Elliott Bay/Duwamish Restoration Program:
Year 1 Intertidal Habitat Projects Monitoring Report

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Report prepared for the Elliott Bay/Duwamish Restoration Program Panel

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Elliott Bay/Duwamish Restoration Program
Year 2001 Monitoring Report

The U. S. Fish and Wildlife Service (Service) initiated the monitoring component of the Elliott Bay/Duwamish Restoration Program (EB/DRP) during the winter of 2000/2001. One goal of the EB/DRP is to restore intertidal habitats in Elliott Bay and the Duwamish River at selected sites (Figure 1). The monitoring component, as outlined in EB/DRP (2000), is a 10-year project to monitor the physical and biological characteristics of four restoration sites associated with the EB/DRP and their respective reference sites. The restoration sites have been described in detail (EB/DRP 2000). This report describes the 2001 (Year 1) monitoring implemented by the Service and subsequent analyses and results.

Figure 1. Location of the Elliott Bay/Duwamish Estuary Restoration Program sites (image courtesy of People For Puget Sound).

SITE INFORMATION

Year 1 Monitoring Sites

Monitoring efforts for 2001 have been limited to the Hamm Creek Estuary and the Herring's House (formerly Seaboard Lumber) sites, and their respective reference sites. It should be noted that monitoring efforts at Hamm Creek Estuary are limited to the mouth of Hamm Creek upstream to a point just above the confluence of the creek with the freshwater marsh (pictured in Appendix A).

Two of the original four restoration projects listed in EB/DRP (2000) have not yet been completed. Construction of the Kenco Marine and North Wind's Weir sites was initially scheduled for completion by fall/winter 2001, but has not yet occurred. Construction of these sites will begin pending finalization of environmental compliance and permitting processes. A start date for construction is unavailable at this time, and monitoring of these restoration sites will begin following completion of the projects.

All surveys were performed according to guidance outlined in the EB/DRP (2000) monitoring plan, unless otherwise specified.

Reference Areas

Location and the number of reference areas vary for each restoration site, based on the availability of similar sites and requirements for each monitoring parameter (Appendix B). For Hamm Creek, four reference sites were used. A natural area forming a peninsula (near a small creek adjacent to Turning Basin #3) was used as the reference site for both fish and bird surveys. Fish were surveyed at a beach just north of this site, while birds were surveyed in the estuary in the northern portion of the peninsula. A small marsh on the eastern bank of the Duwamish River, across from North Winds Weir, was used as a reference site for vegetation for Hamm Creek Estuary. The fourth reference area, for sediments and macroinvertebrates, consisted of a small fringe marsh located along the shoreline adjacent to the Hamm Creek Estuary, just above and below the restoration site.

For Herring's House, three reference sites were used. 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 northwest edge of Kellogg Island (directly across from the Puget Creek Estuary in Figure 1) was used as the reference site for bird surveys. The third reference site, for marsh vegetation, sediments and macroinvertebrates, has a small patch of naturally occurring vegetation (*Carex lyngbyei* and *Scirpus validus)* and was located just upstream of the Herring's House restoration site.

MONITORING CRITERIA

During the initial year of post-construction monitoring, 13 criteria were grouped under 10 different physical and biological parameters. Parameters (Table 1) consisted of a single criterion, with the exception of marsh vegetation establishment (3 criteria) and riparian vegetation establishment (2 criteria). The following sections describe, for each parameter, the methods and results of the 2001 surveys. Methods and results for parameters with multiple components and/or criteria are grouped together by subsection.

Table 1. Physical and biological criteria categories monitored at the Elliott Bay/Duwamish Restoration Program sites (from EB/DRP 2000).

Physical Criteria Category	Biological Criteria Category
Intertidal Area	Marsh Vegetation Establishment
Tidal Regime	Riparian Vegetation Establishment
Slope Erosion	Bird Use
Sediment Structure	Fish Access/Presence
Sediment Quality	Invertebrate Prey Resource Production

Physical Characteristics

Intertidal Area (Physical Success Criterion 1) Total restored area between an elevation of +12.0 Mean Low Low Water (MLLW) and –2.0 MLLW will be at least 90% of the target intertidal elevation for each site. Target intertidal areas for the Hamm Creek Estuary and Herring's House sites are 1.0 and 2.0 acres, respectively.

Comparison with As-built Surveys

The Hamm Creek and Herring's House sites were surveyed using a Spectra-Physics® *Laserplane* 500[1] laser level and standard surveying techniques (Harrelson et al. 1994) to survey a grid of the area (±0.003 cm equipment accuracy, ±0.127 cm sampling accuracy). The Hamm Creek survey was completed in January and February 2001, and the resulting data have been analyzed and stored using GIS/ArcView®[1] software. A preliminary survey was completed at the Herring's House site in February 2001. This preliminary survey consisted of benchmark establishment and spot-checking specific elevation points throughout the project noted in the as-built survey provided by the City of Seattle Department of Parks and Recreation. No obvious changes were detected at either site when compared with the as-built survey, which was conducted upon the projects' completion in 2000.

Calculations of Intertidal Areas

The intertidal area at Hamm Creek and Herring's House was mapped using the Trimble GeoExplorer 3[1] Global Positioning System (GPS). The data points were downloaded and

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

stored in GIS/ArcView software. The intertidal areas were then calculated for Hamm Creek and Herring's House (±5 m with differential correction).

The intertidal area estimated for Hamm Creek was 0.7 acres (2,833 m^2), lower than the value specified in the criterion description (90% of 1.0 acre). Alternatively, the intertidal area of Herring's House (2.1 acres or 8,499 m^2) was greater than the value in the criterion description (90% of 2.0 acres).

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.

Continuous-recording tide gages (Global Water Level Loggers) were installed within and adjacent to the Hamm Creek and Herring's House restoration sites to monitor tidal timing and magnitude within the restoration sites and in the mainstem Duwamish River adjacent to their respective restoration sites (accuracy: 0.2% overall, 0.1% linearity). Tide gages recorded data for two complete tidal cycles. During the first survey, February 28 through March 1, 2001, data were retrieved successfully from one gage, but the corresponding gage experienced mechanical problems. This gage was returned to the manufacturer for replacement. To prevent further potential damage to the tide gage, and due to the threat of vandalism and theft, gages were not left in place for extended periods of time for additional monitoring. A second tidal regime survey was performed January 31, 2002.

During the second survey, the timing and magnitude of the tidal cycle at both restoration sites and the Duwamish River adjacent to each restoration site were virtually the same (Figures 2a, 2b). Discontinuities in the gage readings were due to the gages becoming dewatered at lower tides. The current tidal connections of both the Hamm Creek and Herring's House restoration sites are adequate to allow for the full range of tidal timing and magnitude.

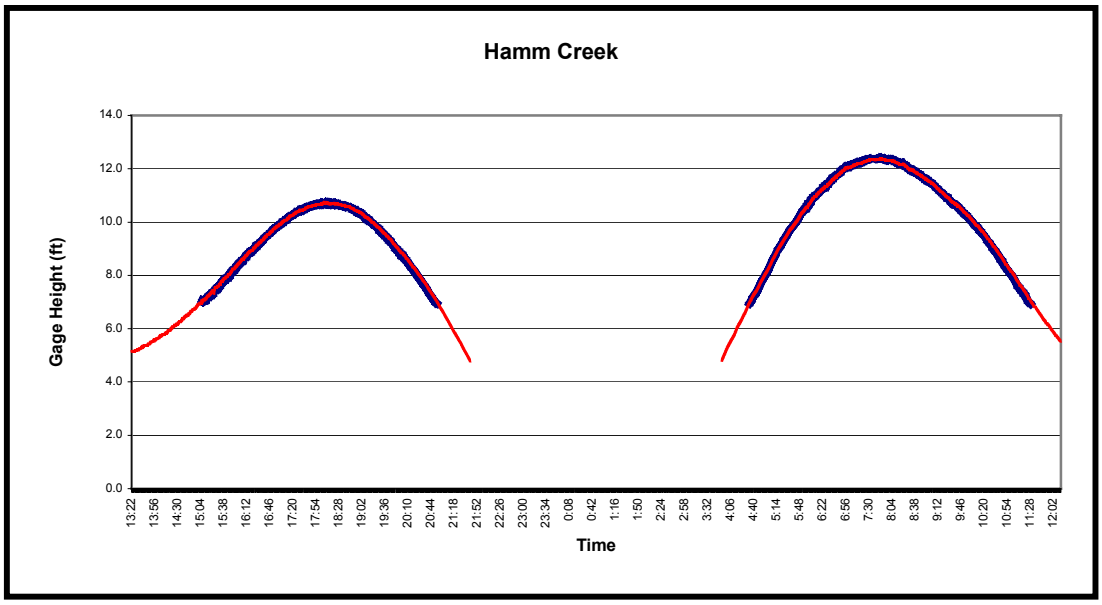

Figure 2a. Tidal regime at Hamm Creek Estuary restoration site (blue line) and in the mainstem Duwamish River adjacent to the restoration site (red line), January 31, 2002.

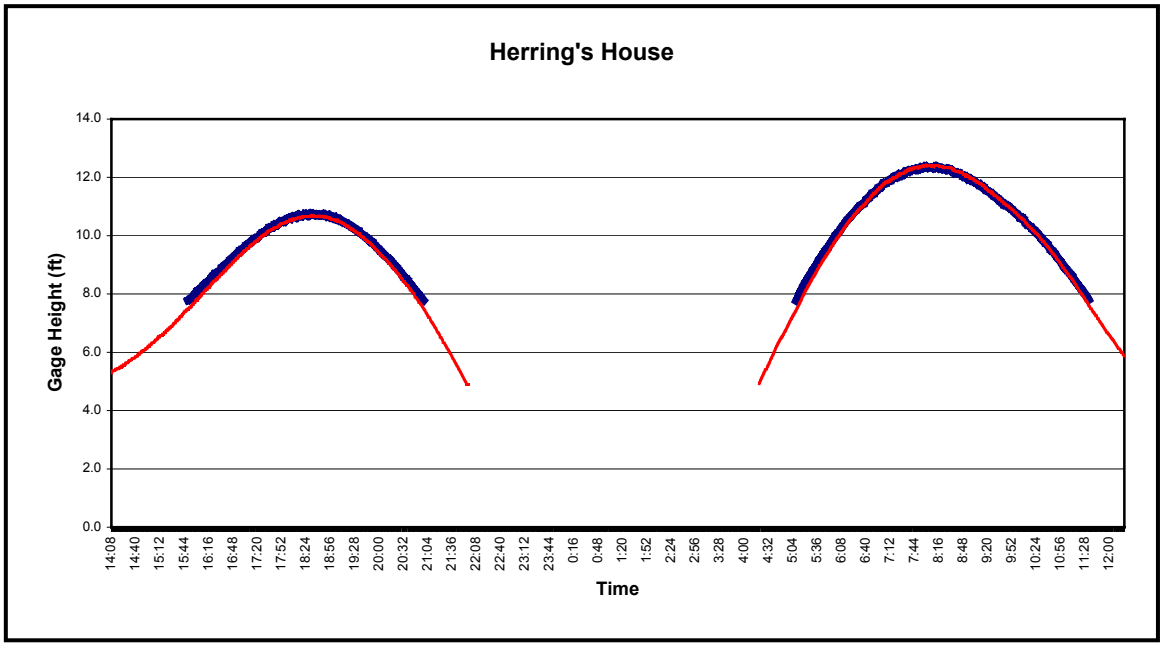

Figure 2b. Tidal regime at Herring's House restoration site (blue line) and in the mainstem Duwamish River adjacent to the restoration site (red line), January 31, 2002.

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

Slope erosion at Hamm Creek and Herring's House was monitored by comparing physical survey profiles (see *Intertidal Area Criterion*) to the as-built survey data provided by the City of Seattle Department of Parks and Recreation. Additionally, Service field staff installed rebar pins at the sites in early 2001 along regions where erosion was of particular concern. If erosion occurs near the rebar pins during the extended monitoring period, the amount of rebar exposed will be measured and an erosion rate calculated. During site visits, informal visual inspections of these areas were made to determine any obvious bank erosion. Stable photo points were established at both Hamm Creek and Herring's House in February 2001 to provide consistent reference points for photo-documentation of erosion.

The Hamm Creek site experienced significant erosion of the instream channel to the extent that structural maintenance was implemented. Erosion was observed in the outlet to the Duwamish River during monitoring conducted in 2001. This erosion of the site's unconsolidated sand and mud steadily increased with time, and as a result, the channel continued to head-cut approximately 20 meters up into the estuary by winter 2001. The U.S. Army Corps of Engineers placed large boulders and large woody debris into the channel along the area of erosion during spring and summer 2001. Erosion adjacent to these hard points has continued due to the nature of the substrate in the area (Figures 3a, 3b). One photo point and most of the rebar pins installed to monitor erosion have been lost due to the erosion

occurring at the site. It is unknown at this time whether the observed erosion is part of the natural site stabilization process or will require further action in the future.

To date, the Herring's House site has remained stable.

Figure 3a. Erosion at mouth of Hamm Creek Estuary, summer 2001. Arrow in site photo (l) indicates angle of view for photo of undercut bank (r).

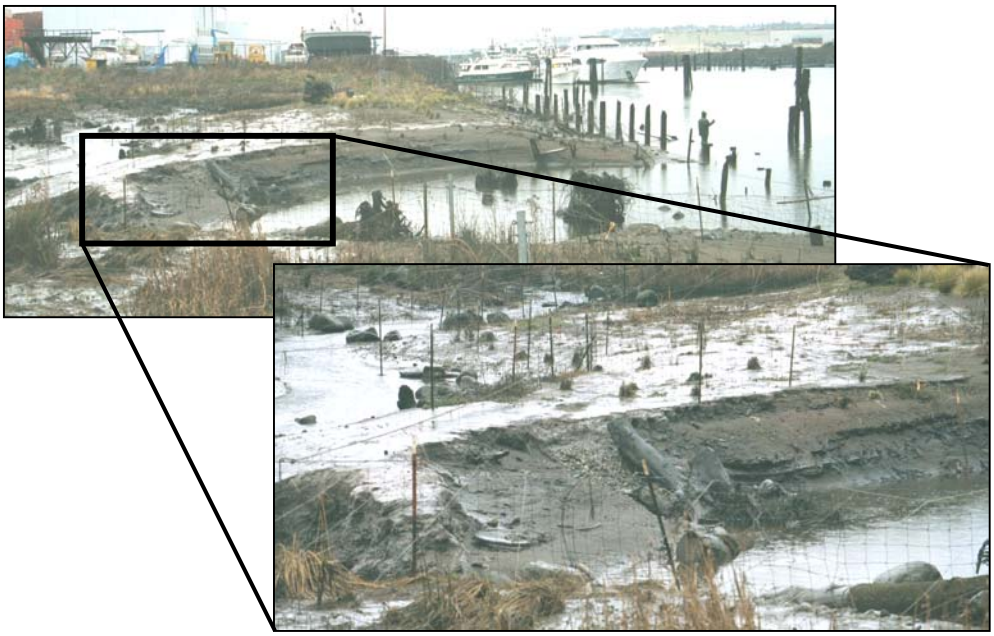

Figure 3b. Erosion at mouth of Hamm Creek Estuary, January 2002, with close-up of eroding area (inset).

<u>Sediment Structure (Physical Success Criterion 4)</u> 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.

Sediment core samples were collected at the Hamm Creek and Herring's House restoration sites and their respective reference sites, in areas which were also sampled for invertebrates (Biological Success Criterion 8). Six sediment samples were collected at each site. Core sampling was stratified by vegetated (3 samples per site,+10 ft MLLW and above) and unvegetated (3 samples per site, +9 ft MLLW and below) areas at the Herring's House restoration and reference sites. Stratification was not considered necessary or appropriate at Hamm Creek because of the creek's influence on invertebrate habitat in the intertidal zone (see Biological Success Criterion 8). Samples were sent out to a contracted lab for analyses; detailed results from analysis of Total Organic Carbon (TOC) and sediment grain size distribution are included in Appendix C.

Total Organic Carbon
Mean TOC values were similar for Hamm Creek (0.9%) and its reference site (0.8%) (Table 2). Corresponding mean TOC values for Herring's House vegetated (5.9%) and unvegetated (4.1%) samples were higher than values at the reference site (2.5% and 2.3%, respectively).

Grain Size Analysis
Grain size analysis results for both Hamm Creek and Herring's House restoration and reference sites were similar, in that the sand component made up the highest percentage of substrate at each site. The remaining substrate consisted of silt and a smaller percentage of clay (Table 2).

Sand comprised 64% of the substrate at Hamm Creek and 83% at its reference site, while silt values were 30% and 14%, respectively. Clay made up the remaining substrate, with values of 6% and 4%, respectively.

Table 2. Mean percent Total Organic Carbon (TOC) and mean percent composition by grain size for Hamm Creek and Herring's House restoration sites and corresponding reference sites, 2001.

Site	TOC (%)	Mean Grain Size		
		Sand (%)	Silt (%)	Clay (%)
Hamm Creek Estuary	0.9	64	30	6
Hamm Creek Reference	0.8	83	14	4
Herring's House				
Vegetated	5.9	78	17	5
Unvegetated	4.1	79	15	6
Herring's House Reference				
Vegetated	2.5	92	4	4
Unvegetated	2.3	80	15	4

The percentages of sand in the substrate samples were higher for the Herring's House reference vegetated (92%) and unvegetated (80%) samples than those at the restoration site (78% and 79%, respectively). Silt values were similar for both Herring's House sites (15-17%) except for the reference vegetated samples (4%). Clay values were similar for both Herring's House sites (4-6%).

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)

Visual inspections were made during most field surveys to ensure that riprap and/or soils remained stable as compared to the as-built surveys. No such noticeable migration of riprap or soils occurred at the Herring's House site.

The Washington State Department of Ecology (WDE) has issued a voluntary cleanup order for this site, requiring installation of three groundwater monitoring wells for compliance purposes (C. Tanner, USFWS, personal communication). As of this date, groundwater monitoring has not yet occurred at the Herring's House site. Service staff will coordinate with Seattle City Parks staff to ensure completion of this task per WDE requirements.

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).*

Biological Success Criterion 1 - Areal Extent
Vegetation sampling occurred in late July and August 2001, and reference site surveys were completed within 36 hours of the restoration site surveys. The perimeters of vegetation patches (*C. lyngbyei, S. maritimus, S. americanus,* and *S. validus*) were mapped using the Trimble GeoExplorer 3 GPS to determine the baseline areal extent of marsh vegetation for Year 1 monitoring. Vegetation patches at Hamm Creek totaled 450 m^2 (0.11 acres), or 16% of the total intertidal area (measured for Physical Success Criterion 1), while patches at the Hamm Creek reference site totaled 560 m^2 (0.14 acres) (Table 3). Herring's House vegetation patches totaled 342 m^2 (0.08 acres), or 4% of the intertidal area. The Herring's House reference site totaled 100 m^2 (0.02 acres). Reference site intertidal areas were not mapped under Physical Success Criterion; therefore, percent of total intertidal area could not be calculated.

Biological Success Criterion 2 - Species Composition
Permanent transects were established using physical markers and GPS readings at the restoration and reference sites to determine species composition of both native and non-native wetland plant species. Due to site layout and other concerns, transects were not established perpendicular to the shore, as described in the monitoring plan. After discussion

Table 3. Areal extent of vegetation patches of *Carex lyngbyei*, *Scirpus* spp., and mixed patches of these genera for all sites, summer 2001. The percentage of the intertidal area that was vegetated at each restoration site is also shown below.

Site (Total intertidal area)	**Areal Extent of Vegetation (m^2)**				**% of Total Intertidal Area**
	Scirpus	***Carex***	**Mixed**	**Site Total - m^2 (acres)**	
Hamm Creek Estuary (2,809 m^2)	-	411	39	**450 (0.11)**	**16**
Hamm Reference	51	508	0.5*	**560 (0.14)**	**-**
Herring's House (8,679 m^2)	-	-	341.5*	**342 (0.08)**	**4**
HH Reference	72	28	-	**100 (0.02)**	**-**

*This value includes a small patch of vegetation which was visually estimated to be 0.5 m^2

with agency staff, fewer transects were created in meandering lines along elevation contours (Appendix A), which allowed for more effective comparisons of specific communities at each elevation surveyed. In addition, this change to the plan should minimize disturbance to the plant communities by foot traffic, due to trampling concerns as the result of multiple organizations surveying vegetation in the relatively small restoration site. This disturbance would likely be further intensified if multiple transects were sampled in closer proximity, as specified in the monitoring plan.

Numbers and/or lengths of transects varied to some extent at each site or subsection of a site, depending on site conditions and topography. The Hamm Creek (Figure 4a) estuarine survey consisted of three transects (5, 13, and 6 plots per transect), while its reference site had two transects (6 and 5 plots). Herring's House (Figure 4b) and its reference site consisted of 2 transects each, with 10 plots per transect at the restoration site and 5 plots per transect at the

Figure 4a. Intertidal area near the mouth of Hamm Creek, with goose exclusion devices, summer 2001.

Figure 4b. Intertidal area at Herring's House restoration site, with goose exclusion devices, spring 2001.

reference site. The distance from the start of the transect to the first plot was randomly selected within 10 meters of the starting point, with additional plots at regular intervals from the first plot. Along each transect, plots were sampled for target vegetation species (*C. lyngbyei* and *Scirpus* spp.) and estuarine understory species composition by visually estimating percent cover to the nearest 1% within 0.25 m^2 quadrats.

There were 4 target species and 28 species of understory plants observed in transects at Hamm Creek, Herring's House, and their reference sites (Table 4). All four sites contained *C. lyngbyei* and at least one *Scirpus* specie. Of the understory plants observed, six were not identified to species: one alga, one grass, one lotus, and three other vascular plants. The Hamm Creek restoration site contained 22 understory species (including all 6 unknown species), more than any other site. The Hamm Creek reference site included five understory species, while Herring's House and its reference site contained six and four understory species, respectively. All sites had at least one understory species on each transect.

The understory at Hamm Creek consisted primarily of *Potentilla anserina* (9% total site coverage), *Agrostis* sp. (6%), *Eleocharis palustris* (5%) and *Juncus bufonius* (5%). The remaining species at this site individually contributed less than 4% of total site coverage. Hamm Creek's reference site consisted primarily of *E. parvula* (14%) and *P. anserina* (8%), with each of the remaining species comprising less than 3% of the site's total coverage. The Herring's House restoration site had an understory consisting primarily of *Cotula coronopifolia* (14%), *Triglochin maritimum* (11%), and *E. parvula* (9%), with each of the remaining understory species making up less than 1% of the percent cover at the site. The reference site for Herring's House contained the following understory plants: *J. balticus* (25%), *Distichlis spicata* (13%), *P. anserina* (12%), and *Plantago maritima* (2%).

Table 4. Mean percent cover of target species (*Carex lyngbyei* and *Scirpus* spp.) and understory species observed in estuarine transects during vegetation sampling, summer 2001. All mean values have been rounded to the nearest whole number, and values less than 0.5 are represented as < 1.

Species	Percent Cover by Transect and Site												
	Hamm Creek				Hamm Reference			Herring's House			HH Reference		
	1	2	3	Site	1	2	Site	1	2	Site	1	2	Site
TARGET SPECIES													
Carex lyngbyei	-	4	48	**14**	51	90	**69**	4	6	**5**	14	12	**13**
Scirpus americanus	-	<1	-	**<1**	-	-	**-**	-	-	**-**	-	-	**-**
Scirpus maritimus	-	6	-	**3**	-	-	**-**	-	3	**2**	-	-	**-**
Scirpus validus	-	-	-	**-**	17	< 1	**9**	-	-	**-**	-	36	**18**
UNDERSTORY SPECIES													
1. *Agrostis* sp.	-	10	1	**6**	-	6	**3**	-	-	**-**	-	-	**-**
2. *Atriplex patula*	-	3	2	**2**	-	-	**-**	-	-	**-**	-	-	**-**
3. *Chenopodium album*	-	<1	-	**<1**	-	-	**-**	-	-	**-**	-	-	**-**
4. *Cotula coronopifolia*	-	1	4	**1**	-	-	**-**	7	21	**14**	-	-	**-**
5. *Cytisus scoparius*	-	<1	-	**<1**	-	-	**-**	-	-	**-**	-	-	**-**
6. *Distichlis spicata*	-	-	-	**-**	-	-	**-**	-	-	**-**	22	5	**13**
7. *Eleocharis palustris*	-	9	-	**5**	-	-	**-**	-	-	**-**	-	-	**-**
8. *Eleocharis parvula*	-	-	-	**-**	26	-	**14**	7	12	**9**	-	-	**-**
9. *Glaux maritima*	-	-	1	**<1**	-	-	**-**	-	-	**-**	-	-	**-**
10. *Juncus balticus*	-	-	-	**-**	-	-	**-**	-	-	**-**	50	-	**25**
11. *Juncus bufonius*	-	5	6	**5**	-	-	**-**	-	-	**-**	-	-	**-**
12. *Juncus uncialius*	-	<1	-	**<1**	-	-	**-**	-	-	**-**	-	-	**-**
13. *Lilaeopsis occidentalis*	-	<1	6	**2**	< 1	-	**< 1**	< 1	-	**< 1**	-	-	**-**
14. *Plantago maritima*	-	-	-	**-**	-	-	**-**	-	-	**-**	3	-	**2**
15. *Polygonum* sp.	-	1	<1	**<1**	<1	-	**<1**	-	-	**-**	-	-	**-**
16. *Potentilla anserina*	5	11	10	**9**	<1	18	**9**	-	-	**-**	12	11	**12**
17. *Rumex crispus*	-	2	<1	**1**	-	-	**-**	-	-	**-**	-	-	**-**
18. *Rumex maritimus*	-	2	-	**1**	-	-	**-**	-	-	**-**	-	-	**-**
19. *Salicornia virginica*	-	-	-	**-**	-	-	**-**	< 1	-	**< 1**	-	-	**-**
20. *Spergularia canadensis*	-	<1	<1	**<1**	-	-	**-**	-	< 1	**< 1**	-	-	**-**
21. *Trifolium* sp.	-	< 1	-	**< 1**	-	-	**-**	-	-	**-**	-	-	**-**
22. *Triglochin maritimum*	-	-	-	**-**	-	-	**-**	7	15	**11**	-	-	**-**
23. Unidentified algae	-	6	-	**3**	-	-	**-**	-	-	**-**	-	-	**-**
24. Unidentified grass	-	< 1	-	**< 1**	-	-	**-**	-	-	**-**	-	-	**-**
25. Unidentified lotus	-	< 1	-	**< 1**	-	-	**-**	-	-	**-**	-	-	**-**
26. Other unidentified spp*. (3)	-	2	-	**1**	-	-	**-**	-	-	**-**	-	-	**-**
Number of understory species per transect and site	1	21	10	**22**	4	2	**5**	5	4	**6**	4	2	**4**

*Consists of three different unidentified vascular plant species.

Biological Success Criterion 3 - Plant Vigor

Within sampled quadrats, plant vigor was assessed by measuring the height of the tallest three shoots of each target species to the nearest centimeter, and by counting the total number of *C. lyngbyei* and *Scirpus* spp. shoots. Differences in mean shoot heights between restoration and their respective reference sites were determined using a t-test, and differences in shoot densities were examined using a Mann-Whitney U test (Zar 1984). Mean shoot heights of *C. lyngbyei* and *Scirpus* spp. at the Hamm Creek and Herring's House reference sites were significantly larger (all P values < 0.04) than the mean heights of the respective species at the corresponding restoration sites (Table 5). The mean shoot heights of *C. lyngbyei* at the Hamm Creek reference and restoration sites were 125 cm and 96 cm, respectively. The mean shoot heights for *Scirpus* spp. at the same sites were 157 cm and 72 cm, respectively. Mean shoot heights at the Herring's House reference site for both *C. lyngbyei* (76 cm) and *Scirpus* spp. (146 cm) were more than double those at the restoration site (21 cm and 61 cm, respectively).

Table 5. Plant vigor results for *Carex lyngbyei* (C) and *Scirpus* spp. (S) at restoration sites and associated reference sites during 2001 monitoring.

	# Plots with target species		**Mean (cm)**		**Minimum (cm)**		**Maximum (cm)**		**Standard Deviation**	
Shoot Height (cm)	C	S	C	S	C	S	C	S	C	S
Hamm Creek Estuary	18	18	96	72	45	20	177	118	38	30
Hamm Reference	15	6	125	157	48	56	176	200	36	52
Herring's House (HH)	29	3	26	61	5	55	50	65	13	6
HH Reference	12	15	76	146	65	76	90	215	8	45
Hamm Creek Estuary/Reference: t-test - *Carex* (t = -2.214, df = 32, P < 0.001), *Scirpus* (t = -3.763, n = 7, P = 0.009) Herring's House/Reference: t-test - *Carex* (t = -14.844, df = 41, P < 0.001), *Scirpus* (t = -7.102, n = 17, P < 0.001)										
Shoot Density (# shoots / plot)	Total # Plots		C	S	C	S	C	S	C	S
Hamm Creek Estuary	24		5	1	0	0	39	10	11	3
Hamm Reference	11		14	2	0	0	30	18	10	5
Herring's House (HH)	20		4	0.4	0	0	19	7	5	2
HH Reference	10		6	6	0	0	17	17	8	7
Mann-Whitney U test Hamm Creek Estuary/Reference: *Carex* (R^1 = 354, R^2 = 426, U = -24; U' = 288, n^1 = 11, n^2 = 24, critical value = 188, P < 0.05) *Scirpus* (R^1 = 280, R^2 = 500, U = 50; U' = 214, n^1 = 11, n^2 = 24, critical value = 188, P < 0.05) Herring's House/Reference: *Carex* (R^1 = 182.5, R^2 = 349.5, U = 72.5; U' = 127.5, n^1 = 10, n^2 = 20, critical value = 145, P > 0.05) *Scirpus* (R^1 = 243.5, R^2 = 281.9, U = 11.5; U' = 188.5, n^1 = 10, n^2 = 20, critical value = 145, P < 0.05)										

Shoot densities of *C. lyngbyei* and *Scirpus* spp. at the reference sites were greater than or equal to shoot densities at the corresponding restoration sites; however, there were significant differences (P < 0.05) in three of the comparisons. Shoot densities were significantly greater at the Hamm Creek reference site for *C. lyngbyei* (14 shoots/0.25 m^2) and *Scirpus* spp. (2 shoots/0.25 m^2) than at the restoration site (5 shoots/0.25 m^2 and 1 shoot/0.25 m^2, respectively). Shoot densities were also higher for *Scirpus* spp. at the Herring's House reference site (6 shoots/0.25 m^2) than at the restoration site (0.4 shoots/0.25 m^2).

Non-native Species

The extent of non-native species establishment was also assessed by recording percent cover of any non-native species present in a transect plot, especially cordgrass (*Spartina* spp.), purple loosestrife (*Lythrum salicaria*), reed canarygrass (*Phalaris arundinacea*), and common reed (*Phragmites communis*), as described by the monitoring plan. While none of these target species were encountered in the Hamm Creek or Herring's House marsh vegetation transects in 2001, another non-native species, Scot's broom (*Cytisus scoparius*) was observed in a single Hamm Creek transect plot, and in the estuarine area outside of the transects (Figure 5a). This species made up approximately 2% of the plot's cover, but a potential future source of this and other invasive plant species can be readily found in the upland and adjacent portions of the marsh (Figure 5b).

Figure 5a. Non-native Scot's broom at Hamm Creek Estuary, January 2002.

Figure 5b. Non-native Scot's broom at Hamm Creek Estuary (left), and upland, potential Himalayan blackberry seed source (right), indicated by red lines, January 2002.

Issues of Concern
The following concerns regarding vegetation establishment at the restoration sites were noted during field work in 2001. The Hamm Creek and Herring's House restoration sites have experimental Canada goose exclusion devices installed to prevent potentially destructive herbivory on the developing estuarine vegetation. Both sites have a webbed network of ropes (Figures 4a, 4b) to prevent geese from landing in the site. In addition, cages have been installed at the Herring's House site to prevent goose access to certain parts of the estuary. The partial failure of the goose exclusion devices at Hamm Creek and Herring's House have provided one or more entry points at each site for geese, which may affect further development of vegetation at the sites. Additionally, as mentioned earlier, multiple parties are involved in monitoring efforts at Hamm Creek, and without due care, impacts from repeated human disturbance may impede growth and/or development of the vegetation. Finally, anecdotal observations by Service field staff during site visits indicate that the site is being used as an informal dog exercise area. This use may impact vegetation development by trampling and digging.

Riparian Vegetation Establishment (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 ten years, and invasive plant coverage should be minimal (criterion 4). Survival of riparian plantings in each cover class should be at least 75% at the end of three years (criterion 5).

Biological Success Criterion 4 - Areal Extent
Riparian vegetation sampling occurred in August and September 2001. The perimeters of riparian vegetation at each site were mapped using the Trimble GeoExplorer 3 GPS to determine areal extent of riparian vegetation in a similar manner as for the marsh vegetation. During the construction of both restoration sites, most of the area upland of the estuarine marsh was planted with riparian vegetation (shrubs and trees) in a somewhat uniform fashion during restoration, with herbaceous plants soon beginning to colonize the disturbed areas between the plantings.

Due to this uniformity of plantings, much of the area upland from the estuarine marsh was already vegetated by summer field sampling, although most of the shrubs and trees were small and provided little cover at this early stage of monitoring. As a result, the entire riparian area at each site was included in the aerial extent of the Hamm Creek (2,104 m^2) and Herring's House (9,186 m^2) riparian zone estimates.

Percent Cover
Permanent transects were established in the riparian zone to assess the percent cover of the herb, shrub, trees, and non-native vegetation layers, as specified in the monitoring plan (EB/DRP 2000). Some variations from the monitoring plan were necessary, however, in the placement of the transects in order to maximize the riparian area surveyed. At Hamm Creek, two transects were established in the riparian area. One 50-m transect (5 plots) was positioned perpendicular to the Duwamish River at the north end of the site, while a 100-m transect (10 plots) was positioned parallel to the river, on the terrace between the estuary and the freshwater marsh (Appendix A). Plots were established 10 m apart, with a randomly

chosen starting point along the transect within 10 m of the starting point. At Herring's House, one 100-m transect (ten plots) was established within the riparian zone in the northwest portion of the site, and one 30-m transect (3 plots) was located on the peninsula south of the entrance channel to the estuary (Appendix A). Because certain parts of the riparian zone at Herring's House are carefully maintained as a public use park, both transects at Herring's House were located in areas that were less developed and less accessible to the public in order to monitor more natural vegetation development.

Each plot was surveyed for herbaceous, shrub, tree, and non-native species vegetation layers. The herbaceous layer was sampled using a 0.25 m^2 quadrat. The shrub, tree, and non-native vegetation layers were sampled using a 3-m marked line which formed the radius of a circle (area 28.3 m^2) around the center point of the plot. Percent cover was visually estimated to the nearest 5% for each layer. Means were calculated for all plot values, both (a) within each transect, and (b) for each site, yielding respective transect and site means for each vegetation layer.

At the Hamm Creek site, mean percent cover by layer was 28% herbaceous, 7% shrub, and 11% tree (Table 6). Mean percent cover at Herring's House was 44% herbaceous, 27% shrub, and 26% tree. Target values for vegetation layer percent covers were outlined in the monitoring plan for Monitoring Years 3, 5, and 10, and are reproduced in Table 7 in this document for reference purposes.

Table 6. Mean percent cover of riparian vegetation by transect, 2001.

Site	Transect	Length (m)	Plots (#)	Mean Percent Cover			
				Herbaceous	Shrub	Tree	Non-Native
Hamm Creek Estuary	1	50	5	38	3	12	5
	2	100	10	23	9	11	3
	Site Average		**15**	**28**	**7**	**11**	**4**
Herring's House	1	100	10	41	33	29	1
	2	30	3	53	9	15	5
	Site Average		**13**	**44**	**27**	**26**	**5**

Table 7. Target values for vegetation layer percent cover during full monitoring period. (From Elliott Bay/Duwamish Restoration Program 2000).

Vegetation Layer	Year 3 coverage	Year 5 coverage	Year 10 coverage
Herbaceous	> 70%	may decline, but not more than 10% bare ground	
Shrub	> 30%	> 50%	> 80%
Tree	> 25%	> 40%	> 70%
Non-native	< 10%	< 20%	< 20%

Non-native Species
Non-native species were also surveyed in the plots (Table 6). Bull thistle (*Cirsium vulgare*), Scot's broom, reed canarygrass, Himalayan blackberry (*Rubus discolor*), sow thistle (*Sonchus* sp.), common tansy (*Tanacetum vulgare*) and clover (*Trifolium* sp.) comprised 4% of the vegetative cover at Hamm Creek. At Herring's House, non-native species included butterfly bush (*Buddleja* sp.), bull thistle, Scot's broom, Himalayan blackberry, and common tansy, and comprised 5% of the vegetative cover at the site. Invasive non-native species, such as Scot's broom, reed canarygrass, Himalayan blackberry and common tansy, should be monitored closely during the next several years, due to the proximity of the site to nearby seed sources of most, if not all, of these species.

Biological Success Criterion 5 - Plant Survival
Although the first year of monitoring served to establish the baseline number of plantings along the transects, mortalities of riparian plantings and highly stressed vegetation in the shrub and tree cover classes were noted during sampling events (Table 8). Six plots at Hamm Creek contained dead or severely stressed trees. Five of the plots each had a single affected tree, while the remaining plot had two affected trees (50% survival).

Table 8. Number of shrubs and trees by plot, transect, and restoration site, and an estimate of the percent survival of vegetation, summer 2001. Shaded numbers indicate survival of less than 100% (dead or severely stressed vegetation present in plot).

Site	Transect#	Plot#	# Shrubs	Shrub % survival	# Trees	Tree % survival
Hamm Creek Estuary	1	1	3	100	4	100
		2	1	100	7	100
		3	0	N/A	8	88
		4	2	100	5	100
		5	0	N/A	5	100
	2	1	6	100	1	100
		2	6	100	4	75
		3	3	100	4	100
		4	3	100	5	80
		5	1	100	7	100
		6	9	100	4	50
		7	7	100	4	100
		8	9	100	5	80
		9	6	100	7	100
		10	7	100	4	75
Herring's House	1	1	31	100	1	100
		2	8	100	8	100
		3	9	100	2	100
		4	42	100	10	100
		5	6	100	2	100
		6	19	100	4	100
		7	8	100	3	100
		8	10	100	13	100
		9	18	100	11	100
		10	35	100	5	100
	2	1	0	N/A	10	100
		2	16	100	25	100
		3	3	100	36	100

Dead or stressed shrubs or trees were not found on transects during surveys at the Herring's House restoration site. Plant replacement activities at this site have been limited to the areas adjacent to the parking lot (which experienced some plant mortality) and on the North Spit (Kevin Stoops, City of Seattle, personal communication). Field crews observed some of this plant replacement during spring 2001.

Issues of Concern
There is some concern that future management activities at the Hamm Creek Estuary may influence survival or percent coverage of the shrub and tree layers, therefore biasing future analyses. For example, if new trees are planted to encourage shading of the freshwater areas adjacent to the estuary, this addition may cause misinterpretation of monitoring data. We recommend, the future management by a third party be coordinated with Service field staff so that data collected in subsequent years are reported and interpreted accurately.

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 appropriate reference sites.

Bird use was assessed by area searches using the protocols described by Cordell et al. (1999) with a few modifications. Surveys began at dawn on days when sunrise coincided with high tide events to maximize both the presence of passerines and increasing foraging opportunities for waterfowl and shorebirds. Several surveys were conducted each survey day for short periods of time (<30 minutes) from dawn/high tide until mid-morning/low tide. The first bird surveys (April) at Hamm Creek and its reference site was performed differently from all subsequent surveys, due to lack of planning time to field test the bird protocol. Surveys in April at the Hamm Creek sites consisted of observations of all birds present in an extended period of time (70+ minutes). All subsequent surveys at all sites consisted of short, 10-20 minute area searches which alternated on a given day between restoration sites and their associated reference sites. Mean lengths of surveys differed between some sites, but were similar between restoration sites and their respective references sites: Hamm Creek restoration site (16 minutes) and reference site (16 minutes), and Herring's House restoration site (14 minutes) and reference site (12 minutes). Species and numbers of birds were recorded. All observations from the sites were tallied by individual survey (3-4 per day), and summed over all surveys.

Sampling occurred on a quarterly basis: April, June, September and December 2001. All four bird use surveys for 2001 were completed as specified, with one modification: the planned March survey was performed in April to include more of the annual waterfowl and shorebird staging and migration. A summary of the survey results is included in Table 9. A list of survey dates, a complete species list indicating presence/absence information, and the mean number of species observed per survey at each site is included in Appendix D.

There were 32 taxa recorded at the Hamm Creek restoration site during 2001 monitoring, with the largest numbers of taxa (15 and 14) observed in June and September 2001. More observations were made in the September surveys (154) than in any other month, although it should be noted that some individuals were likely counted more than once each survey day.

A total of 32 taxa were observed at the reference area, with the highest number of taxa (15) occurring in June. The greatest number of observations (128) was recorded in September.

Table 9. Number of bird taxa observed at each site during 1st quarter (April), 2nd quarter (June), 3rd quarter (September) and 4th quarter (December) surveys, 2001.

	Hamm Creek Estuary				Turning Basin Reference Site				Herring's House				Kellogg Island Reference Site			
Sampling Period/ Quarter	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
# Observations*	34	80	154	91	52	72	128	47	55	27	448	286	288	98	332	327
# Taxa	8	15	14	11	13	15	10	8	6	11	13	13	9	12	9	8
Total Taxa At Each Site	32				32				27				20			

*Summation of all sightings reported per sampling period, and therefore may include birds counted more than once per day.

Observers at Herring's House restoration site recorded 27 taxa during the first monitoring year, with a maximum of 13 taxa observed during each day of the September and December surveys. A total of 448 observations were counted during the September survey. The reference site observations consisted of 20 different taxa, with peak of 12 taxa during the June survey. Over 250 observations were made during each month in April (288), September (332), and December (327).

Anecdotal observations were also recorded during field sampling. Nesting by killdeer, and subsequent predation on the eggs by crows, was observed in uplands adjacent to Hamm Creek. Other potential predators, such as ospreys and bald eagles, nested near both restoration sites and would occasionally fly over the Hamm Creek restoration site and both Herring's House sites. This behavior would often flush most of the birds present at the sites.

Issues of Concern

Concerns exist for the quality of habitat for birds at the restoration sites, especially at Hamm Creek, due to human use of the sites. Field staff observed a high level of pedestrian traffic. Some of the visitors were observed multiple times per week. Dogs accompany many of the visitors, and most use the site as an off-leash pet area. Most of the off-leash dogs observed chased any birds present at the site, especially waterfowl, and some dogs greatly disturbed or damaged vegetation. An additional concern is the intentional release of animals at the site, such as squirrels and domesticated rabbits, by private citizens. While field staff have not directly observed this action, domesticated rabbits have been spotted occasionally, and visitors to the site have reported releases by others. These concerns should be considered when evaluating avifaunal use of habitat in future monitoring years.

<u>Fish Access/Presence (Biological Success Criteria 7)</u> Estuarine fish 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.

Two different sampling techniques were employed to assess fish access/presence at the Hamm Creek and Herring's House restoration sites and the two reference sites, because of the physical differences between the restoration sites and their respective reference sites. Fyke nets were used at the restoration sites, which have tidal channels, while beach seining was employed at the reference sites, both of which were located on the shoreline adjacent to the main channel of the Duwamish River. Due to limited habitat alternatives in the lower Duwamish waterway, appropriate reference sites with tidal channels were not available.

Fish surveying began on March 5, 2001 and concluded on June 13, 2001 (Table 10). A total of 28 surveys were conducted, 7 at each site. All fish collected were identified to species, counted, and released unharmed. In addition, all salmonid species, with the exception of Chinook salmon (*Oncorhynchus tshawytscha*), were subsampled (30 fish/species) and measured to fork-length (to the nearest millimeter). Chinook salmon were counted and released immediately to minimize handling stress.

Hamm Creek

Overall, juvenile chum salmon (*O. keta)* was the most common salmonid observed at the Hamm Creek restoration and reference sites, followed by juvenile Chinook salmon and coho salmon (*O. kisutch*) (Table 10). Chum salmon were present in every sample at the restoration site, and in all but the first two samples (March 7th and 22nd) at the reference site (Table 10). The highest numbers (> 200) of chum salmon captured at the restoration site occurred from the end of March through early May, reaching a high of 2,906 during the April 25th survey. Chum salmon numbers also peaked at the reference site during the same day, with 802 fish captured. Chinook salmon were present in all surveys except March 21st at the restoration site and March 7th and April 4th at the reference site. Peak use by Chinook salmon occurred in late May at the restoration site (219 fish) and the reference site (137 fish). Coho salmon were captured in late April, early May, and early June at the restoration site, and in late May to early June at the reference site. Two cutthroat trout (*O. clarki*) and a single steelhead (*O. mykiss*) were captured at the reference site in May and June, respectively.

Herring's House

Juvenile Chinook salmon were the most abundant salmonid captured at the Herring's House restoration site, followed closely by chum. No other salmonids were captured at the restoration site during 2001 sampling efforts. Juvenile chum were the most common salmonid at the reference site. Chum salmon were present in all but one sample each at the restoration site (absent March 22nd) and reference site (absent June 13th) (Table 10). Chum salmon numbers peaked at the restoration site (281 fish) on April 10th and the reference site (342 fish) on April 25th. Chinook salmon were captured at the restoration site in 4 of 7 surveys and at the reference site in the last three surveys. Chinook salmon numbers peaked at over 400 during late May to early June surveys at the restoration site and in early June (39 fish) at the reference site. Coho salmon were present in a single survey (May 10th) at the reference site. None were captured during 2001 surveys at the restoration site.

Non-salmonids
A list of non-salmonid species captured during the 2001 sampling season is detailed by site in Appendix E. Species commonly observed include sculpin (Cottidae), threespine stickleback (*Gasterosteus aculaetus*), flatfish (Pleuronectiformes), and shiner perch (*Cymatogaster aggregata*).

Table 10. Number of juvenile salmonids observed by site during 2001 sampling period ("*" denotes smolts).

Site	Month	Day	Chinook	Chum	Coho	Cutthroat	Steelhead
Hamm Creek Estuary	March	5	4	8	0	0	0
		21	0	825	0	0	0
	April	11	2	199	0	0	0
		25	5	2906	*1	0	0
	May	8	125	2371	11, *1	0	0
		23	219	105	0	0	0
	June	5	14	12	5	0	0
Turning Basin Reference Site	March	7	0	0	0	0	0
		22	1	0	0	0	0
	April	4	0	84	0	0	0
		25	8	802	0	0	0
	May	10	19	272	0	2	0
		30	137	59	23, *1	0	0
	June	13	79	1	2	0	1
Herring's House	March	6	0	1	0	0	0
		22	0	0	0	0	0
	April	10	2	281	0	0	0
		26	0	200	0	0	0
	May	9	1	241	0	0	0
		24	461	24	0	0	0
	June	6	434	16	0	0	0
Kellogg Island Reference Site	March	7	0	4	0	0	0
		22	0	47	0	0	0
	April	4	0	34	0	0	0
		25	0	342	0	0	0
	May	10	*2	63	*3	0	0
		30	11	6	0	0	0
	June	13	39	0	0	0	0

While numbers of fish captured during surveys are provided in this report, the differences in habitat and sampling methodology between restoration and reference sites preclude any direct numerical comparison. Juvenile salmonids were observed at all sites during most of the sampling period, although timing between restoration and reference sites often varied among species.

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.

Sampling for fallout insects from riparian areas and benthic invertebrates from intertidal areas, collectively described as invertebrate prey resource production, was conducted using the protocols described by Cordell et al. (1994, 1999). Invertebrate sampling was conducted once a month in April, May, and June. Due to unforeseen difficulties in logistics and contract negotiations, a March sample was not collected.

Invertebrate sampling at the restoration and reference sites (Table 11) included 5 fallout insect traps and 10 core samples taken monthly from each of the following habitats: (1) macrofauna from the vegetated region of the higher intertidal zone, (2) macrofauna from the mudflat area of the lower intertidal zone, and (3) meiofauna from the mudflat area of the lower intertidal zone. At Hamm Creek, however, 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 (J. Cordell, personal communication). For this reason, sampling of the mudflat area of the Hamm Creek restoration and reference was eliminated.

Table 11. Number and location of invertebrate samples by site, 2001

Sample Type	Hamm Creek Estuary	Turning Basin Reference	Herring's House	Kellogg Island Reference	Total
Fallout Traps					
Insects	15	15	15	15	60
Core Samples					
Vegetated Macrofauna	30	30	30	30	120
Mudflat Macrofauna	-	-	30	30	60
Mudflat Meiofauna	-	-	30	30	60
Grand Total	45	45	105	105	300

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.

The draft report (Cordell 2002) indicates positive development of the Hamm Creek and Herring's House invertebrate communities. Benthic macrofauna results suggest that colonization by pioneering species has occurred at both sites, and it is likely that the communities will diversify as the sites mature. The presence of juvenile salmonid prey such as harpacticoid and gammarid amphipods and chironomid fly larvae is also encouraging. A draft invertebrate monitoring report has been submitted to FWS and, when finalized, will be included in the 2002 interim monitoring report.

DISCUSSION

The results presented in this report represent the baseline post-restoration monitoring data for the Hamm Creek and Herring's House sites. Most of the results from the Year 1 monitoring indicate that both restoration sites are progressing in a satisfactory manner, when initially evaluated according to the Physical and Biological Criteria delineated for monitoring purposes at these locations.

There are a few concerns regarding the physical criteria, especially at Hamm Creek. The intertidal area (Physical Criterion 1) at this site does not yet meet the target area as defined in the monitoring plan criteria (EB/DRP 2000), although this may be due in part to the age of the project. In addition, erosion at Hamm Creek is considerable (Physical Criterion 2), and attempts to physically correct the situation have not slowed the process. Neither of these concerns is relevant at Herring's House at the present time.

Although riprap and soil appear stable at this time, the delay of the installation of groundwater monitoring wells at Herring's House has raised some concerns. As a result of this delay, groundwater monitoring at this site will not follow the schedule set in the monitoring plan, and corrective action for any potential pollutant will also be delayed. The remaining physical criteria, namely tidal regime and sediment structure, do not appear to present any concerns for either of the sites at this time.

Evaluation of the biological characteristics of the sites is positive at this early juncture. Marsh vegetation growth appears to be successful, with the marsh vegetation community especially diverse at Hamm Creek. The riparian vegetation community also seems to be progressing well at both sites, although the effects of initial replantings or future enhancement by site caretakers may partially mask the success or failure of the sites for a short time, and should be taken into consideration during subsequent monitoring efforts. Great care should be taken in the future at both sites to control the presence of several non-native plant species in both the marsh and riparian areas of the sites. Placement of transects within the more natural area of the riparian zone at Herring's House should be taken into consideration in future analyses of monitoring. The remainder of the riparian zone is a park setting with foot paths, picnic tables, and observation points, and transects established within the site are not a true representation of the entire site.

Site use by birds and presence of fish has been well documented at both sites, and a final report on invertebrate sampling is forthcoming. It may be advantageous, however, to increase the sampling effort for birds. Due to seasonal variations and the migratory nature of shorebirds, waterfowl and other birds, surveys for the presence of avifauna may be more effective when they occur more frequently. This is especially true during peak migration periods (spring and fall). Simenstad et al. (1991) recommend weekly bird surveys during peak migration periods and monthly surveys throughout the remainder of the year.

It should be noted, however, that while the data from the physical and biological criteria monitoring may show some preliminary indications of the sites' responses to restorative actions, these data primarily function as baseline data. They will likely provide more value when compared with results from subsequent years of monitoring effort. Additional monitoring data and information on the restoration sites has been compiled by People for Puget Sound (2001) and is available on their website.

The following section summarizes the results for each of the physical and biological criteria at the Hamm Creek and Herring's House sites, and presents several issues of concern at the restoration sites.

SUMMARY

The U.S. Fish and Wildlife Service began monitoring two sites in the Elliott Bay/Duwamish Restoration Program, Hamm Creek Estuary and Herring's House, in the winter of 2000/2001. Results for the first year of monitoring are presented in this report. Construction of the two remaining Program sites, North Wind's Weir and Kenco Marine, has not yet begun at the time of this report. Monitoring will commence at these sites once construction has been completed.

During the first year's monitoring efforts, consideration was given to nine physical and biological criteria, as described in the monitoring plan (EB/DRP 2000). Physical criteria included intertidal area, tidal regime, slope erosion, and sediment quality. The five biological criteria included marsh vegetation establishment, riparian vegetation establishment, bird use, fish access and presence, and invertebrate prey resource production. The results for these criteria are summarized for each site in the following paragraphs.

Intertidal Area
The intertidal areas at both Hamm Creek Estuary and Herring's House were mapped and compared to as-built surveys, which were conducted at each project's completion in 2000. No obvious changes were detected at either site. The intertidal area at Hamm Creek Estuary was determined to be 0.7 acres (2,833 m^2), while the area at Herring's House was 2.1 acres (8,499 m^2). Target intertidal areas specified in the criterion for the Hamm Creek Estuary and Herring's House site are 90% of 1.0 acres (4,047 m^2) and 2.0 acres (8,094 m^2), respectively.

Tidal Regime
Continuous-recording tide gages were used to monitor tidal timing and magnitude both inside and outside of the restoration sites. Difficulties were encountered during the first monitoring attempt, and the data was discarded. The results of a second survey in January 2002 indicate that the tidal regime both inside and outside of the Hamm Creek Estuary and Herring's House sites are similar.

Slope Erosion
Erosion was monitored at the restoration sites by: (1) comparing physical survey profiles and as-built survey data to determine extent of any erosion, (2) installing rebar pins where erosion was of particular concern, and (3) visual inspections to determine any obvious erosion. Hamm Creek experienced significant erosion of the instream channel near the mouth of the creek. Structural actions were taken to curtail the erosion, but it continues to increase, and the mouth of the channel has widened considerably. Herring's House has remained stable to date.

Sediment Structure
Sediment core samples were collected at both restoration sites and their respective reference sites and analyzed for sediment grain size and Total Organic Content (TOC). Analyses indicate that grain size is similar for both sites in comparison to their reference sites, with sand comprising the highest percentage of substrate ($\geq$ 64%) at all sites. Silt (4-30%) and clay ($\leq$ 6%) comprised the remaining substrate components at the sites. TOC values were similar for Hamm Creek Estuary (0.9%) and its reference site (0.8%). Herring's House restoration site TOC values were higher than those at the reference site, with values categorized by vegetated (5.9% and 2.5%, respectively) and unvegetated (4.1% and 2.3%) samples. Stratification of the Herring's House samples was deemed appropriate due to site characteristics (EB/DRP 2000).

Sediment Quality
Visual inspections of riprap and soil stability were made during field visits, and no noticeable migration of either was noticed. Groundwater monitoring wells, which are required at Herring's House, have not yet been installed.

Marsh Vegetation Establishment
Patches of *C. lyngbyei* and *Scirpus* spp. were mapped at each restoration and reference site to determine baseline areal extent of intertidal vegetation. Areas were then calculated for Hamm Creek Estuary (450 m^2) and its reference area (559.5 m^2), and for Herring's House (341.5 m^2) and its reference area (100 m^2). Hamm Creek Estuary had more understory species (22) than the remaining three sites (4-6 species each). Plant vigor at the sites was also surveyed, and mean shoot heights of *C. lyngbyei* and *Scirpus* spp. at the reference sites were found to be significantly greater (all P values < 0.05) than those at the restoration sites. Shoot densities for the same species at the reference sites were greater than or equal to shoot densities at the corresponding restoration sites; furthermore, mean shoot density of *C. lyngbyei* was significantly greater ($P < 0.05$) at the Hamm Creek reference site than at the respective restoration site, and mean shoot densities of *Scirpus* spp. at both reference sites were significantly greater ($P < 0.05$) than at their respective restoration sites. Non-native

species were also surveyed, although the only taxa observed in estuarine sampling was Scot's broom (Hamm Creek Estuary).

Riparian Vegetation Establishment
Riparian vegetation areas were calculated for Hamm Creek Estuary (2,104 m^2) and Herring's House (9,186 m^2). Percent cover of riparian vegetation was visually estimated by layers (herbaceous, shrub, tree, and non-native) to serve as baseline data for the next monitoring year. Several sampling plots at Hamm Creek Estuary had stressed or dead trees, although none were observed during the Herring's House survey.

Bird Use
Bird surveys were performed quarterly beginning in April 2000. Total numbers of taxa were similar for both Hamm Creek Estuary (32) and its reference site (32), and for the Herring's House restoration (27) and reference (20) sites.

Fish Use
Fish sampling of restoration and reference sites was conducted from March through June. Juvenile Chinook salmon and chum salmon were the most common salmonids observed in the Hamm Creek Estuary and Herring's House restoration and reference sites, while coho salmon and cutthroat trout were also observed at one or more of the sites. Timing of peak numbers of Chinook salmon and coho salmon juveniles was similar between the restoration and their associated reference sites, although some variability was present.

Invertebrate Prey Resource Production
Samples were collected and are currently being analyzed by University of Washington School of Aquatic and Fisheries Sciences staff, who will provide a report on the findings. The results of this portion of the monitoring effort will be included in the 2002 interim monitoring report.

Recommendations
The following recommendations are presented for future monitoring efforts:

- Potential negative impacts to vegetation development and bird use should be addressed, if the Hamm Creek Estuary restoration site is to reach its full potential. These problems include the use of the Hamm Creek Estuary site by pedestrians and dogs, and the resulting impacts to vegetation and birds.

- The replacement of goose exclusion equipment should be addressed, if the equipment is to remain in place. Failures exist at both sites, and in their current state, the ropes are a potential hazard to both field staff and wildlife.

- Bird surveys should be increased during spring and fall migration and staging events, to more effectively monitor this resource.

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