant	-	-	-	3	-	-	-	10	-	-	1	-	-	-	2	1	2	-	1	4	11	-	1	2
Wading birds																								
Great blue heron	-	-	2	2	-	-	-	1	-	3	3	2	-	-	1	-	-	3	2	2	-	1	-	-
Shorebirds																								
Killdeer	1	3	-	-	3	3	28	-	-	-	-	-	-	4	1	-	1	-	-	-	1	3	13	-
Greater yellowlegs	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spotted sandpiper	-	2	-	-	-	1	-	-	-	2	-	-	-	5	-	-	-	-	-	-	-	-	-	-
Common Snipe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-
Raptors																								
Bald eagle	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Red tailed hawk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Hawk sp.	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Osprey	-	-	4	-	1	-	1	-	-	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-

	2001 survey								2002 survey								2003 survey							
	Hamm Cr				Turning Basin				Hamm Cr				Turning Basin				Hamm Cr				Turning Basin			
	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec
Kingfishers																								
Belted kingfisher	-	-	3	-	-	1	-	-	1	-	1	-	-	-	2	2	1	1	1	4	-	-	2	-
Passerines																								
Barn swallow	-	2	-	-	-	2	-	-	-	5	4	-	-	3	-	-	-	1	-	-	-	-	-	-
Cliff swallow	-	-	-	-	-	1	-	-	-	7	2	-	-	-	4	-	-	-	-	-	-	-	-	-
Tree swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
N. rough-winged swallow	-	-	-	-	-	2	-	-	-	2	-	-	-	12	-	-	-	1	-	-	-	-	-	-
Violet-green swallow	-	10	-	-	-	2	-	-	-	2	-	-	-	1	-	-	-	1	-	-	-	-	-	-
Swallow spp.	-	7	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cedar waxwing	-	-	-	-	-	-	-	-	-	-	1	-	-	-	9	-	-	-	-	-	-	1	-	-
Black-capped chickadee	-	-	-	-	-	1	-	-	-	-	-	-	-	-	4	1	-	-	2	-	-	9	-	1
Bewick's wren	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	1
Marsh wren	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
Wren spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	2	-	1	1	-
Golden-crowned kinglet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Ruby-crowned kinglet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Orange-crowned warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-
Pine siskin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-
Bush tit	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-
Song sparrow	1	-	-	-	2	2	2	-	3	2	3	7	1	5	8	9	8	4	2	2	5	4	5	6
Savannah sparrow	-	-	-	-	-	-	-	-	-	-	4	1	-	-	-	-	-	-	26	-	-	-	-	-
White-crowned sparrow	-	-	-	4	-	-	-	-	-	-	4	32	-	-	-	-	5	4	18	6	-	-	8	-
Sparrow spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	4	-	-	2	2
American goldfinch	-	2	4	-	-	1	-	-	-	2	2	-	-	-	5	15	-	7	2	-	8	-	5	12
Purple finch	-	-	42	-	1	-	10	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
House finch	-	20	-	-	-	1	-	-	-	-	76	-	-	-	2	2	-	35	23	2	-	15	-	-
Passerine spp.	-	6	14	4	5	3	-	-	-	-	-	1	-	-	-	2	-	-	-	-	1	-	-	-
Finch spp.	-	-	-	-	-	-	-	-	-	4	-	-	-	-	3	-	-	-	-	-	-	-	-	-
American robin	-	1	1	-	-	2	-	-	-	6	-	-	2	3	3	3	6	1	-	-	5	4	-	-
Crow	11	4	2	-	1	-	-	1	1	3	3	-	-	2	1	2	9	1	2	-	1	2	2	9
Red-winged blackbird	-	3	-	-	5	4	-	-	-	2	-	-	1	7	1	1	-	5	-	-	14	17	1	1
Nonnatives																								
Rock dove/Pigeon	-	-	-	-	-	-	-	-	2	-	-	-	-	-	2	-	3	2	1	-	21	-	-	-
European starling	8	1	70	5	1	1	-	-	1	1	7	25	-	9	7	-	456	6	220	-	35	9	-	-
House sparrow	-	2	-	-	-	-	-	-	-	2	-	-	-	-	2	-	-	7	-	-	-	-	-	-
Total number of birds	37	114	189	91	239	34	128	47	80	71	116	170	40	54	128	69	539	105	314	112	171	76	117	42
Total number of species	**8**	**17**	**14**	**12**	**20**	**22**	**10**	**8**	**12**	**19**	**15**	**13**	**9**	**12**	**30**	**15**	**16**	**22**	**16**	**14**	**21**	**15**	**20**	**12**

Appendix 3.3. Number of birds seen at the Herring's House restoration and reference sites during quarterly surveys in 2001, 2002, and 2003.

	2001 survey								2002 survey								2003 survey							
	Herring's House				Kellogg Island				Herring's House				Kellogg Island				Herring's House				Kellogg Island			
	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec
Waterfowl																								
Canada goose	31	-	21	54	62	69	55	15	17	2	-	-	33	71	2	-	-	27	-	-	29	70	-	12
Gadwall	32	-	1	36	14	-	-	2	46	-	-	15	5	-	-	8	21	-	-	20	2	-	-	-
Mallard	7	-	29	108	11	1	17	1	4	-	45	50	22	-	4	2	4	16	75	24	2	16	26	45
Green-winged teal	-	-	-	-	-	-	-	-	5	-	-	17	3	-	-	10	1	-	-	10	8	-	-	2
Bufflehead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2	-	-	-
Barrow's goldeneye	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common goldeneye	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
Red-breasted merganser	-	-	-	-	-	-	-	8	2	-	-	-	2	1	-	-	-	-	-	-	3	-	-	5
Common merganser	-	-	-	-	-	-	-	3	-	-	-	-	-	-	24	11	-	-	-	-	1	5	-	-
Hooded merganser	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	4	-	-	-	2	1	-	-	-
Merganser spp.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	36	-
Gull/Terns/Waterbirds																								
Glaucous-winged gull	-	-	2	-	-	-	-	-	-	-	-	-	-	-	16	16	-	-	-	-	11	-	25	20
Mew gull	-	-	-	-	-	-	-	45	-	-	-	-	-	-	18	-	-	-	-	-	41	-	5	-
Ring-billed gull	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	7	-	-	-	-	-	-	20	-
Gull spp	-	-	-	7	223	-	74	243	-	-	-	2	26	-	11	8	2	4	1	4	28	2	18	4
Caspian tern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Tern spp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Pied-bill grebe	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Western grebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Double-crested cormorant	-	-	-	1	1	-	-	-	1	-	-	-	-	-	3	17	-	-	-	-	5	-	-	61
Wading birds																								
Great blue heron	2	-	-	1	-	-	-	-	1	1	-	-	1	1	-	1	1	-	-	-	-	1	4	-
Shorebirds																								
Killdeer	4	3	4	-	-	5	2	-	-	12	1	-	-	2	4	24	-	14	3	-	-	12	36	-
Spotted sandpiper	-	1	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	1	-	-	-	-	-	-
Sandpiper spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	2	-
Shorebird spp.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Raptors																								
Bald eagle	-	-	-	1	1	3	-	-	2	-	-	-	-	2	-	1	-	-	-	1	-	1	-	1
Red tailed hawk	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Osprey	-	-	-	-	1	-	-	-	-	1	-	-	-	1	2	-	-	3	1	-	-	-	4	-
Cooper's hawk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-

Appendix 3.3, continued.

	2001 survey								2002 survey								2003 survey							
	Herring's House				Kellogg Island				Herring's House				Kellogg Island				Herring's House				Kellogg Island			
	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec
Kingfishers																								
Belted kingfisher	1	2	2	-	1	3	2	-	-	-	1	1	-	2	2	2	-	-	-	-	-	2	1	-
Passerines																								
Barn swallow	-	1	3	-	-	-	-	-	-	-	4	-	-	2	-	-	-	4	-	-	-	2	-	-
Cliff swallow	-	5	-	-	-	2	-	-	-	1	12	-	-	-	-	-	-	-	-	-	-	1	-	-
Tree swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
N. rough-winged swallow	-	-	4	-	-	-	-	-	-	-	-	-	-	11	-	-	-	4	-	-	-	2	-	-
Violet-green swallow	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	3	-	-	-	1	-	-
Black-capped chickadee	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	11	-	-	-	-	-	-
Pine siskin	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	2	-	-	-	-	-	-	-
Bush tit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-
Song sparrow	-	-	20	-	-	-	-	-	4	3	2	14	-	2	-	-	4	2	2	2	-	2	-	-
White-crowned sparrow	-	-	2	-	-	-	-	-	-	3	12	-	-	-	-	-	2	2	7	-	-	-	-	-
Sparrow spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	-	-	-	-	-
American goldfinch	-	3	-	-	-	-	-	-	-	6	11	12	-	-	-	-	4	7	35	3	-	1	1	-
Purple finch	-	-	8	-	-	-	-	-	6	6	-	-	-	3	-	-	-	-	-	-	-	-	-	-
House finch	-	-	-	23	-	-	-	-	-	-	50	35	-	-	-	-	-	2	21	3	-	-	2	-
Finch spp.	-	-	-	-	8	-	-	-	-	5	-	-	-	-	-	13	-	-	-	-	-	-	-	-
Passerine spp.	-	4	-	3	-	2	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
American robin	-	1	-	-	-	1	-	-	2	1	1	-	-	-	-	-	3	2	12	29	-	-	-	-
Crow	14	-	2	9	14	2	10	10	-	1	2	-	15	-	16	7	4	5	4	-	27	10	12	17
Red-winged blackbird	-	-	-	-	15	-	-	-	-	-	-	-	-	14	-	-	-	1	-	2	7	1	-	30
Yellow warbler	-	-	-	-	-	-	-	-	-	-	1	17	-	-	-	-	-	-	-	9	-	-	-	-
Warbler spp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Brown-headed cowbird	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Purple martin	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-	-	-	2	-	-	-	3	-	-
Oriole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Woodpecker																								
Northern flicker	-	-	-	2	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1	-	-	1	1	-
Nonnatives																								
Rock dove/Pigeon	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-
European starling	32	4	350	40	7	8	170	-	2	113	100	7	-	716	45	-	13	68	155	24	-	1	443	-
House sparrow	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-
Domestic Goose	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Total number of birds	**123**	**27**	**448**	**286**	**358**	**98**	**332**	**327**	**98**	**159**	**243**	**180**	**111**	**840**	**155**	**132**	**65**	**185**	**342**	**133**	**174**	**137**	**636**	**197**
Total number of species	**8**	**11**	**13**	**13**	**12**	**12**	**9**	**8**	**13**	**16**	**14**	**14**	**9**	**16**	**15**	**16**	**13**	**22**	**15**	**13**	**17**	**21**	**16**	**10**

Appendix 3.4. Number of birds seen at the North Wind's Weir restoration and reference sites during quarterly surveys in 2001, 2002, and 2003.

	2003 survey							
	North Wind's Weir				Turning Basin			
	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec
Waterfowl								
Canada goose	-	-	-	-	4	-	13	5
Gadwall	-	-	-	-	4	-	-	-
Mallard	1	6	-	-	-	5	34	-
Green-winged teal	-	-	-	-	2	-	-	-
Bufflehead	-	-	-	-	-	-	-	2
Common merganser	-	-	-	-	1	-	-	-
Merganser spp.	-	-	2	1	-	-	15	-
Gull/Terns/Waterbirds								
Glaucous-winged gull	-	-	6	-	6	-	5	1
Mew gull	-	-	-	-	39	-	6	-
Ring-billed gull	-	-	-	1	-	-	2	-
Gull spp	-	-	-	1	-	2	1	-
Piped-bill grebe	-	-	-	-	-	-	1	-
Double-crested cormorant	2	-	-	5	11	-	1	2
Wading birds								
Great blue heron	-	2	-	1	-	1	-	-
Shorebirds								
Killdeer	-	8	-	-	1	3	13	-
Sandpiper spp.	-	4	-	-	-	-	-	-
Common Snipe	-	-	-	-	1	-	-	-
Raptors								
	-	-	-	-	-	-	-	-
Kingfishers								
Belted kingfisher	3	2	2	-	-	-	2	-
Passerines								
Barn swallow	-	4	-	-	-	-	-	-
Cedar waxwing	-	-	-	-	-	1	-	-
Black-capped chickadee	4	20	3	8	-	9	-	1
Bewick's wren	-	4	-	-	2	2	-	1
Wren spp.	-	-	-	-	-	1	1	-
Golden-crowned kinglet	-	-	-	-	2	-	-	-
Ruby-crowned kinglet	1	-	-	-	-	-	-	-
Pine siskin	-	-	-	-	6	-	-	-
Bush tit	-	-	-	9	2	1	-	-
Song sparrow	1	22	-	1	5	4	5	6
White-crowned sparrow	-	-	-	-	-	-	8	
Sparrow ssp.	-	-	-	-	-	-	2	2
American goldfinch	-	-	-	-	8	-	5	12
House finch	-	16	-	-	-	15	-	-
Passerine spp.	-	5	-	-	1	-	-	-
American robin	4	14	1	1	5	4	-	-
Crow	5	18	7	8	1	2	-	9
Red-winged blackbird	-	-	-	-	14	17	1	1
Yellow-rumped warbler	-	-	-	1	-	-	-	-
Woodpeckers								
Downy woodpecker	-	1	-	-	-	-	-	-
Northern flicker	-	-	-	1	-	-	-	-
Nonnatives								
Rock dove/Pigeon	-	-	-	-	21	-	-	-
European starling	-	22	35	-	35	9	-	-
House sparrow	-	11	-	-	-	-	-	-
Total number of birds	**21**	**159**	**56**	**38**	**171**	**76**	**115**	**42**
Total number of species	**8**	**16**	**7**	**12**	**21**	**15**	**20**	**12**

Appendix 4.1. Forklength (mm) of salmonids sampled at the Hamm Creek Estuary Restoration site, 2001-2003. SD=standard deviation, n=number of fish measured.

	Chum			Coho			Steelhead			Cutthroat		
Date	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
03/05/2001	39.5	1.31	8									
03/21/2001	36.9	3.19	30									
04/11/2001	37.4	3.58	30									
04/25/2001	40.1	2.81	30	125		1						
05/08/2001			0									
05/23/2001	45.3	5.56	30	62.5	6.36	2						
06/05/2001	60.4	10.93	12	71.8	4.27	5						
03/04/2002	37.2	5.09	30									
03/19/2002	28.0		1									
04/02/2002	38.1	1.85	30							300		1
04/15/2002	38.5	2.64	30	37		1						
04/29/2002	39.2	3.18	30	40		1						
05/13/2002	38.7	1.97	32	54.7	4.84	6						
05/28/2002	41.3	5.28	30	65	7.72	7						
04/02/2003	36.8	3.62	28									
04/16/2003	37.6	6.20	30									
04/30/2003	41.7	5.44	30									
05/14/2003	47.5	6.52	31									
05/28/2003	53.5	16.26	2									
06/11/2003	67.0	8.49	2									

Appendix 4.2. Forklength (mm) of salmonids sampled at the Hamm Creek and North Wind's Weir reference site (Turning Basin), 2001-2003. SD=standard deviation, n=number of fish measured.

	Chum			Coho			Steelhead			Cutthroat		
Date	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
04/04/2001	37.5	3.40	31									
04/25/2001	38.9	4.54	30									
05/10/2001	46.9	7.38	30							270.0	43.84	2
05/30/2001	51.5	5.62	17	140.0		1						
06/13/2001							185.0		1			
03/05/2002	39.2	2.48	12									
03/25/2002	38.3	5.10	10									
04/03/2002	36.7	4.04	3									
04/16/2002	38.7	2.45	30	38.0		1						
04/30/2002	40.1	3.41	30	94.7	26.30	6	202.5	53.03	2			
04/30/2002 [1]				126.7	6.45	7						
05/14/2002	40.0	2.40	10	71.0	18.38	2	181.0	20.70	14			
05/14/2002 [1]							200.4	12.02	16			
05/29/2002	43.2	5.63	5	119.9	17.76	30						
06/12/2002	47.0		1	112.0	3.61	3						
04/03/2003	36.5	1.87	11	135.3	13.65	3				214.00		1.00
04/17/2003	39.3	5.85	30				206.3	12.37	6.00			
05/01/2003	42.0		2									
05/15/2003	47.0	3.32	29	78.0		1						
05/29/2003	5.5	5.50	28									
06/12/2003				105.0	8.49	2				214.00		1.00

[1] Forklength data for AD-clipped fish.

Appendix 4.3. Forklength (mm) of salmonids sampled at the Herring's House Restoration site, 2001-2003. SD=standard deviation, n=number of fish measured.

	Chum			Coho			Steelhead			Pink		
Date	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
03/06/2001	38		1									
04/10/2001	40.5	3.23	30									
04/26/2001	43	4.66	31									
05/09/2001	41	3.02	31									
05/24/2001	44.2	4.41	9									
06/06/2001	57	7.78	8									
03/04/2002	36.2	4.3	19									
03/19/2002	38.4	3.68	28									
04/02/2002	38.3	3.66	30									
04/15/2002	39.2	3.87	30									
04/15/2002[1]				148		1						
04/29/2002	38.6	1.85	30									
05/13/2002	40.2	2.12	53	108.8	13.02	11	225		1			
05/13/2002[1]				130		1						
05/28/2002				102		1						
06/11/2002	76.2	16.1	20	84.6	9.91	5						
04/02/2003	39.1	2.93	43	124	15.56	2						
04/03/2003	40.1	2.93	40							36.00		1.00
04/16/2003	44.8	8.03	88									
04/17/2003	45.8	9.13	58									
04/30/2003	41.5	4.50	20	108.0		1						
05/01/2003	40.1	3.34	9	117.7	24.95	6						
05/13/2003	50.5	12.45	8	107.0	2.83	6						
05/15/2003	45.7	3.87	45	111.8	19.42	10						
05/17/2003							194.5	14.85	2			
05/28/2003	51		1									

[1] Forklength data for AD-clipped fish.

Appendix 4.4. Forklength (mm) of salmonids sampled at the Herring's House reference site (Kellogg Island), 2001-2003. SD=standard deviation, n=number of fish measured.

	Chum			Coho			Steelhead			Cutthroat		
Date	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
03/07/2001	40.3	0.96	4									
03/22/2001	40	2.77	41									
04/04/2001	36.5	4.48	32									
04/25/2001	42.4	2.98	31									
05/10/2001	39.9	2.35	30	119.7	5.51	3						
05/30/2001	46.5	3.94	6									
03/05/2002	35.4	3.24	9									
03/25/2002	38.4	2.25	30									
04/03/2002	35		1									
04/16/2002	37.8	2.63	4									
04/30/2002	43.5	8.72	22	124		1						
05/14/2002	36.8	1.15	15									
05/29/2002	40.6	2.93	30									
06/12/2002	79	3	3									
04/03/2003	41		1									
04/17/2003	40.36	3.95	30									
05/01/2003	39.33	1.52	4									
05/15/2003				109		1						
05/29/2003	50.75	2.21	4									
06/12/2003	63		1									
07/10/2003	95		1									

Appendix 4.5. Forklength (mm) of salmonids sampled at the North Wind's Weir Restoration site, 2003. SD=standard deviation, n=number of fish measured.

	Chum			Coho			Steelhead			Cutthroat		
Date	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
04/16/2003	39.3	2.52	4									
04/30/2003	40.6	6.63	8									
05/14/2003	46.4	4.75	39	112.88	23.66	9						
05/28/2003	55.0	2.65	4									
06/11/2003				51		1				199		1