2008

Year 7 (2008) Monitoring Report for Commencement Bay Habitat Restoration Sites

Prepared for the

Commencement Bay

Natural Resource Damage Assessment

and Restoration Trustees

YEAR 7 (2008) MONITORING REPORT

FOR COMMENCEMENT BAY HABITAT RESTORATION SITES

Prepared for the

Commencement Bay

Natural Resource Damage Assessment and Restoration Trustees

Prepared by

RIDOLFI Inc.

May 2009

EXECUTIVE SUMMARY

The National Oceanic and Atmospheric Administration (NOAA) is the lead agency of the Commencement Bay Natural Resource Trustees (Trustees) and is responsible for managing restoration projects under the Commencement Bay Natural Resource Damage Assessment and Restoration program. In 2000, the Trustees prepared a Restoration Monitoring Plan for Commencement Bay in order to measure the success of restoration efforts, identify adaptive management approaches if projects are not achieving goals, address monitoring requirements specified by permitting agencies, and serve as an outreach tool to disseminate project information to interested parties.

Under the direction of NOAA, RIDOLFI Inc. conducted Year 7 (2008) monitoring at 10 habitat restoration sites on or adjacent to Commencement Bay in Tacoma, Washington:

- Yowkwala
- Skookum Wulge
- Squally Beach
- Mowitch
- Hylebos Creek Off-Channel (Jordan)
- Middle Waterway (Simpson/Trustees)
- Middle Waterway (City of Tacoma)
- Olympic View
- Puget Creek
- Sha Dadx

Four biological success criteria (BSCs) were monitored in various combinations at the different sites to evaluate marsh development/species composition (BSC 2), riparian vegetation/areal coverage (BSC 6), fish access and presence (BSC 7), and bird use (BSC 9). Not all criteria were required to be monitored at all sites in Year 7. In addition, physical success was assessed using aerial photography, and chemical conditions were assessed using surface water chemistry.

The data were analyzed to evaluate whether the sites are meeting performance objectives. Overall performance is summarized in Table ES-1. The individual performance of each restoration site for the Year 7 monitoring season is discussed below.

Yowkwala

The Yowkwala site was monitored for BSC 7. Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the Yowkwala site.

Skookum Wulge

The Skookum Wulge site was monitored for BSC 7. Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the Skookum Wulge site.

Squally Beach

The Squally Beach site was monitored for BSC 2 and BSC 6, as well as surface water baseline chemistry. Percent cover of native species has increased along Transect 1-1 and Transect 1-2 and meets BSC 2 for percent cover of native species. Year 7 will serve as the new baseline year for Transect 1-3; as a result no conclusions can be reached about the success of Transect 1-3 for this round of monitoring. Non-native plant cover along all three transects was less than 5 percent, which meets BSC 2 for non-native cover. BSC2 is being met at the Squally Beach site.

For BSC 6, the tree cover criterion is met at Squally Beach, but the shrub criterion is not met. However, for native shrubs it should be noted that the upper boundary of the 95 percent confidence interval (95CI) exceeds the criterion. The criterion for non-native or invasive (NNI) species is also not met. Cover by native species showed a significant increase from Year 5 to Year 7, while NNI species cover showed no significant increase. BSC 6 is being partially met at the Squally Beach site.

Table ES-1. Performance summary for Year 7 (2008) monitoring

Site Name	BSC 2 (Marsh)	BSC 6 Riparian	BSC 7[a] (Fish)	BSC 9[a] (Birds)	Surface Water Baseline Chemistry
Yowkwala			🟢		
Skookum Wulge			🟢		
Squally Beach	🟢[b] ↑	🟡 ↑			🔴
Mowitch	🟡[b] ↑	🟡 ↑ ↓			🔴
Hylebos Creek Off-Channel (Jordan)	🟡 ↑	🟡	🟡	🟢	🔴
Middle Waterway (Simpson/Trustees)	🟡[b] ↑	🟡 ↑ ↓	🟢		🔴[c]
Middle Waterway (City of Tacoma)			🟢		🔴[c]
Olympic View			🟢		
Puget Creek			🟢		
Sha Dadx				🟢	

LEGEND

Biological Success Criteria (BSC)

Marsh Development/Species Composition = BSC 2

Riparian Vegetation/Areal Coverage = BSC 6

Fish Access/Presence = BSC 7

Bird Use = BSC 9

Baseline Chemical Conditions

Surface Water Baseline Chemistry

🟢 = Criterion met

🟡 = Criterion partially met or improving

🔴 = Exceeds one or more screening levels for surface water quality

↑ = Total native species cover increasing

↓ = Total non-native species cover decreasing

a: Reference not available for quantitative comparison; evaluation based on site observations.

b: Variability is high and one limit of the confidence interval may not meet the criterion.

c: One Middle Waterway surface water sample was collected at point between the Simpson/Trustees and City of Tacoma sites.

Surface water samples were collected from four sites, including the Squally Beach site. The maximum copper concentration, which was detected in the sample from station SW-01 at the Squally Beach site, exceeded the screening level by a factor of four; the copper concentration detected in the sample from station SW-02 exceeded the screening level by a factor of just over 3.5. Total nitrogen detected at Squally Beach station SW-01 exceeded the screening level by a factor of eight, while the concentration of total nitrogen detected at station SW-02 was almost three times the screening level. The concentrations of total phosphorous at Squally Beach sampling stations exceeded the screening level by one order of magnitude at station SW-01and a factor of approximately eight at station SW-02. The fecal coliform concentration detected at Squally Beach station SW-02 exceeded the screening level by one order of magnitude. The fecal coliform concentration detected at Squally Beach station SW-01 exceeded the screening level by a factor of close to four.

Mowitch

The Mowitch site was monitored for BSC 2 and BSC 6, as well as surface water chemistry. Percent cover of native marsh species has increased along both Transect 1-1 and Transect 1-2, meeting the BSC 2 success criterion for percent cover of native marsh species. Non-native cover for both transects was greater than 5 percent and therefore does not meet BSC 2 for non-native cover. BSC 2 is being partially met at the site.

For BSC 6, the shrub and tree cover criteria are not met at Mowitch. However, it should be noted that the upper boundary of the 95CI on the mean for native shrub cover exceeds the criterion. Additionally, both native shrub and tree species showed significant increases in cover between Year 5 and Year 7. Therefore, the shrub cover criterion at the site is partially met. The NNI criterion is met based on the stratified mean estimate, but the upper boundary of the 95CI on the mean is equal to the criterion. NNI species cover decreased significantly between Year 5 and Year 7. BSC 6 is being partially met at the site.

The concentration of copper detected in surface water collected at the Mowitch site slightly exceeded the screening level. The concentrations of total nitrogen and total phosphorous both exceeded screening levels by one order of magnitude. The concentration of fecal coliform exceeded the screening level by a factor of close to seven.

Hylebos Creek Off-Channel (Jordan)

The Hylebos Creek Off-Channel (Jordan) site was monitored for BSC 2, BSC 6, BSC 7, and BSC 9, as well as surface water chemistry. Based on the presence of native plant species along both transects, BSC 2 appears to be met at the site. However, percent cover of native marsh plant species remaining stable or increasing over time cannot be assessed based on a single year of monitoring. Non-native cover on both transects was greater than 5 percent, and therefore does not meet BSC 2 for non-native cover. BSC 2 is being partially met at the site.

For BSC 6, the shrub cover criterion is not met at the site, but the tree cover criterion is met. The NNI criterion is not met. BSC 6 is being partially met at the site.

BSC 7 appears to be met for resident non-salmonid species at the site and partially met for salmonids.

BSC 9 appears to be met for indigenous and native bird species at the site.

Copper was detected in the surface water sample collected from the Hylebos Creek Off-Channel (Jordan) site, but the concentration did not exceed the screening level. The concentrations of total nitrogen and total phosphorous both exceeded screening levels by more than an order of magnitude. The maximum concentration of fecal coliform detected among the four sampled sites occurred at the Hylebos Creek Off-Channel (Jordan) site and exceeded the screening level by more than two orders of magnitude.

Middle Waterway (Simpson/Trustees)

The Middle Waterway (Simpson/Trustees) site was monitored for BSC 2, BSC 6, and BSC 7, as well as surface water baseline chemistry. Percent cover of native species has increased significantly along Transect 1-1, meeting the BSC 2 success criterion for percent cover of native species. Native cover along Transect 1-2 showed no statistically significant change, so it is possible, but uncertain whether, this transect also met the success criterion. Non-native cover for both transects was less than 5 percent and therefore meets the success criterion for non-native cover. BSC 2 is being partially met at the site.

For BSC 6, the shrub cover criterion is not met at the site, while the tree cover criterion is met. The NNI criterion is met on the stratified mean estimate but the upper boundary of the 95CI on the mean exceeds the NNI criterion, therefore the NNI criterion is partially met. Native shrub and tree species cover significantly increased at the site between Year 5 and Year 7, while NNI species significantly decreased. BSC 6 is being partially met at the site.

Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the site.

The concentration of copper detected in the surface water sample collected from the Middle Waterway site exceeded the screening level by a factor of just over three. Total nitrogen and total phosphorous exceeded screening levels by one order of magnitude. The concentration of fecal coliform detected at the site exceeded the screening level by a factor of just over five.

Middle Waterway (City of Tacoma)

The Middle Waterway (City of Tacoma) site was monitored for BSC 7, as well as surface water baseline chemistry. Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the site. One surface water sample was collected to represent both Middle Waterway sites; the analytical results for that sample are discussed above.

Olympic View

The Olympic View site was monitored for BSC 7. Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the site.

Puget Creek

The Puget Creek site was monitored for BSC 7. Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the site.

Sha Dadx

The Sha Dadx site was monitored for BSC 9. Based on the presence of resident and migratory bird species, BSC 9 appears to be met for indigenous and native bird species at the Sha Dadx site.

Adaptive Management Recommendations

Based on the Year 7 monitoring results presented here, the following key actions are recommended for adaptive management of the sites indicated:

Squally Beach, Mowitch, and Middle Waterway (Simpson/Trustees) Sites

- Manually remove NNI species in the riparian areas.
- Eradicate reed canarygrass from the marsh areas to prevent this highly invasive species from spreading.
- Replant native trees and shrubs in the southern portion of the riparian area at Mowitch. Consider marking a designated trail through this area for volunteers to access the site.
- Remove debris from the sites.
- Locate the marsh and riparian sampling transects and plots using a global positioning system (GPS), which will make relocating transects and plots more efficient during future years of monitoring.
- Monitor surface water chemistry and determine the source(s) of nutrient and bacterial contamination.

Hylebos Creek Off-Channel (Jordan) Site

- Manually remove NNI species in the riparian areas.
- Eradicate reed canarygrass from the marsh areas to prevent this highly invasive species from spreading.
- Remove debris from the site.
- Locate the marsh and riparian sampling transects and plots using GPS, which will make relocating transects and plots more efficient during future years of monitoring.
- Monitor surface water chemistry and determine the source(s) of nutrient and bacterial contamination.
- If sand continues to be deposited in the off-channel habitat area and Hylebos Creek, efforts should be made to determine and control the source and potentially to remove some of the excess material.
- Create more cover for juvenile salmonids in the off-channel habitat area by adding additional LWD, root wads, and boulders.
- Monitor depth of openings, channels, and flow in the off-channel habitat area.
- Consider modifications to the openings in Reach 3 of the off-channel habitat area to ensure continued flow of water from Hylebos Creek through the site.
- Consider conducting a benthic indicator of biological integrity (IBI) study to gain a better understanding of the condition of the aquatic habitat at the site.

TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1 Yowkwala Site 2
1.2 Skookum Wulge Site 2
1.3 Squally Beach Site 3
1.4 Mowitch Site 4
1.5 Hylebos Creek Off-Channel (Jordan) Site 4
1.6 Middle Waterway (Simpson/Trustees) Site 4
1.7 Middle Waterway (City of Tacoma) Site 5
1.8 Olympic View Site 5
1.9 Puget Creek Site 6
1.10 Sha Dadx Site 6

2.0 DESCRIPTION OF METHODS 18

2.1 Biological Success Criterion 2 – Marsh Development/Species Composition 20
2.2 Biological Success Criterion 6 – Riparian Vegetation/Areal Coverage 21
2.3 Biological Success Criterion 7 – Fish Access/Presence 21
2.4 Biological Success Criterion 9 – Bird Use 22
2.5 Physical Success: Aerial Photography 22
2.6 Baseline Chemical Conditions: Surface Water Chemistry 23

3.0 MONITORING RESULTS 24

3.1 Biological Success Criterion 2 – Marsh Development/Species Composition 24

3.1.1 Squally Beach 26
3.1.2 Mowitch 27
3.1.3 Hylebos Creek Off-Channel (Jordan) 28
3.1.4 Middle Waterway (Simpson/Trustees) 29

3.2 Biological Success Criterion 6 – Riparian Vegetation/Areal Coverage 31

3.2.1 Squally Beach 31
3.2.2 Mowitch 32
3.2.3 Hylebos Creek Off-Channel (Jordan) 33
3.2.4 Middle Waterway (Simpson/Trustees) 34

3.3 Biological Success Criterion 7 – Fish Access/Presence 35

3.3.1 Yowkwala 35
3.3.2 Skookum Wulge 38
3.3.3 Middle Waterway (Simpson/Trustees) 41
3.3.4 Middle Waterway (City of Tacoma) 43
3.3.5 Olympic View 46
3.3.6 Puget Creek 48
3.3.7 Hylebos Creek Off-Channel (Jordan) 51

3.4 Biological Success Criterion 9 – Bird Use 52
3.4.1 Hylebos Creek Off-Channel (Jordan).....53
3.4.2 Sha Dadx 57
3.5 Physical Success: Aerial Photography.....59
3.6 Baseline Chemical Conditions: Surface Water Chemistry 59
4.0 DISCUSSION OF MONITORING TO DATE AND COMPARISON OF SITES 64
4.1 Biological Success Criterion 2 – Marsh Development/Species Composition.....64
4.1.1 Discussion – BSC 2 67
4.2 Biological Success Criterion 6 – Riparian Vegetation/Areal Coverage 68
4.2.1 Squally Beach.....69
4.2.2 Mowitch 69
4.2.3 Middle Waterway (Simpson/Trustees).....70
4.2.4 Discussion – BSC 6 70
4.3 Biological Success Criterion 7 – Fish Access/Presence 71
4.3.1 Beach Seine and Block Net Results 72
4.3.2 Snorkel Survey Results 81
4.4 Biological Success Criterion 9 – Bird Use 84
5.0 Summary and Recommendations.....87
5.1 Monitoring Summary.....87
5.1.1 Yowkwala.....87
5.1.2 Skookum Wulge.....87
5.1.3 Squally Beach.....87
5.1.4 Mowitch 89
5.1.5 Hylebos Creek Off-Channel (Jordan).....90
5.1.6 Middle Waterway (Simpson/Trustees).....91
5.1.7 Middle Waterway (City of Tacoma) 91
5.1.8 Olympic View 91
5.1.9 Puget Creek 92
5.1.10 Sha Dadx 92
5.2 Adaptive Management Recommendations 92
5.2.1 Squally Beach, Mowitch, and Middle Waterway (Simpson/Trustees) Sites 92
5.2.2 Hylebos Creek Off-Channel (Jordan) Site 93
6.0 REFERENCES.....94

LIST OF TABLES

Table 2-1 Monitoring conducted in Year 7 (2008) by site and parameter 19

Table 3-1 Performance summary for Year 7 (2008) monitoring 25

Table 3-2 Summary of the three most prevalent native marsh species observed along each transect at Squally Beach 26

Table 3-3 Summary of the three most prevalent native marsh species observed along each transect at Mowitch 27

Table 3-4 Summary of the three most prevalent native marsh species observed along each transect at Hylebos Creek Off-Channel (Jordan) 28

Table 3-5 Summary of the three most prevalent native marsh species observed along each transect at Middle Waterway (Simpson/Trustees) 30

Table 3-6 Riparian development at Squally Beach 32

Table 3-7 Riparian development at Mowitch 33

Table 3-8 Riparian development at Hylebos Creek Off-Channel (Jordan) 34

Table 3-9 Riparian development at Middle Waterway (Simpson/Trustees) 35

Table 3-10 Summary of total juvenile salmon caught and average numbers of salmon per set observed at the Yowkwala site for Year 7 (2008) monitoring 38

Table 3-11 Summary of total juvenile salmon caught and average numbers of salmon per set observed at the Skookum Wulge site for Year 7 (2008) monitoring 41

Table 3-12 Summary of total juvenile salmon caught and average numbers of salmon per set observed at the Middle Waterway (Simpson/Trustees) site for Year 7 (2008) monitoring 43

Table 3-13 Summary of total juvenile salmon caught and average numbers of salmon per set observed at the Middle Waterway (City of Tacoma) site for Year 7 (2008) monitoring 46

Table 3-14 Summary of total juvenile salmon caught and average numbers of salmon per set observed at the Olympic View site for Year 7 (2008) monitoring 49

Table 3-15 Summary of total juvenile salmon caught and average numbers of salmon per set observed at the Puget Creek site for Year 7 (2008) monitoring 52

Table 3-16 Summary of fish species and numbers observed at the Hylebos Creek Off-Channel (Jordan) site, Year 7 (2008) 54

Table 3-17 Surface water analytical results for the Commencement Bay restoration sites, Year 7 (2008) 63

Table 4-1 Highlights of Commencement Bay fish monitoring, Years 1-3 and 7 75

Table 4-2 Summary of fish species and numbers observed at the Hylebos Creek Off-Channel (Jordan) site in Year 5 (2006) and Year 7 (2008) 83

Table 5-1 Performance summary for Year 7 (2008) monitoring 90

LIST OF FIGURES

Figure 1-1 Vicinity Map and Locations of Habitat Restoration Sites 8
Figure 1-2 Yowkwala Site Features 9
Figure 1-3 Skookum Wulge Site Features 10
Figure 1-4 Squally Beach Site Features 11
Figure 1-5 Mowitch Site Features 12
Figure 1-6 Hylebos Creek Off-Channel (Jordan) site features 13
Figure 1-7 Middle Waterway (Simpson/Trustees and City of Tacoma) site features 14
Figure 1-8 Olympic View site features 15
Figure 1-9 Puget Creek site features 16
Figure 1-10 Sha Dadx site features 17
Figure 3-1 Total number of fish species caught at each site, Year 7 (2008) 36
Figure 3-2 Total number of fish species caught at Yowkwala per sampling event, Year 7 (2008) 37
Figure 3-3 Average number of Chinook caught per set at Yowkwala, Year 7 (2008) 38
Figure 3-4 Total number of fish species caught at Skookum Wulge per sampling event, Year 7 (2008) 40
Figure 3-5 Average number of Chinook caught per set at Skookum Wulge, Year 7 (2008) 41
Figure 3-6 Total number of fish species caught at Middle Waterway (Simpson/Trustees) per sampling 42
Figure 3-7 Average number of Chinook caught per set at Middle Waterway (Simpson/Trustees), Year 7 (2008) 43
Figure 3-8 Total number of fish species caught at Middle Waterway (City of Tacoma) per sampling event, Year 7 (2008) 45
Figure 3-9 Average number of Chinook caught per set at Middle Waterway (City of Tacoma), Year 7 (2008) 46
Figure 3-10 Total number of fish species caught at Olympic View per sampling event, Year 7 (2008) 48
Figure 3-11 Average number of Chinook caught per set at Olympic View, Year 7 (2008) 49
Figure 3-12 Total number of fish species caught at Puget Creek per sampling event, Year 7 (2008) 51
Figure 3-13 Average number of Chinook caught per set at Puget Creek, Year 7 (2008) 52
Figure 3-14 Total number of bird species observed at Hylebos Creek Off-Channel (Jordan) and Sha Dadx, Year 7 (2008) 56

Figure 3-15 Total number of bird species observed at Hylebos Creek Off-Channel (Jordan) and Sha Dadx per sampling event, Year 7 (2008) 56

Figure 4-1 Total percent cover of non-native and native plant species at the Squally Beach site from 2002 through 2008 with trendlines 67

Figure 4-2 Total percent cover of non-native and native plant species at the Mowitch site from 2002 through 2008 with trendlines. 68

Figure 4-3 Total percent cover of native plant species at the Middle Waterway site from 2002 through 2008 with trendlines 68

Figure 4-4 Total number of fish species caught per site, Years 1-3 and 7 76

Figure 4-5 Total number of fish species caught per month 77

Figure 4-6 Average number of salmon caught per month, Years 1-3 and 7 81

Figure 4-7 Average number of salmon caught per site, Years 1-3 and 7 82

Figure 4-8 Total number of bird species observed at the Hylebos Creek Off-Channel (Jordan) and Sha Dadx 88

Figure 4-9 Total number of bird species observed at the Hylebos Creek Off-Channel (Jordan) and Sha Dadx by season, Year 5 (2006) and Year 7 (2008) 88

LIST OF UNITS

°C	degrees Celsius
cm	centimeter
ft	foot/feet
ha	hectare
m	meter
mm	millimeter
ppt	parts per thousand
sq.ft.	square feet/foot

LIST OF ABBREVIATIONS AND ACRONYMS

90CI	90 percent confidence interval
95CI	95 percent confidence interval
Adolfson	ESA Adolfson (formerly Adolfson Associates, Inc.)
ARI	Analytical Resources, Inc.
BSC	biological success criterion
Champion	Champion International Corporation
CHB	Citizens for a Healthy Bay
CPUE	catch per unit effort
CWT	coded wire tag
DO	dissolved oxygen
Ecology	Washington Department of Ecology
FL	fork length
GPS	global positioning system
IBI	indicator of biological integrity
LWD	large woody debris
MHHW	mean higher high water
MHW	mean high water
MLLW	mean lower low water
MSL	mean sea level
MLW	mean low water
NNI	non-native or invasive species
NOAA	National Oceanic and Atmospheric Administration
OVRA	Olympic View Resource Area
OVT	Olympic View Triangle
poly-line	polypropylene line
rebar	reinforcing steel bar
Ridolfi	RIDOLFI Inc.
SAP	sampling and analysis plan
Simpson	Simpson Tacoma Land Company

sp./spp.	species
SPECTRA	SPECTRA Laboratories
SR	species richness
TerraStat	TerraStat Consulting Group
Trustees	Commencement Bay Natural Resource Trustees
USEPA	U.S. Environmental Protection Agency
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources

1.0 INTRODUCTION

The National Oceanic and Atmospheric Administration (NOAA) issued Task Order No. TOO22 under Contract ABB3C-03-CQ-0002 to RIDOLFI Inc. (Ridolfi) to conduct Year 7 (2008) monitoring activities at 10 habitat restoration sites on or adjacent to Commencement Bay in Tacoma, Washington (Figure 1-1). NOAA is the lead agency of the Commencement Bay Natural Resource Trustees[1] (Trustees) and is responsible for managing restoration projects under the Commencement Bay Natural Resource Damage Assessment and Restoration program.

The Trustees and other private and public entities that have Natural Resource and Damage Assessment (NRDA) responsibilities under CERCLA, have an obligation to restore habitat that has been degraded due to chemical releases. Over 90 percent of the nearshore habitat in Commencement Bay no longer exists because of shoreline hardening, filling, and dredging activities. Consequently, the Trustees have focused their efforts on restoring and protecting intertidal habitat with an emphasis on marsh, mudflats, and adjacent riparian buffers. The Trustees have also purchased sites where the restoration efforts were minimal but protection from development was a primary concern. One of the goals of the restoration efforts is to create physical structure (elevation, type of substrate, presence of large woody debris, etc.) that will support ecological functions, such a primary production, foraging locations for fish and birds, with the overall goal that species including juvenile salmon will benefit. Another goal is to restore enough habitat areas so that there is an increased degree of connectedness between the sites. This is particularly important for juvenile salmon which need abundant feeding and refuge locations in the estuary as they migrate to the ocean.

[1] The Commencement Bay Natural Resource Trustees consist of the following entities: the National Oceanic and Atmospheric Administration; the U.S. Fish and Wildlife Service; the Puyallup Tribe of Indians; the Muckleshoot Indian Tribe; the Washington Department of Ecology; the Washington Department of Fish and Wildlife; and the Washington Department of Natural Resources.

The Trustees prepared a Restoration Monitoring Plan for Commencement Bay (Trustees, 2000) that identifies several purposes of the monitoring program:

- To measure the success of the restoration efforts;
- To identify adaptive management approaches if projects are not achieving goals;
- To address monitoring requirements specified by permitting agencies; and
- To serve as an outreach tool to disseminate project information to interested parties.

To fulfill those purposes, this monitoring report describes the Year 7 monitoring activities and field work, assesses progress toward meeting the success criteria, and recommends adjustments (adaptive management) for future monitoring years.

The 10 restoration sites where monitoring occurred in Year 7 and the restoration activities previously conducted at each site are briefly described below. The monitoring data were collected by Ridolfi personnel with support from Restoration Logistics of Seattle, Washington.

1.1 Yowkwala Site

The Yowkwala site, which is approximately 15 acres (6 hectares [ha]) in size, is between the Tyee Marina and Browns Point (Figure 1-2). The site is a gravel and cobble beach at the base of a sandy and gravel bluff. The Trustees purchased the site and restored the beach to a more natural condition in March 2000.The beach cleanup involved demolishing and disposing of two derelict wooden barges stranded on the shoreline and removing debris from one former dry dock and a sunken concrete float. The barges were demolished on site, then hauled away via an existing access road. The demolition occurred at low tide to minimize risks or impacts to the marine environment. The majority of the wood debris was chipped and recycled rather than transported to a landfill.

1.2 Skookum Wulge Site

The Skookum Wulge site is on a parcel just outside of the mouth of the Hylebos Waterway that is owned by the Puyallup Tribe (Figure 1-3). The site, which covers less than 1 acre (under 0.4 ha), is bounded by Marine View Drive to the northeast and residential properties to the southeast and northwest.

The site was reportedly occupied by a residential structure until the mid-1930s, when a landslide from the steep, undeveloped, wooded hillside adjacent to Marine View Drive swept the structure into Commencement Bay. The site has been undeveloped since that time. The site slopes gently from Marine View Drive toward Commencement Bay. A low, steep, erosional bluff, approximately 2 to 4 ft (0.6 to 1.2 m) in height, separates the upland portion of the site from the beach below. The upland area is semicircular and protrudes approximately 100 ft (30 m) toward the southwest into Commencement Bay. This landform is apparently the remnant of the landslide. Wave action is eroding the steep face at the edge of the upland area and cutting it back toward Marine View Drive.

The beach below the upland bluff is composed of gravel and cobble-sized materials similar to materials present in the exposed bluff. The beach grades uniformly toward the benthic environment in a radial pattern that is consistent with erosion from a relatively recent landslide. The beach slopes at approximately 10 to 12 percent away from the bluff.

In 1999, the Trustees evaluated restoration alternatives for the Skookum Wulge site and concluded that the site's susceptibility to erosion made the no-action alternative that is protection from development preferable.

1.3 Squally Beach Site

The Squally Beach site is located along the northern shoreline of the Hylebos Waterway, south of Marine View Drive and immediately west of East 11th Street (Figure 1-4). The site consists of approximately 0.66 acre (0.27 ha) of uplands bordering the largest expanse of original mudflats in Commencement Bay.

The Trustees led a restoration project at the Squally Beach site that included lowering the grade of the upland portions of the site to create a salt marsh with a riparian buffer, redirecting stormwater across the site in sinuous channels, removing contaminated soil, and removing trash other debris. The project was constructed in 2000 and native plants were installed in 2001.

1.4 Mowitch Site

The Mowitch site is at the confluence of Hylebos Creek and Hylebos Waterway on land owned by the Port of Tacoma (Figure 1-5). The site is approximately 2.3 acres (0.9 ha) and is bounded on the south by Hylebos Creek; on the west by a railroad right-of-way adjacent to Marine View Drive; on the north by a cedar fence; and on the west by the Hylebos Waterway. The Trustees directed a restoration effort at the Mowitch site in 2000 that consisted of removing fill material to create three intertidal pools connected to Hylebos Creek, with associated marsh zones, and a riparian buffer. Large woody debris (LWD) and boulders were placed in the pools for habitat complexity and native plants were installed in 2001 with several in-fill planting efforts in subsequent years.

1.5 Hylebos Creek Off-Channel (Jordan) Site

The Hylebos Creek Off-Channel (Jordan) site, formerly known as the Jordan property, was acquired and annexed by the City of Fife in cooperation with the Trustees. The 15.3 acres (6.1 ha) site, is bounded on the west and southwest by Hylebos Creek, on the south by private property and 8th Street, on the east by a bluff, and on the north by the property line extending east from the end of 4th Street (Figure 1-6).

In the fall of 2005, the site was re-graded to create off-channel habitat for juvenile salmonids adjacent to Hylebos Creek. A backwater channel that connects to Hylebos Creek via five inlets was constructed, and pools and islands were created to add complexity to the habitat provided by the backwater channel. Native vegetation was planted at the newly constructed site in the winter of 2005 and spring of 2006.

1.6 Middle Waterway (Simpson/Trustees) Site

The Middle Waterway (Simpson/Trustees) site is a 3.3-acre (1.3-ha) nearshore area situated on property owned by Simpson Tacoma Land Company (Simpson) in a highly industrialized area at the southeast end of the Middle Waterway (Figure 1-7).

The objective of the project was to provide estuarine habitat adjacent to one of the largest remaining areas of original Commencement Bay intertidal mudflats. Under the settlement agreement, monitoring was initiated at the site in 1994, prior to construction, and continued through the summer of 2000. Construction was initiated in early 1995, and planting was undertaken between October 1995 and May 1996.

1.7 Middle Waterway (City of Tacoma) Site

As part of the City of Tacoma's settlement agreement, the City developed an estuarine shoreline wetland restoration project on the south west side of Middle Waterway across from the Middle Waterway (Simpson/Trustees) site (Figure 1-7).

Excavation and regrading of the 1.85-acre (0.75-ha) vacant upland property created an intertidal marsh and riparian buffer bordering one of the few remaining original mudflats within Commencement Bay. Since construction an extensive pickleweed bed has established at the site.

1.8 Olympic View Site

The Olympic View site is located at the northern tip of the peninsula that separates the Thea Foss Waterway and the Middle Waterway. It comprises two properties: the Olympic View Resource Area (OVRA) and the Olympic View Triangle (OVT).

The OVRA includes the City of Tacoma's acquisition of 0.7 acre (0.3 ha) of upland and intertidal property bordering the 11.7-acre (4.7-ha) lease site of state-owned aquatic lands (Figure 1-8). In 2002, the U.S. Environmental Protection Agency (USEPA) managed a remedial action that included removing dioxin-contaminated sediments and backfilling the excavation with clean sediments. Pilings were removed and the site restoration included softening the shoreline to enhance the intertidal habitat and create a riparian buffer. The project goal is to protect and enhance nearshore eelgrass and intertidal habitat for an assemblage of aquatic species in a manner consistent with low-impact public use and enjoyment of shoreline and water areas.

The OVT is located on state-owned aquatic lands administered by WDNR. The site is bordered by the Thea Foss Waterway to the west, the Shore Terminal facility to the south, Commencement Bay to the north, and the OVRA to the east. A riprap bank and sheet pile retaining wall run along the OVT's seaward perimeter, adjacent to the Thea Foss Waterway and Commencement Bay. The site is approximately triangular in shape and occupies an area of about 1.2 acres (0.4 ha); it serves as a breakwater and buffer area to protect the adjacent fuel storage facility.

In the summer of 2007, soil contaminated with arsenic was removed from the site and then the site was graded to provide marsh and riparian habitat. The marsh area opens toward the bay to the north east and a gravel berm was constructed across the opening to provide some protection during storms.

1.9 Puget Creek Site

The Puget Creek site is a sandy beach on the western shore of Commencement Bay near the intersection of Alder Street and Ruston Way, Tacoma, Washington. The Puget Creek Restoration Society has led a number of restoration efforts intended to improve habitat in the creek, however these actions have been focused upstream of the beach.

Puget Creek flows through a culvert under Ruston Way into Commencement Bay (Figure 1-9). Puget Creek provides spawning and rearing habitat for coho and chum salmon. The intertidal beach habitat at the mouth of Puget Creek provides rearing habitat for juvenile Chinook, coho, chum, and pink salmon and is also used by forage fish and resident fish. The Puget Creek site is a documented spawning beach for sand lance (WDFW, 2008).

1.10 Sha Dadx Site

The Sha Dadx site is located in Fife, Washington. The site is bordered by the north levee of the Puyallup River to the south, Frank Albert Road to the west, the Union Pacific rail line to the north, and 54th Avenue East and a low-density residential area to the east (Figure 1-10). The portion of the site selected by the Trustees for habitat restoration encompasses approximately

11.5 acres (4.7 ha) of existing wetlands; it contains a meander section of the former channel of the Puyallup River that was abandoned when the river was straightened and the north and south levees were constructed at the beginning of the 20th century.

From June through October 2008, a restoration effort was constructed on behalf of the Trustees under the direction of NOAA. Two large backchannels and two islands were constructed to provide off-channel habitat for juvenile salmonids. The channels were aligned to preserve the existing trees, which provide natural shade.

A ring levee was constructed around the restoration habitat area with a top elevation that matches North Levee Road. The existing wetland and islands are inundated with water when the river reaches 10 ft (3 m) above MSL. A culvert was jacked and bored through the existing north levee to provide a connection to the Puyallup River.

Topsoil with high organic content, which was reclaimed during clearing and grubbing, was stockpiled and reused to help the new vegetation become established. Trees felled during construction were reused on site: 100 trees with large root wads were used as LWD in the channels and along the islands to provide shade and refuge for juvenile salmon. The remaining downed trees were ground up and used as mulch. In October 2008, trees, shrubs, and emergent plants were installed at the site and the slopes of the ring levee were hydroseeded with a mix of native grasses and forbs.

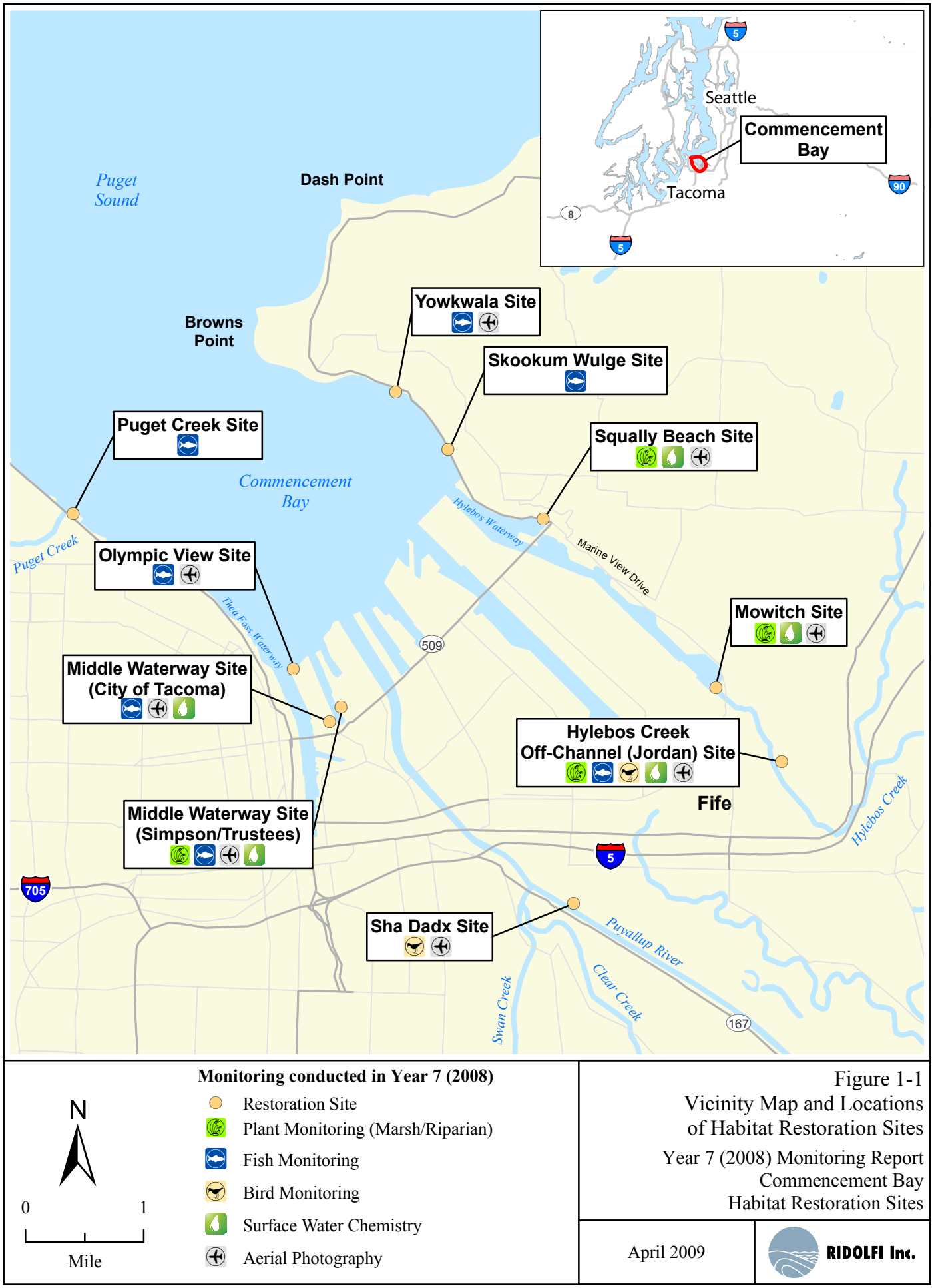


Figure 1-1
Vicinity Map and Locations of Habitat Restoration Sites

Year 7 (2008) Monitoring Report
Commencement Bay
Habitat Restoration Sites

April 2009

RIDOLFI Inc.

Monitoring conducted in Year 7 (2008)

Fish Monitoring

Aerial Photography

Legend

Approximate Location of Fishing Sets

Note:
Airphoto Date - August 2008

N

0 150

Feet

Figure 1-2
Yowkwala Site Features

Year 7 (2008) Monitoring Report
Commencement Bay
Habitat Restoration Sites

April 2009

RIDOLFI Inc.

N

0 100

Feet

Monitoring conducted in Year 7 (2008)

Fish Monitoring

Legend

Approximate Location of Fishing Sets

Note:
Airphoto Date - June 2005

Figure 1-3
Skookum Wulge Site Features

Year 7 (2008) Monitoring Report
Commencement Bay
Habitat Restoration Sites

April 2009

RIDOLFI Inc.

Monitoring conducted in Year 7 (2008)

- Plant Monitoring (Marsh/Riparian)
- Surface Water Chemistry
- Aerial Photography

Legend

- Surface Water Sample
- Outfall
- Management Zones

Note:
Airphoto Date - August 2005

N

0 50
Feet

Figure 1-4
Squally Beach Site Features

Year 7 (2008) Monitoring Report
Commencement Bay
Habitat Restoration Sites

April 2009

RIDOLFI Inc.

Monitoring conducted in Year 7 (2008)

- Plant Monitoring (Marsh/Riparian)
- Surface Water Chemistry
- Aerial Photography

Legend

- Surface Water Sample
- Management Zones

Notes:
- Airphoto Date - August 2008
- Zones F1-F7 are riparian zones, all other zones are marsh zones.

N

0 100

Feet

Figure 1-5
Mowitch Site Features

Year 7 (2008) Monitoring Report
Commencement Bay
Habitat Restoration Sites

April 2009

RIDOLFI Inc.

Monitoring conducted in Year 7 (2008)

- Plant Monitoring (Marsh/Riparian)
- Bird Monitoring
- Fish Monitoring
- Surface Water Chemistry
- Aerial Photography

Legend

- Surface Water Sample
- Management Zones

Note:
Airphoto Date - August 2008

N

0 100
Feet

Figure 1-6
Hylebos Creek Off-Channel (Jordan)
Site Features

Year 7 (2008) Monitoring Report
Commencement Bay
Habitat Restoration Sites

April 2009

RIDOLFI Inc.

Monitoring conducted in Year 7 (2008)

Simpson/Trustees

- Plant Monitoring (Marsh/Riparian)
- Fish Monitoring
- Surface Water Chemistry
- Aerial Photography

City of Tacoma

- Fish Monitoring
- Aerial Photography
- Surface Water Chemistry

Legend

- Approximate Location of Fishing Sets
- Surface Water Sample
- Outfall
- Management Zones

Note:
Airphoto Date - August 2008

N

0 100
Feet

Figure 1-7
Middle Waterway Site Features
(Simpson/Trustees & City of Tacoma)

Year 7 (2008) Monitoring Report
Commencement Bay
Habitat Restoration Sites

April 2009

RIDOLFI Inc.

Monitoring conducted in Year 7 (2008)

Fish Monitoring

Aerial Photography

Legend

Approximate Location of Fishing Sets

Olympic View Resource Area

Note:
Airphoto Date - August 2008

N

0 100

Feet

Figure 1-8
Olympic View Site Features

Year 7 (2008) Monitoring Report
Commencement Bay
Habitat Restoration Sites

April 2009

RIDOLFI Inc.

Monitoring conducted in Year 7 (2008)

Fish Monitoring

Legend

Approximate Location of Fishing Sets

Outfall

Note:
Airphoto Date - June 2005

N

0 100

Feet

Figure 1-9
Puget Creek Site Features

Year 7 (2008) Monitoring Report
Commencement Bay
Habitat Restoration Sites

April 2009

RIDOLFI Inc.

Monitoring conducted in Year 7 (2008)

Bird Monitoring

Aerial Photography

Note:
Airphoto Date - August 2008

N

0 150

Feet

Figure 1-10
Sha Dadx Site Features

Year 7 (2008) Monitoring Report
Commencement Bay
Habitat Restoration Sites

April 2009

RIDOLFI Inc.

2.0 DESCRIPTION OF METHODS

This section describes the procedures used to evaluate progress toward restoration goals at the 10 restoration sites during Year 7 (2008) monitoring. Table 2-1 summarizes the criteria by site; these include biological success criteria (BSCs) as well as physical success criteria and chemical baseline information. The relevant BSCs are defined as:

- BSC 2—Marsh Development/Species Composition
- BSC 6—Riparian Vegetation/Areal Coverage
- BSC 7—Fish Access/Presence
- BSC 9—Bird Use

The field work conducted during Year 7 monitoring differed from that outlined in the project work plan (Ridolfi and Adolfson, 2001). Based on monitoring results for Years 1, 2, 3, and 5 (2002-2004, 2006), the Trustees determined that it would be more effective to reallocate efforts among sites and success criteria. In addition, methods for BSC 6 and BSC 7 were modified from those described in the 2001 work plan; the methods used are discussed below.

Table 2-1. Monitoring conducted in Year 7 (2008) by site and parameter

Site Name	BSC 2	BSC 6	BSC 7	BSC 9		
Yowkwala			✓		✓	
Skookum Wulge			✓			
Squally Beach	✓	✓			✓	✓
Mowitch	✓	✓			✓	✓
Hylebos Creek Off-Channel (Jordan)	✓	✓	✓	✓	✓	✓
Middle Waterway (Simpson/Trustees)	✓	✓	✓		✓	✓ [a]
Middle Waterway (City of Tacoma)			✓		✓	✓ [a]
Olympic View			✓		✓	
Puget Creek			✓			
Sha Dadx				✓	✓	

LEGEND

Biological Success Criteria (BSC)

Marsh Development/Species Composition = BSC 2

Riparian Vegetation/Areal Coverage = BSC 6

Fish Access/Presence = BSC 7

Bird Use = BSC 9

Physical Success

Aerial Photography

Baseline Chemical Conditions

Surface Water Chemistry

a: One Middle Waterway surface water sample was collected at a point between the Simpson/Trustees and City of Tacoma sites.

2.1 Biological Success Criterion 2 – Marsh Development/Species Composition

MARSH DEVELOPMENT/SPECIES COMPOSITION. *Species composition of native wetland/emergent plant species should be comparable to that of appropriate reference or comparison sites. If planted, survival should reach or show a trend toward 50 percent by Year 3. The project should not contain more than 5 percent cover by area of non-native or invasive plant species. Invasive plant species of special concern include, but are not limited to,* Spartina *spp. (cordgrass),* Lythrum salicaria *(purple loosestrife),* Phalaris arundinacea *(reed canarygrass), and* Phragmites communis *(common reed)* (Ridolfi and Adolfson, 2001).

MONITORING OBJECTIVES:
(1) Determine the percent cover of non-native or invasive (NNI) species along each marsh transect with acceptable precision. (2) Determine if the percent cover of NNI species is increasing, decreasing, or remaining stable through time. (3) Determine if individual native marsh species are increasing, decreasing, or remaining stable through time (Shelly, 2004).

The monitoring protocol for BSC 2 has evolved over the years by incorporating information from previous sampling results and to account for changes at sites, such as erosion, that have modified sampling locations. Specific monitoring protocols and changes that have been made from year to year are discussed in Appendix A. The general approach for measuring the extent and type of vegetation in the marsh zone at the sites is to establish one or more transects in the marsh zone and visually identify the types of plants present in small square boxes called quadrats that are placed in along the transect. Statistical methods were used to estimate the total coverage along the transect from the average cover within each individual quadrat. Non-native plants are separately identified to check whether the plant community in the marsh zone is being infested with undesirable plants. To increase comparability from year to year, the project biologists monitored plants in September and October each time.

2.2 Biological Success Criterion 6 – Riparian Vegetation/Areal Coverage

RIPARIAN VEGETATION/AREAL COVERAGE. *Areal extent of native trees, shrubs, herbs, and other riparian vegetation should be stable or increasing over time, and cover not less than 90 percent of the upland vegetated area of a project after 10 years. Invasive plant coverage should be minimal; species of special concern include* Rubus procerus *(Himalayan blackberry),* Cytisus scoparius *(Scot's broom), and* Polygonum cuspidatum *(Japanese knotweed). By Year 5, minimum percent coverage of vegetation layers should be: >50 percent (shrubs); > 40 percent (trees); and <5 percent (non-native invasive vegetation), and bare ground should not be >10 percent* (Ridolfi and Adolfson, 2001).

MONITORING OBJECTIVES:
(1) Determine whether the areal extent of riparian vegetation is stable, increasing, or decreasing over time. (2) Determine the percent cover of herbs, shrubs, trees, NNI, and individual species in riparian areas with acceptable precision (Shelly, 2004).

Riparian plant monitoring was conducted in September and October 2008 at the Squally Beach, Mowitch, Hylebos Creek Off-Channel (Jordan), and Middle Waterway (Simpson/Trustees) sites. Each site was divided into management zones so that the monitoring data could be used to guide location-specific adaptive management decisions. Field biologists counted plants along established line intercept transects in the riparian zone. The overall plant coverage was estimated by statistically evaluating the results from the individual transects. More details of the riparian monitoring methods are provided in Appendix A.

2.3 Biological Success Criterion 7 – Fish Access/Presence

FISH ACCESS/PRESENCE. *Estuarine fish will access the project, with increasing utilization and colonization by resident species. Juvenile salmonid presence within the project should be comparable to that of appropriate reference sites at the end of 10 years* (Ridolfi and Adolfson, 2001).

One of the principal goals of the Commencement Bay restoration program is to provide habitat for juvenile salmon. To monitor progress toward this goal, Ridolfi personnel employed various sampling methods as appropriate to each of the seven sites monitored for BSC 7: Yowkwala, Skookum Wulge, Hylebos Creek Off-Channel (Jordan), Middle Waterway (Simpson/Trustees), Middle Waterway (City of Tacoma), Olympic View, and Puget Creek.

A three-person crew used block nets and beach seine nets to sample fish at six sites, and a two-person crew conducted snorkel surveys at one site.

2.4 Biological Success Criterion 9 – Bird Use

BIRD USE. *Use of project sites including an area beyond 50 meters of the site boundaries by indigenous/native bird species should be comparable to reference/comparison site* (Ridolfi and Adolfson, 2001).

Bird monitoring was conducted at the Sha Dadx and Hylebos Creek Off-Channel (Jordan) sites. On 10 occasions between April and December 2008, bird use was observed and recorded for one hour per site visit. The monitoring team approached each site in a manner that minimized disturbance, making observations from relatively inconspicuous locations. Using a standardized form, observers recorded the bird species observed on site and within approximately 150 ft (50 m) of the site boundary, as well as the type of observation (i.e., seen, heard, tracks, flyover) and climatic and tidal factors that could influence bird use of the site.

Data collected in the field were entered into a database by Ridolfi staff. Bird use was recorded for each site, and numbers of species observed per season were recorded by site. Bird species counts were totaled for each site, and numbers of species using different habitat segments were also recorded. The results were compared to previous monitoring years by total number of species and groups of species (e.g., waterfowl, gulls, raptors).

2.5 Physical Success: Aerial Photography

Walker and Associates of Seattle, Washington, took aerial photographs (not orthorectified) of the Yowkwala, Squally Beach, Mowitch, Hylebos Creek Off-Channel (Jordan), Middle Waterway (Simpson/Trustees), Middle Waterway (City of Tacoma), Olympic View, and Sha Dadx sites. The aerial photographs were used to examine overall site conditions and vegetation coverage and include a minimum 100-foot (30-m) buffer on all sides of the property boundary.

2.6 Baseline Chemical Conditions: Surface Water Chemistry

To inform the Trustees about current chemical conditions in surface water, water quality sampling and analysis were performed in accordance with the sampling and analysis plan (SAP) (Ridolfi, 2008). Surface water samples were collected from the Squally Beach, Mowitch, and Hylebos Creek Off-Channel (Jordan) sites and from the Middle Waterway at a point between the City of Tacoma and the Simpson/Trustees sites.

3.0 MONITORING RESULTS

This section describes monitoring results by site and criterion. Biological observations were recorded on data forms in the field and then entered into a database developed for the project. Ridolfi personnel performed the data entry; entries were spot-checked for quality control. The database was queried to generate the site-specific summary tables discussed in this section. Fish monitoring data, which were collected and summarized by Ridolfi personnel, were subsequently imported into the database for archival purposes. Table 3-1 summarizes performance at the 10 restoration sites during Year 7 for BSCs 2, 6, 7, and 9, as well as for surface water baseline chemistry.

3.1 Biological Success Criterion 2 – Marsh Development/Species Composition

Ridolfi and Restoration Logistics performed marsh vegetation monitoring at the Squally Beach, Mowitch, Hylebos Creek Off-Channel (Jordan), and Middle Waterway (Simpson/Trustees) sites. Statistical analysis was performed by TerraStat Consulting Group (TerraStat) of Seattle, Washington. Complete observation records for all sampling events were entered into an Excel spreadsheet to facilitate data analysis and the development of tables and figures. The sampling methods functioned as intended and were conducted as described in Appendix A. Statistical analysis was conducted as described in Appendix A.

Refer to the Year 1 (2002), Year 2 (2003), and Year 3 (2004) monitoring reports (Ridolfi and Adolfson, 2003a, 2003b, 2005) for results for the baseline years at each site. The baseline data were used to determine the overall success of the marsh development and plant species composition for Year 7.

Table 3-1. Performance summary for Year 7 (2008) monitoring

Site Name	BSC 2 (Marsh)	BSC 6 (Riparian)	BSC 7[a] (Fish)	BSC 9[a] (Birds)	Surface Water Baseline Chemistry
Yowkwala			🟢		
Skookum Wulge			🟢		
Squally Beach	🟢[b] ↑	🟡 ↑			🔴
Mowitch	🟡[b] ↑	🟡 ↑↓			🔴
Hylebos Creek Off-Channel (Jordan)	🟡 ↑	🟡	🟡	🟢	🔴
Middle Waterway (Simpson/Trustees)	🟡[b] ↑	🟡 ↑↓	🟢		🔴[c]
Middle Waterway (City of Tacoma)			🟢		🔴[c]
Olympic View			🟢		
Puget Creek			🟢		
Sha Dadx				🟢	

LEGEND

Biological Success Criteria (BSC)

Marsh Development/Species Composition = BSC 2
Riparian Vegetation/Areal Coverage = BSC 6
Fish Access/Presence = BSC 7
Bird Use = BSC 9

Baseline Chemical Conditions

Surface Water Baseline Chemistry

🟢 = Criterion met
🟡 = Criterion partially met or improving
🔴 = Exceeds one or more screening levels for surface water quality
↑ = Total native species cover increasing
↓ = Total non-native species cover decreasing

a: Reference not available for quantitative comparison; evaluation based on site observations
b: Variability is high and one limit of the confidence interval may not meet the criterion
c: One Middle Waterway surface water sample was collected at point between the Simpson/Trustees and City of Tacoma sites.

3.1.1 Squally Beach

The Squally Beach site was successfully sampled for marsh plant development and species composition. Sampling occurred over a two-day period in late September 2008 during low tide. In total, three marsh transects containing 55 quadrats were sampled. Marsh management zone locations are shown on Figure 1-4. Monitoring results for each transect are provided in Appendix B. A summary of the results is shown in Table 3-2.

Table 3-2. Summary of the three most prevalent native marsh species observed along each transect at Squally Beach

Common Name	Scientific Name	Unbiased Average Quadrat Canopy Cover (%)		
		Transect 1-1	Transect 1-2	Transect 1-3
Native [a]				
Lyngby's sedge	*Carex lyngbyei*		33.2	
seashore saltgrass	*Distichlis spicata*	11.0	12.8	22.7
fleshy jaumea	*Jaumea carnosa*	20.8	25.4	12.1
Pickleweed	*Salicornia virginica*	21.4		16.9
Statistical Result [b, c]		+	+	*

a: Information is only provided for the three most prevalent plants along each transect. If blank, the species was not present or did not rank in the top three.

b: Statistical results show change in total native plant cover from 2002 to 2008.

c: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05).

*: Statistical results could not be calculated for Transect 1-3 because it was moved to a new location in 2008. The 2008 data will serve as the baseline.

All of the herbivory avoidance fencing was removed from the site after the Year 5 monitoring season. Year 7 saw a significant increase for both diversity of native plant species and percent cover of native plant species, suggesting the native plants are well established at the site and are not affected by the lack of herbivory avoidance fencing.

BSC 2 for marsh plant development and species composition at the Squally Beach site is evaluated by percent cover of native marsh plant species that remains stable or increases over time and whether percent cover of NNI species is less than 5 percent.

Based on the Year 7 monitoring, percent cover of native species has increased along Transect 1-1 and Transect 1-2 and meets BSC 2 for percent cover of native species. Year 7 will serve as the new baseline year for Transect 1-3, so the success of that transect cannot yet be evaluated.

Non-native cover at all three transects was less than 5 percent. BSC 2 is being met at the site.

3.1.2 Mowitch

The Mowitch site was successfully sampled for marsh plant development and species composition. Sampling occurred over a three-day period in early October 2008 during low tide. In total, two marsh transects containing 69 quadrats were sampled. Marsh management zone locations are shown on Figure 1-5. Monitoring results for each transect are provided in Appendix B. A summary of the results is shown in Table 3-3.

Table 3-3. Summary of the three most prevalent native marsh species observed along each transect at Mowitch

Common Name	Scientific Name	Unbiased Average Quadrat Canopy Cover (%)	
		Transect 1-1	Transect 1-2
Native [a]			
spike-rush	*Eleocharis sp.*		23.3
fleshy jaumea	*Jaumea carnosa*	13.2	
seaside plantain	*Plantago maritima*	13.3	
Pickleweed	*Salicornia virginica*	14.6	9.9
Canadian sandspurry	*Spergularia canadensis*		7.1
Statistical Result [b, c]		+	+

a: Information is only provided for the three most prevalent plants along each transect. If blank, the species was not present or did not rank in the top three.

b: Statistical results show change in total native plant cover from 2002 to 2008 for Transect 1-1 and from 2003 to 2008 for Transect 1-2.

c: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05).

BSC 2 for marsh plant development and species composition at the Mowitch site is evaluated by percent cover of native marsh plant species that remains stable or increases over time and whether percent cover of NNI species is less than 5 percent. Based on the Year 7 monitoring, percent cover of native species has increased along Transect 1-1 and Transect 1-2 and meets BSC 2 for percent cover of native species.

Non-native cover for Transects 1-1 and Transect 1-2 was greater than 5 percent, which does not meet BSC 2 for non-native cover. BSC 2 is being partially met at the site.

3.1.3 Hylebos Creek Off-Channel (Jordan)

The Hylebos Creek Off-Channel (Jordan) site was successfully sampled for marsh plant development and species composition. Sampling occurred over a five-day period in mid-October 2008 during low tide. Two marsh transects containing a total of 54 quadrats were sampled. Marsh management zone locations are shown on Figure 1-6. Monitoring results for each transect are provided in Appendix B. A summary of the results is shown in Table 3-4.

Table 3-4. Summary of the three most prevalent native marsh species observed along each transect at Hylebos Creek Off-Channel (Jordan)

Common Name	Scientific Name	Unbiased Average Quadrat Canopy Cover (%)	
		Transect 1-1	Transect 1-2
Native [a]			
Lyngby's sedge	*Carex lyngbyei*	5.4	
slough sedge	*Carex obnupta*		8.1
willowherb	*Epilobium sp.*		1.6
common rush	*Juncus effusus*	13.2	17.0
softstem bullrush	*Scirpus tabernaemontani*	6.0	
Statistical Result [b]			

a: Information is only provided for the three most prevalent plants along each transect. If blank, the species was not present or did not rank in the top three.

b: Statistical results could not be calculated for the Hylebos Off-Channel (Jordan) site because 2008 was the first time it was sampled. The 2008 data will serve as the baseline.

The Year 7 monitoring season was the first time the newly built site was monitored. The Year 7 monitoring results will therefore serve as the baseline for future comparisons.

BSC 2 for marsh plant development and species composition at the Hylebos Creek Off-Channel (Jordan) site is evaluated by percent cover of native marsh plant species that remains stable or increases over time and whether percent cover of NNI species is less than 5 percent. Based on the Year 7 monitoring, BSC 2 for percent cover of native plant species appears to be met for both transects. However, whether the percent cover of native marsh plant species is remaining stable or increasing over time cannot be assessed based on a single year of monitoring.

Non-native cover for both transects was greater than 5 percent, which does not meet BSC 2 for non-native cover. BSC 2 is being partially met at the site.

3.1.4 Middle Waterway (Simpson/Trustees)

The Middle Waterway (Simpson/Trustees) site was successfully sampled for marsh plant development and species composition. Sampling occurred on one day in early October 2008 during low tide. Two marsh transects containing a total 33 quadrats were sampled. Marsh management zone locations are shown on Figure 1-7. All of the herbivory avoidance fencing was removed from the site after the Year 5 monitoring season. Monitoring results for each transect are provided in Appendix B. A summary of the results is shown in Table 3-5.

Table 3-5. Summary of the three most prevalent native marsh species observed along each transect at Middle Waterway (Simpson/Trustees)

Common Name	Scientific Name	Unbiased Average Quadrat Canopy Cover (%)	
		Transect 1-1	Transect 1-2*
Native [a]			
Lyngby's sedge	*Carex lyngbyei*		
seashore saltgrass	*Distichlis spicata*	23.5	
fleshy jaumea	*Jaumea carnosa*		
pickleweed	*Salicornia virginica*	38.3	18.7
Canadian sandspurry	*Spergularia canadensis*	1.9	5.4
Statistical Result [b, c]		+	

a: Information is only provided for the three most prevalent plants along each transect. If blank, the species was not present or did not rank in the top three.

b: Statistical results show change in total native plant cover from 2002 to 2008.

c: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05).

If blank, there is no significant change.

*: If there are fewer than three quadrats with non-zero cover estimates unbiased mean cover cannot be estimated. Therefore, unbiased mean cover is only shown for two species for Transect 1-2.

BSC 2 for marsh plant development and species composition at the Middle Waterway (Simpson/Trustees) site is evaluated by percent cover of native marsh plant species that remains stable or increases over time and whether percent cover of NNI species is less than 5 percent. Based on the Year 7 monitoring, percent cover of native species has increased significantly along Transect 1-1, meeting the success criterion for percent cover of native species. Native cover along Transect 1-2 showed no statistically significant change, so it is possible, but uncertain, that this transect also met the success criterion.

Non-native cover for both transects was less than 5 percent, which meets the success criterion for non-native cover. BSC 2 is being partially met at the site.

3.2 Biological Success Criterion 6 – Riparian Vegetation/Areal Coverage

Ridolfi and Restoration Logistics performed riparian vegetation monitoring at the Squally Beach, Mowitch, Hylebos Creek Off-Channel (Jordan), and Middle Waterway (Simpson/Trustees) sites. Statistical analysis was performed by TerraStat. Complete observation records were recorded for all sampling events and entered into an Excel spreadsheet. The sampling methods functioned as intended and were conducted as described in Appendix A. Statistical analysis were conducted as described in Appendix A. The sampling approach was adjusted in Year 5, and the Year 5 results are now the baseline for comparison to Year 7 and future sampling seasons. Year 7 was the first year that the newly built Hylebos Creek Off-Channel (Jordan) site was sampled; the results from Year 7 will serve as baseline information for the site.

3.2.1 Squally Beach

Percent cover of tree and shrub species and of NNI vegetation were measured from 12 line intercept transects located within each riparian management zone at the Squally Beach site (Figure 1-4).

Under BSC 6, restoration of the riparian zone is considered successful if the percent cover of shrubs and trees is stable or increasing over time. Additionally, the shrub and tree areal cover should exceed 5- percent and 40 percent, respectively; and the bare ground and NNI cover should be less than 10 percent and 5 percent, respectively.

Using the statistical methods described in Appendix A, the riparian data for Squally Beach were tabulated and evaluated as shown in Appendix B. The analysis shows the tree cover criterion is met at the Squally Beach site, but the shrub criterion is not met (Table 3-6). The NNI criterion also is not met. Native species cover showed a significant increase from Year 5 to Year 7, while NNI species cover showed no significant increase. The dominant native tree, native shrub, and NNI species were red alder, Nootka rose, and Himalayan blackberry, respectively. In summary, the performance of the riparian vegetation as defined by BSC 6 is being partially met at the site.

Table 3-6. Riparian development at Squally Beach

Cover Class	Bootstrap Estimate			Statistical Result [a]
	Stratified Mean	Lower 95% CI	Upper 95% CI	
Total Native Shrubs	45%	28%	59%	+
Total Native Trees	89%	80%	101%	+
Total Native Species	137%	118%	156%	+
Total Non-native or Invasive	31%	18%	45%	

a: "+" indicates a significant increase in total native plant cover from 2006 to 2008 (two-tailed sign test, alpha = 0.05).

If blank, there is no significant change.

3.2.2 Mowitch

Percent cover of tree and shrub species and of NNI vegetation were measured from 24 line intercept transects located within each riparian management zone at the Mowitch site (Figure 1-5).

Under BSC 6, restoration of the riparian zone is considered successful if the percent cover of shrubs and trees is stable or increasing over time. Additionally, the shrub and tree areal cover should exceed 5- percent and 40 percent, respectively; and the bare ground and NNI cover should be less than 10 percent and 5 percent, respectively.

Using the statistical methods described in Appendix A, the riparian data for Mowitch were tabulated and evaluated as shown in Appendix B. The analysis shows the shrub and tree cover criteria are not met at the Mowitch site (Table 3-7). The NNI criterion is met. Native species cover showed significant increases from Year 5 to Year 7. NNI species cover decreased significantly between Year 5 and Year 7. The dominant native tree, native shrub, and NNI species were red alder, Nootka rose, and reed canarygrass, respectively. In summary, the performance of the riparian vegetation as defined by BSC 6 is being partially met.

Table 3-7. Riparian development at Mowitch

Cover Class	Bootstrap Estimate			Statistical Result[a,b]
	Stratified Mean	Lower 95% CI	Upper 95% CI	
Total Native Shrubs	48%	39%	61%	+
Total Native Trees	28%	22%	34%	+
Total Native Species	82%	70%	96%	+
Total Non-native or Invasive	1.9%	0.0066%	5.0%	-

a: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05).

"-" indicates a significant decrease; other species are not significantly changed.

b: Statistical results show change in total native plant cover from 2006 to 2008.

3.2.3 Hylebos Creek Off-Channel (Jordan)

Percent cover of tree and shrub species and of NNI vegetation were measured from 25 line intercept transects located within each riparian management zone at the Hylebos Creek Off-Channel (Jordan) site (Figure 1-6).

Under BSC 6, restoration of the riparian zone is considered successful if the percent cover of shrubs and trees is stable or increasing over time. Additionally, the shrub and tree areal cover should exceed 5- percent and 40 percent, respectively; and the bare ground and NNI cover should be less than 10 percent and 5 percent, respectively.

Using the statistical methods described in Appendix A, the riparian data for Hylebos Creek Off-Channel (Jordan) were tabulated and evaluated as shown in Appendix B. The analysis shows that the shrub cover criterion is not met at the Hylebos Creek Off-Channel (Jordan) site, but the tree cover criterion is met (Table 3-8). The NNI criterion is not met. The dominant native tree and native shrub species were red alder and red-osier dogwood, respectively. In summary, the performance of the riparian vegetation as defined by BSC 6 is being partially met at the site.

Table 3-8. Riparian development at Hylebos Creek Off-Channel (Jordan)

Cover Class	Bootstrap Estimate		
	Stratified Mean	Lower 95% CI	Upper 95% CI
Total Native Herbs	3.3%	0.56%	7.6%
Total Native Shrubs	20%	14%	31%
Total Native Trees	101%	96%	105%
Total Native Species	125%	117%	134%
Total Non-native or Invasive	28%	18%	41%

3.2.4 Middle Waterway (Simpson/Trustees)

Percent cover of tree and shrub species and of NNI vegetation were measured from 20 line intercept transects located within each riparian management zone at the Middle Waterway (Simpson/Trustees) site (Figure 1-7).

Under BSC 6, restoration of the riparian zone is considered successful if the percent cover of shrubs and trees is stable or increasing over time. Additionally, the shrub and tree areal cover should exceed 5- percent and 40 percent, respectively; and the bare ground and NNI cover should be less than 10 percent and 5 percent, respectively.

Using the statistical methods described in Appendix A, the riparian data for Hylebos Creek Off-Channel (Jordan) were tabulated and evaluated as shown in Appendix B. The analysis shows the shrub cover criterion is not met at the Middle Waterway (Simpson/Trustees) site, while the tree cover criterion is met (Table 3-9). The NNI criterion is partially met. Native shrub and tree species cover significantly increased between Year 5 and Year 7, while NNI species significantly decreased. The dominant native tree, native shrub, and NNI species were Douglas fir, Nootka rose, and Himalayan blackberry, respectively. In summary, the performance of the riparian vegetation as defined by BSC 6 is being partially met at the site.

Table 3-9. Riparian development at Middle Waterway (Simpson/Trustees)

Cover Class	Bootstrap Estimate			Statistical Result[a,b]
	Stratified Mean	Lower 95% CI	Upper 95% CI	
Total Native Shrubs	30%	20%	41%	+
Total Native Trees	61%	51%	72%	+
Total Native Species	91%	81%	104%	+
Total Non-native or Invasive	4.0%	0.3%	10.8%	-

a: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05).
"-" indicates a significant decrease; other species are not significantly changed.
b: Statistical results show change in total native plant cover from 2006 to 2008.

3.3 Biological Success Criterion 7 – Fish Access/Presence

Ridolfi performed fish monitoring at the Yowkwala, Skookum Wulge, Hylebos Creek Off-Channel (Jordan), Middle Waterway (Simpson/Trustees), Middle Waterway (City of Tacoma), Olympic View, and Puget Creek sites. Complete catch and sampling details such as date, time, temperature, weather conditions, and field parameter measurements were recorded for each fishing event and entered into an Excel spreadsheet.

Juvenile pink, chum, and coho salmon were caught in large numbers on a handful of days in April and May 2008. To expedite the sampling procedure and ensure the salmonids were not harmed, the overall count was estimated using a subset sample of each species collected from the net. Approximately 40 fish of each salmonid species served as a representative sample for estimating length and origin. As a result, the final catch numbers may be inflated.

Results of the snorkel survey at the Hylebos Creek Off-Channel (Jordan) site are discussed separately and are not compared to fish-monitoring data derived from other sites, where beach seine nets and block nets were used.

3.3.1 Yowkwala

Introduction. Fish sampling occurred at the Yowkwala site on 33 occasions; the sampling events were conducted bimonthly from mid-February through March and weekly from April through

mid-July 2008. Over the six-month sampling period, 96 individual net sets were completed at the Yowkwala site. Beach seine sampling was conducted as described in Appendix A.

Descriptive Analysis. Complete catch records were kept for all sampling events and lengths were recorded for selected species as described in Appendix A. The species richness (SR) per sampling event ranged from four to 18. In total, 23 different species (total SR) were caught during the various sampling events, giving the Yowkwala site the second highest SR among the beach seine/block net sites (Figure 3-1). The number of different species observed at the site peaked in mid-June (Figure 3-2). Species observed at the site included salmonids, forage fish, flat fish, and resident fish (e.g., sculpin, perch, stickleback). Ninety-five surf smelt and 88 sand lance were observed at the site, with peak catches occurring in mid-May and late June, respectively.

Figure 3-1. Total number of fish species caught at each site, Year 7 (2008)

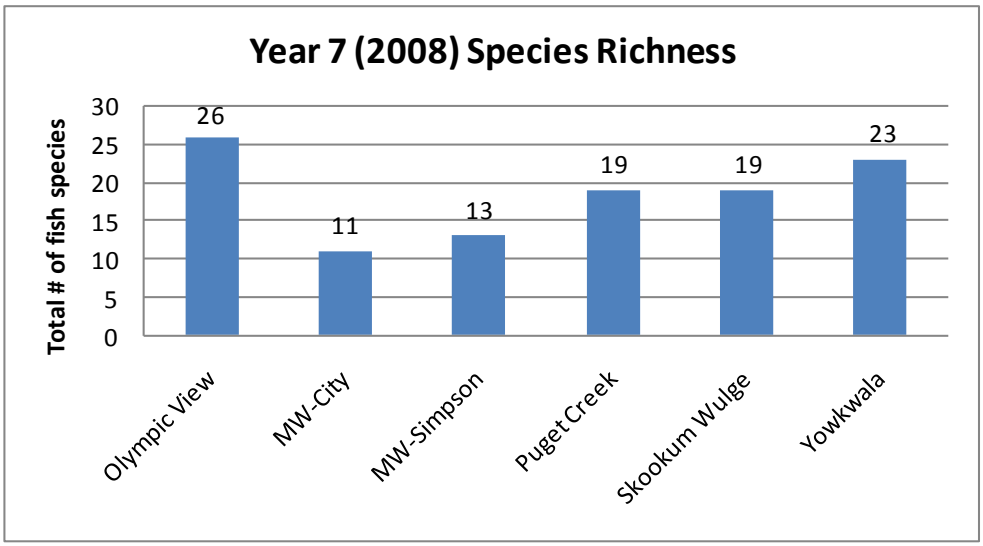
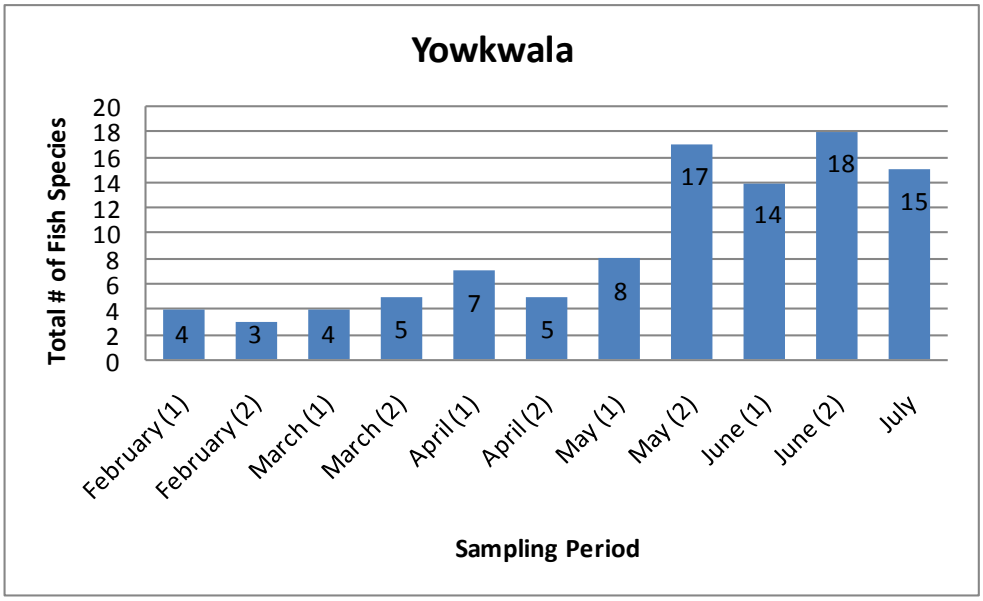


Figure 3-2. Total number of fish species caught at Yowkwala per sampling event, Year 7 (2008)



Approximately 18,000 juvenile salmon were observed during the monitoring events. Juvenile pink salmon were the most abundant species observed, followed by coho and chum salmon.

Six salmonid species were observed, including steelhead and cutthroat trout. Salmonid species were caught throughout the six-month sampling period, with the peak salmonid catch occurring from late April to mid-May. Pink were the most abundant salmonid species, peaking in mid-April. The Chinook catch peaked in early June (Figure 3-3). Peak numbers for coho salmon occurred in early May, while peak numbers for chum salmon occurred in mid-April. Forty-three steelhead trout were sampled at the site, with peak numbers occurring on one day in early April.

Table 3-10 summarizes the catch per unit effort (CPUE) for juvenile salmon caught at the Yowkwala site.

Figure 3-3. Average number of Chinook caught per set at Yowkwala, Year 7 (2008)

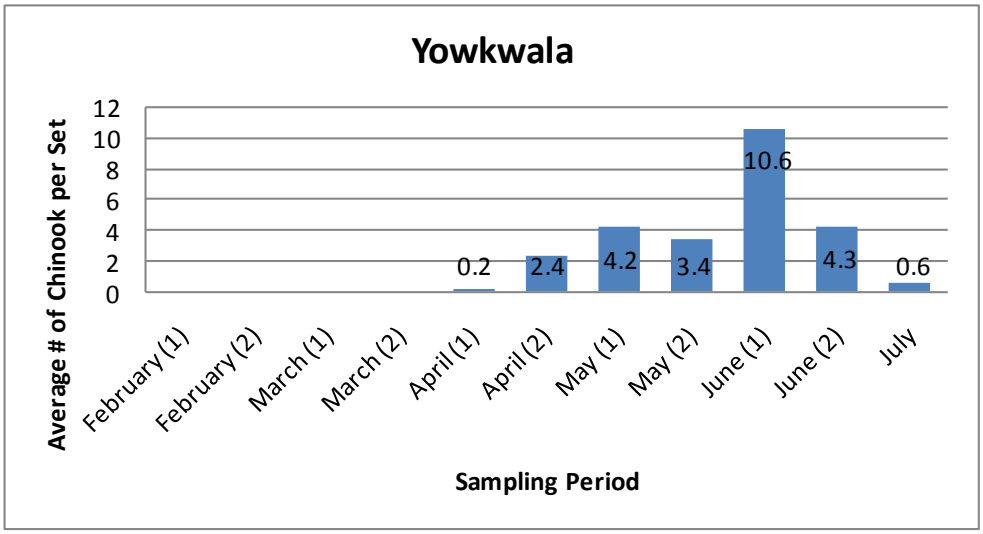


Table 3-10. Summary of total juvenile salmon caught and average numbers of salmon per set observed at the Yowkwala site, Year 7 (2008)

Species	Number of Salmon Caught	Average per Set/Catch per Unit Effort[a]
Chinook	289	3.01
Coho	5,543	57.74
Chum	5,261	54.80
Pink	7,057	73.51
Total salmon	18,150	189.06

a: There were 96 total sets completed at the site.

3.3.1.1 Success Criterion Evaluation

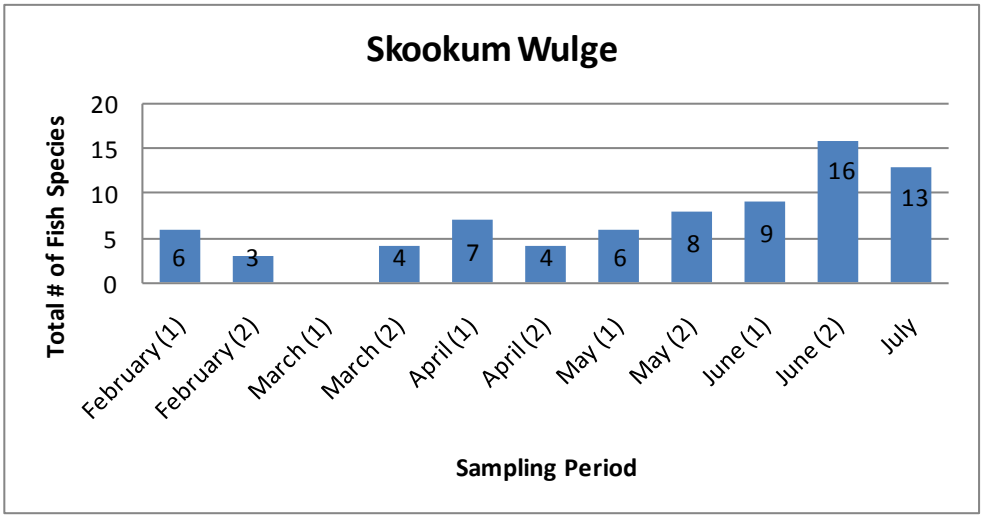
Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the Yowkwala site. No fish-monitoring reference site has been selected for comparison purposes.

3.3.2 Skookum Wulge

Introduction. Fish sampling occurred at the Skookum Wulge site on 30 occasions; the sampling events were conducted bimonthly from mid-February through March and weekly from April through mid-July 2008. Over the six-month sampling period, 36 individual net sets were completed. Beach seine sampling was conducted as described in Appendix A.

Descriptive Analysis. Complete catch records were kept for all sampling events, and lengths were recorded for selected species as described in Appendix A. The SR per sampling event ranged from three to 16. In total, 19 different species (total SR) were caught during the various sampling events. Species richness was fairly constant, with peak numbers of species observed in late June (Figure 3-4). The Skookum Wulge site had the third-highest SR (tied with Puget Creek) among the beach seine/block net sites (Figure 3-1). Species observed included salmonids, forage fish, flat fish, and resident fish (e.g., sculpin, perch, snake prickleback). Four hundred and fifty-two surf smelt, 309 herring, and 102 sand lance were observed. Peak catches for surf smelt occurred in late June, while peak catches for herring and sand lance occurred in early July.

Figure 3-4. Total number of fish species caught at Skookum Wulge per sampling event, Year 7 (2008)



Six salmonid species were present at the site, including cutthroat and steelhead trout, and salmonids were encountered during every sampling event with the exception of one day in late February. Approximately 5,000 juvenile salmon were observed; juvenile pink salmon were the most abundant species, followed by chum and coho salmon. The peak catch of juvenile pink salmon occurred on one day in mid-April. Peak catches of chum coincided with peak catches for pink. The greatest numbers of coho were observed in mid-June. One hundred and eighteen juvenile Chinook salmon were observed, the majority of which were caught in the first half of June (Figure 3-5). Table 3-11 summarizes the CPUE for juvenile salmon caught at the Skookum Wulge site.

Figure 3-5 Average number of Chinook caught per set at Skookum Wulge, Year 7 (2008)

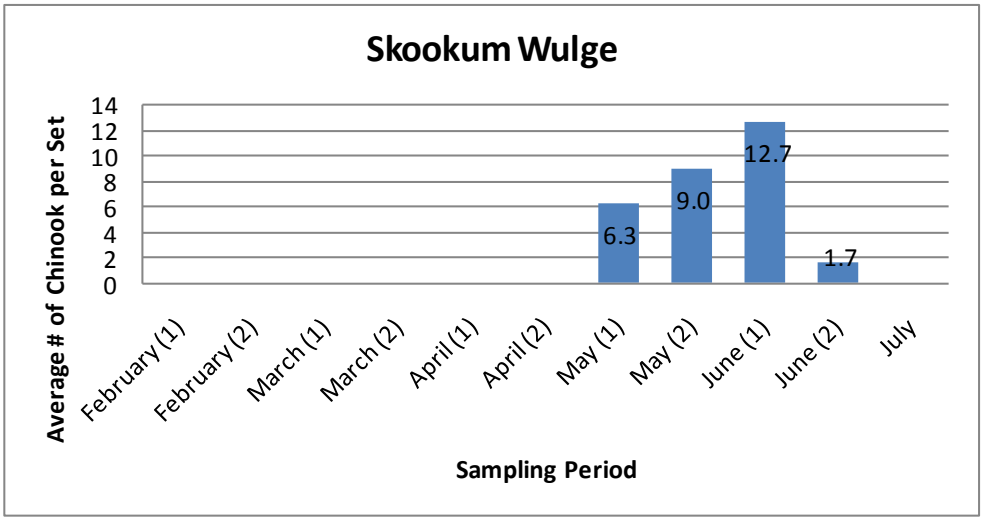


Table 3-11. Summary of total juvenile salmon caught and average numbers of salmon per set observed at the Skookum Wulge site, Year 7 (2008)

Species	Number of Salmon Caught	Average per Set/Catch per Unit Effort [a]
Chinook	118	3.28
Coho	642	17.83
Chum	1,494	41.50
Pink	2,820	78.33
Total salmon	5,074	140.94

a: There were 36 total sets completed at the site.

3.3.2.1 Success Criterion Evaluation

Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the Skookum Wulge site. No fish-monitoring reference site has been selected for comparison purposes.

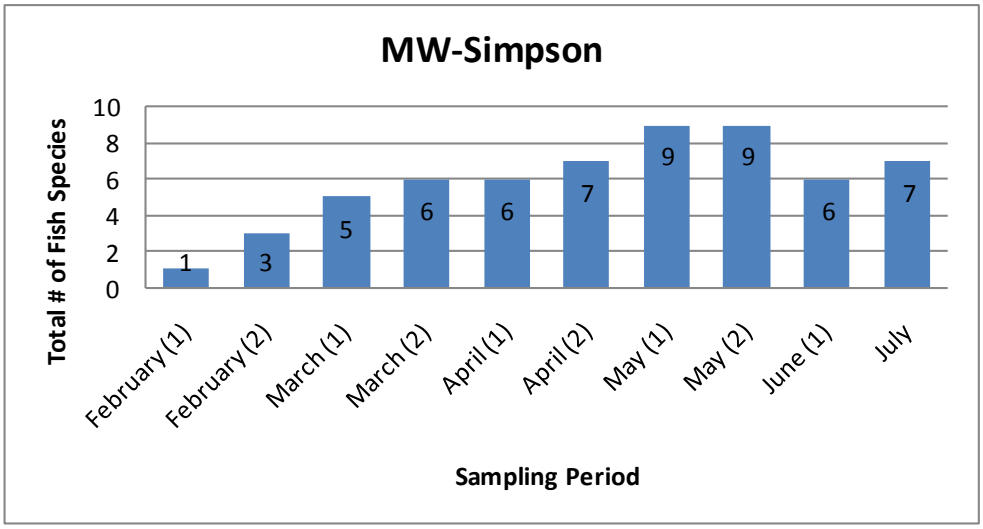
3.3.3 Middle Waterway (Simpson/Trustees)

Introduction. Fish sampling occurred at the Middle Waterway (Simpson/Trustees) site on 19 occasions; the sampling events were conducted bimonthly from mid-February through March and weekly from April through mid-July 2008. The site was not sampled as frequently as the others because it cannot be accessed by boat during tides lower than 8 ft (2 m) MLLW. Over the

sampling period, 44 individual beach seine net sets were completed. Beach seine sampling was conducted as described in Appendix A.

Descriptive Analysis. Complete catch records were kept for all sampling events, and lengths were recorded for selected species as described in Appendix A. The SR per sampling event ranged from one to nine; 13 different species (total SR), including four salmonid species, were caught during the various sampling events. The Middle Waterway (Simpson/Trustees) site ranked fourth among the sites in SR (Figure 3-1), which peaked in May (Figure 3-6). Shiner perch was the most abundant species present, followed by surf smelt and Pacific staghorn. Peak catches of surf smelt occurred in mid-April, and peak catches for shiner perch and Pacific staghorn occurred in mid-May.

Figure 3-6. Total number of fish species caught at Middle Waterway (Simpson/Trustees) per sampling event, Year 7 (2008)



Approximately 680 juvenile salmon were observed at the site. Juvenile Chinook salmon were the most abundant species, followed by pink, chum, and coho salmon. Peak catches of Chinook occurred in the second half of May (Figure 3-7). Pink salmon were the second most abundant salmon species at the site, with peak catches occurring in early May. The chum salmon catch peaked in early May as well. The majority of coho salmon were observed in early June. No trout were caught during any of the sampling events. Table 3-12 summarizes the CPUE for juvenile salmon caught at the Middle Waterway (Simpson/Trustees) site.

Figure 3-7. Average number of Chinook caught per set at Middle Waterway (Simpson/Trustees), Year 7 (2008)

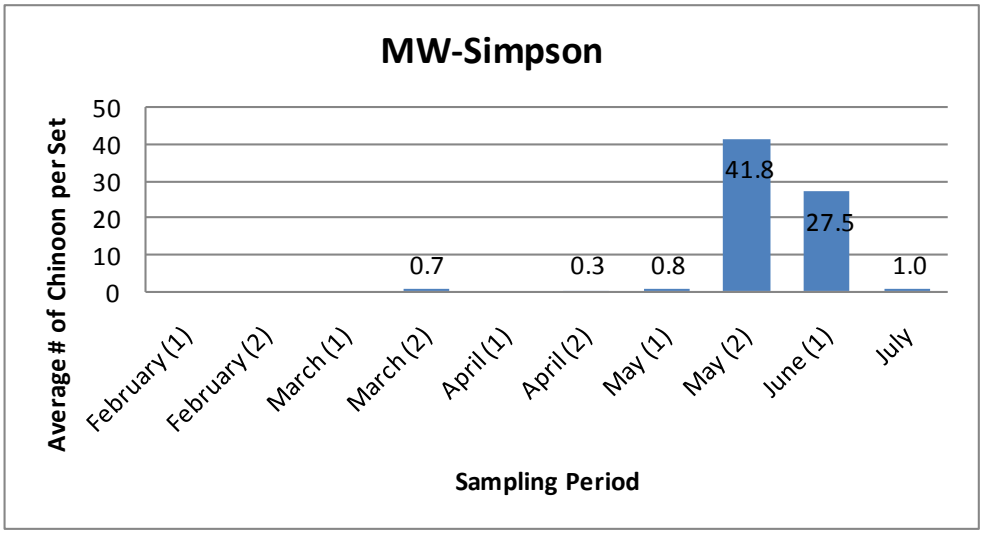


Table 3-12. Summary of total juvenile salmon caught and average numbers of salmon per set observed at the Middle Waterway (Simpson/Trustees) site, Year 7 (2008)

Species	Number of Salmon Caught	Average per Set/Catch per Unit Effort [a]
Chinook	277	6.30
Coho	92	2.09
Chum	140	3.18
Pink	168	3.82
Total salmon	677	15.39

a: There were 44 total sets completed at the site.

3.3.3.1 Success Criterion Evaluation

Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the Middle Waterway (Simpson/Trustees) site. No fish-monitoring reference site has been selected for comparison purposes.

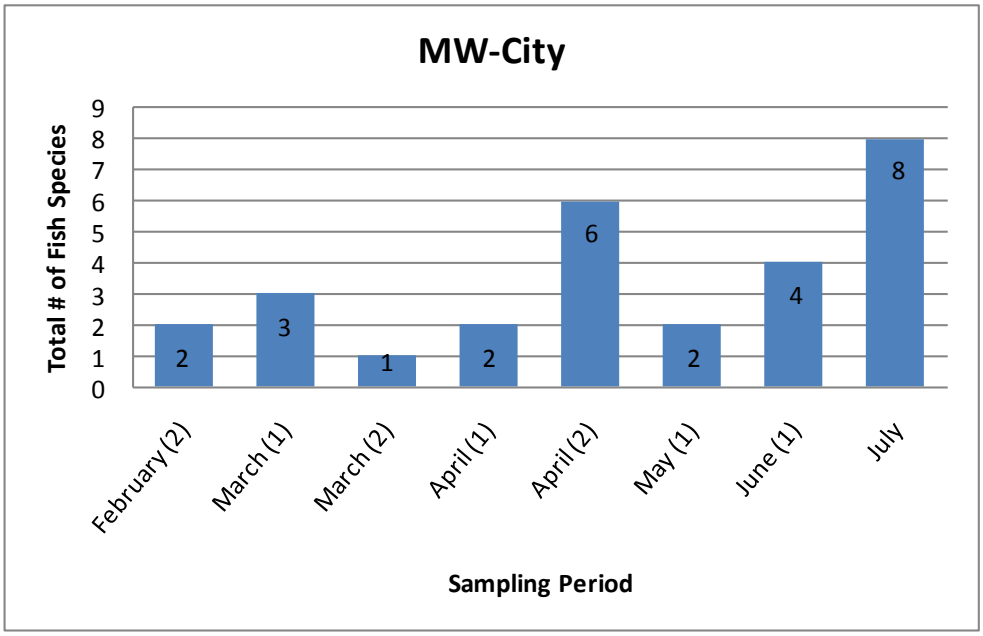
3.3.4 Middle Waterway (City of Tacoma)

Introduction. Fish sampling occurred at the Middle Waterway (City of Tacoma) site on 10 occasions; the sampling events were conducted bimonthly from mid-February through March and weekly from April through mid-July 2008. The site was not sampled as frequently as the

others because it cannot be accessed by boat during tides lower than 8 ft (2 m) MLLW. Over the six-month sampling period, 13 individual beach seine sets were completed. Beach seine sampling was conducted as described in Appendix A.

Descriptive Analysis. Complete catch records were kept for all sampling events, and lengths were recorded for selected species as described in Appendix A. Species richness per sampling event ranged from one to eight. In total, 11 different species (total SR) were caught during the various sampling events (Figure 3-1). The Middle Waterway (City of Tacoma) site had the lowest SR among the sites sampled for fish assemblage composition (Figure 3-1); SR peaked during late April and again in July (Figure 3-8). Shiner perch was the most abundant species observed, followed by coho and pink salmon. No shiner perch were caught during the February through June sampling events, and shiner perch catch peaked in July. Fifteen surf smelt were observed at the site, the majority on one day in early May.

Figure 3-8. Total number of fish species caught at Middle Waterway (City of Tacoma) per sampling event, Year 7 (2008)



Approximately 340 juvenile salmon were observed. Four salmonid species (coho, pink, Chinook, and chum) were encountered over the course of seven of the 10 sampling events, with coho salmon being the most abundant. Coho catch peaked in mid-May, and the majority of pink

salmon were observed in the second half of April. The peak catch for Chinook (Figure 3-9) occurred in early June. Chum salmon were observed only in April; six were sampled during three sampling events. No trout were caught at the site. Table 3-13 summarizes the CPUE for juvenile salmon caught at the Middle Waterway (City of Tacoma) site.

Figure 3-9. Average number of Chinook caught per set at Middle Waterway (City of Tacoma), Year 7 (2008)

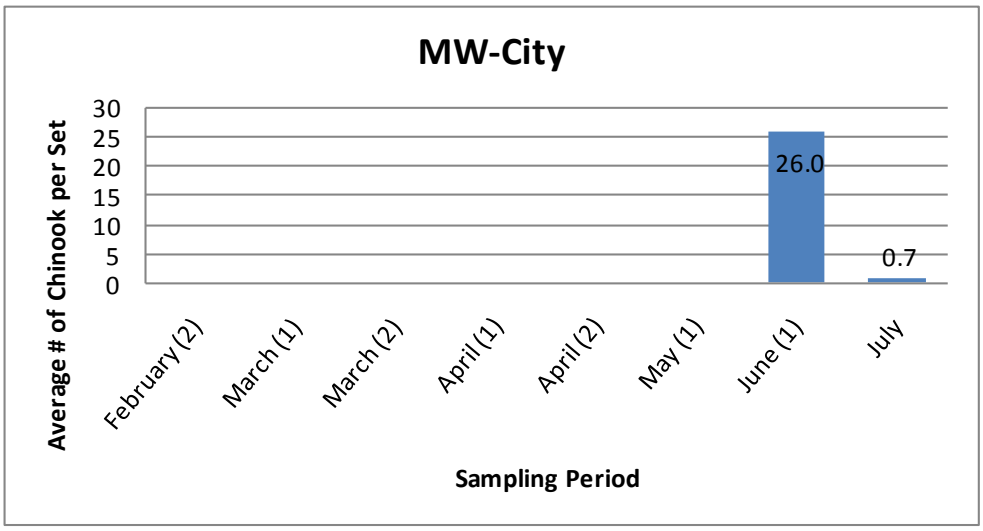


Table 3-13. Summary of total juvenile salmon caught and average numbers of salmon per set observed at the Middle Waterway (City of Tacoma) site, Year 7 (2008)

Species	Number of Salmon Caught	Average per Set/Catch per Unit Effort[a]
Chinook	231	2.78
Coho	694	8.36
Chum	137	1.65
Pink	962	11.59
Total salmon	2,024	24.39

a: There were 83 total sets completed at the site.

3.3.4.1 Success Criterion Evaluation

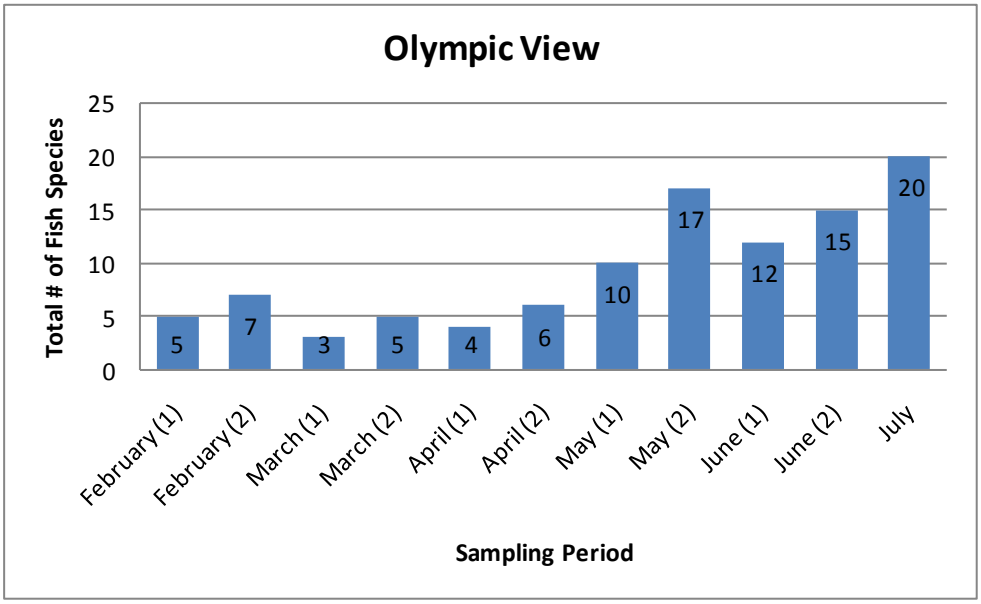
Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the Middle Waterway (City of Tacoma) site. No fish-monitoring reference site has been selected for comparison purposes.

3.3.5 Olympic View

Introduction. Fish sampling occurred at the Olympic View site on 32 occasions; the sampling events were conducted bimonthly from mid-February through March and weekly from April through mid-July 2008. No fish were caught when the site was sampled using the block net. Over the six-month sampling period, 83 individual net sets, including four block net sets, were completed. Beach seine sampling and block net sampling were conducted as described in Appendix A.

Descriptive Analysis. Complete catch records were kept for all sampling events, and lengths were recorded for selected species. The Olympic View site had the highest SR among the sites (Figure 3-1), with the SR per sampling event ranging from three to 20. In total, 26 different species (total SR), including six salmonid species, were caught during the various sampling events. The peak number of species observed occurred in July (Figure 3-10). Species observed included salmonids, forage fish, shiner perch, flat fish, and gunnels. Shiner perch was the most abundant species encountered, with peak catches in mid-May. Pink salmon was the second most abundant species encountered, followed by coho salmon. One hundred and twenty-three sand lance and 115 surf smelt were observed, with peak catches occurring in late June and February, respectively.

Figure 3-10. Total number of fish species caught at Olympic View per sampling event, Year 7 (2008)



Approximately 2,000 juvenile salmon and six salmonid species were observed, including steelhead and bull trout/Dolly Varden. The peak salmonid catch occurred from late April through June. Catch rates for pink salmon peaked in May; coho catch peaked on one day in the first half of June. The Chinook salmon catch peaked in late May (Figure 3-11). Chum salmon were also present at the site, with peak catches in mid-May. In addition, one steelhead and one bull trout/Dolly Varden were caught. The bull trout/Dolly Varden, which was caught in July, was the only specimen of this species sampled at any of the sites. Table 3-14 summarizes the total catch and average per set for juvenile salmon caught at the Olympic View site.

Figure 3-11. Average number of Chinook caught per set at Olympic View, Year 7 (2008)

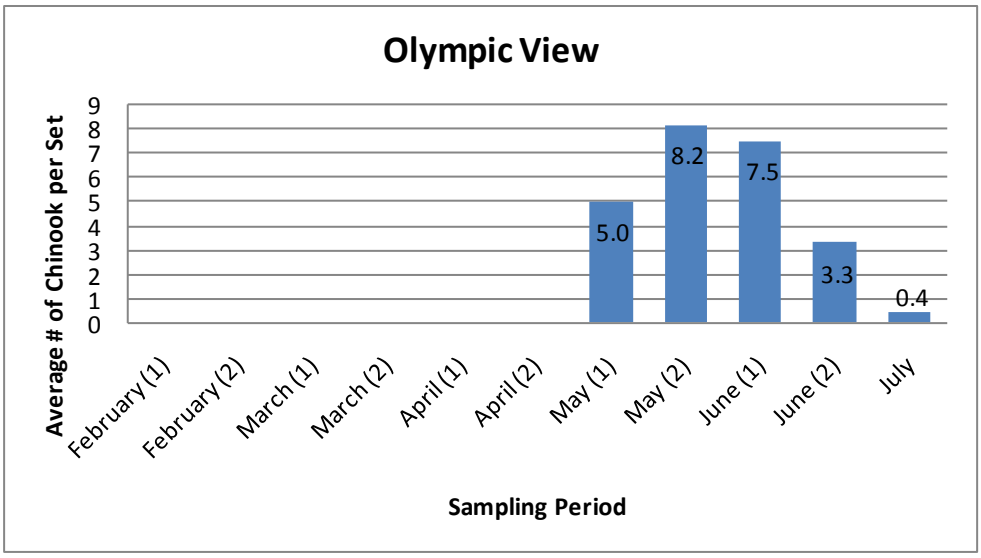


Table 3-14. Summary of total juvenile salmon caught and average numbers of salmon per set observed at the Olympic View site, Year 7 (2008)

Species	Number of Salmon Caught	Average per Set/Catch per Unit Effort[a]
Chinook	231	2.78
Coho	694	8.36
Chum	137	1.65
Pink	962	11.59
Total salmon	2,024	24.39

a: There were 83 total sets completed at the site.

3.3.5.1 Success Criterion Evaluation

Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the Olympic View site. No fish-monitoring reference site has been selected for comparison purposes.

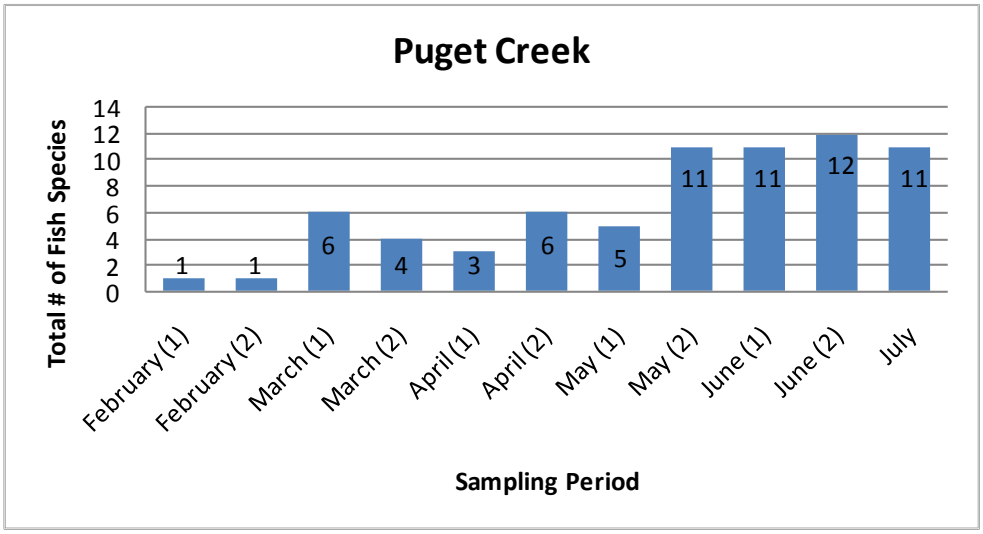
3.3.6 Puget Creek

Introduction. Fish sampling occurred at the Puget Creek site on 31 occasions; the sampling events were conducted bimonthly from mid-February through March and weekly from April

through mid-July 2008. Over the six-month sampling period, 57 individual net sets were completed. Beach seine sampling was conducted as described in Appendix A.

Descriptive Analysis. Complete catch records were kept for all sampling events, and lengths were recorded for selected species as described in Appendix A. The SR per sampling event ranged from one to 12. In total, 19 different species (total SR) were caught during the various sampling events. The Puget Creek site had the third highest SR (tied with Skookum Wulge) among the sites (Figure 3-1), and the number of different species observed peaked in late June (Figure 3-12). Species observed at the site included salmonids, perch, gunnels, and pricklebacks. Although surf smelt, sand lance, and herring were caught, total catch rates were below 10 fish for each species. Pink salmon had the highest numbers observed at the site, followed by chum salmon and shiner perch. Approximately 260 snake pricklebacks were observed; more than 230 of them were sampled on a single day in June. Approximately 13,000 juvenile salmon were observed. Juvenile pink salmon were the most abundant species, followed by chum and coho salmon.

Figure 3-12. Total number of fish species caught at Puget Creek per sampling event, Year 7 (2008)



Five salmonid species were observed, including one cutthroat trout. The peak salmonid catch occurred in late May. Salmonid species were caught throughout the six-month sampling period, with the exception of one day in February. Pink salmon was the most abundant salmonid

species, peaking in mid-April. The Chinook catch peaked in late May (Figure 3-13). Peak numbers for coho salmon occurred in mid-June, while peak numbers for chum salmon occurred in mid-May. Table 3-15 summarizes the CPUE for juvenile salmon caught at the Puget Creek site.

Figure 3-13. Average number of Chinook caught per set at Puget Creek, Year 7 (2008)

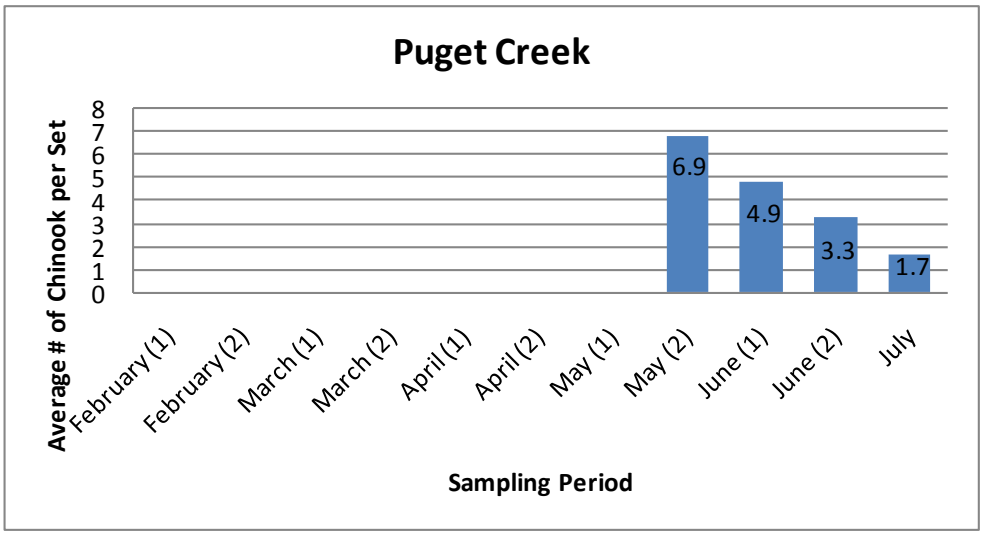


Table 3-15. Summary of total juvenile salmon caught and average numbers of salmon per set observed at the Puget Creek site, Year 7 (2008)

Species	Number of Salmon Caught	Average per Set/Catch per Unit Effort [a]
Chinook	118	2.07
Coho	196	3.44
Chum	3,632	63.72
Pink	9,528	167.16
Total salmon	13,474	236.39

a: There were 57 total sets completed at the site.

3.3.6.1 Success Criterion Evaluation

Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the Puget Creek site. No fish-monitoring reference site has been selected for comparison purposes.

3.3.7 Hylebos Creek Off-Channel (Jordan)

Introduction. The Hylebos Creek Off-Channel (Jordan) site was successfully sampled for fish assemblage composition using the snorkel survey method, which was conducted as described in Appendix A. Ten snorkel surveys were scheduled, but the first of these, scheduled for late April, was cancelled due to zero visibility. Snorkel surveys therefore occurred on nine occasions between May and mid-July. Sampling was conducted weekly from May through June, with the exception of the last week in June. The final snorkel survey occurred in mid-July.

It was not possible to snorkel Reach 3 of the off-channel habitat area or the upper portions of Reach 4 and all of Reach 5 in Hylebos Creek, because water depths were generally less than 8 inches (20 cm). These shallow depths appear to be caused by sand settling from Hylebos Creek. The openings or mouths of the channels connecting Hylebos Creek to Reach 3 of the off-channel habitat area were at times completely blocked by sand and sediment, thus restricting water flow from Hylebos Creek. The source of the sand is unknown. Visual surveys from the bank were conducted in the reaches that were too shallow for snorkeling; however no fish were observed using this method.

Descriptive Analysis. Complete catch records were kept for all sampling events and lengths were recorded for selected species as described in Appendix A. Eight species were observed, including juvenile salmonids, flat fish, sculpin, and stickleback. In both the off-channel habitat area and the Hylebos Creek area, juvenile salmonids were observed holding in deeper water in and around root wads or other woody cover. A total of five juvenile Chinook, 33 juvenile coho, and three chum salmon were observed, the majority of them in Hylebos Creek. All the salmon observed had intact adipose fins. Chinook ranged from 65 to 75 mm in length, coho ranged from 65 to 120 mm in length, and chum ranged from 45 to 50 mm in length. Chinook were observed in the last week of May and the first week of June. Coho were observed in May, June, and July. Chum were observed during the last week of May. All juvenile Chinook and coho salmon were observed in Hylebos Creek in the deeper portions of Reaches 3 and 4, with the exception of nine coho observed in a root wad in Reach 1 of the off-channel habitat area.

Four trout were observed at the site during May and July. Of these, one was identified as a cutthroat trout and three were identified as rainbow trout. The three rainbow trout ranged from 150 to 200 mm in length, and the one cutthroat trout was approximately 250 mm in length. The trout were observed in the Hylebos Creek area in the deeper portions of Reaches 3 and 4.

Table 3-16 summarizes the species observed at the site and their numbers.

Table 3-16. Summary of fish species and numbers observed at the Hylebos Creek Off-Channel (Jordan) site, Year 7 (2008)

Common Name	Scientific Name	Total
Chinook salmon	*Oncorhynchus tshawytscha*	5
Chum salmon	*Oncorhynchus keta*	3
Coho salmon	*Oncorhynchus kisutch*	33
Cutthroat trout	*Oncorhynchus clarki*	1
Rainbow trout	*Oncorhynchus mykiss*	3
Flat fish	*Pleuronectidae spp./Pleuronectiformes spp.*	8
Sculpin	*Cottidae spp.*	10
Stickleback	*Gasterosteus aculeatus*	258

3.3.7.1 Success Criterion Evaluation

Based on the presence of salmonid and non-salmonid fish, BSC 7 appears to be met for resident non-salmonid species at the Hylebos Creek Off-Channel (Jordan) site. BSC 7 is only partially met for salmonids, which were observed at one root wad in Reach 1, not throughout the site. No fish-monitoring reference site has been selected for comparison purposes.

3.4 Biological Success Criterion 9 – Bird Use

Ridolfi performed bird use monitoring at the Hylebos Creek Off-Channel (Jordan) and Sha Dadx sites. Complete records of observations and sampling details such as date, time, temperature, and weather conditions for each birding event were entered into an Excel spreadsheet to facilitate data analysis and the preparation of figures and tables. Detailed tabulations are provided in Appendix B. Figure 3-14 shows the total SR for each site and the average number of bird

species observed for each sampling event. Figure 3-15 shows the number of bird species observed per month for both sites.

3.4.1 Hylebos Creek Off-Channel (Jordan)

Introduction. The Hylebos Creek Off-Channel (Jordan) site was successfully monitored for bird assemblage composition. Ten field visits were conducted from April through December 2008. Visits occurred on a monthly basis, excepting June, when two field visits were performed because June typically coincides with seasonal migratory and breeding patterns in the area. Bird use monitoring was conducted as described in Section 2.4.

Descriptive Analysis. Fifty-four bird species were recorded at the Hylebos Creek Off-Channel (Jordan) site during the sampling season (Figure 3-14). The number of species observed between April and December ranged from four to 25 per site visit (Figure 3-15). The greatest number of bird species was observed in mid-April, and the lowest number was observed in December.

Birds were observed using the site, primarily in the canopy of the riparian areas, during every field visit. Three species (belted kingfisher, gadwall, and mallard) were observed in the open water areas of Hylebos Creek during spring, summer, and fall. In all, five species were observed using the marsh habitat areas; however, these areas were difficult for observers to access because of the growth of the riparian vegetation that borders them. As a result, the number of bird species using the marsh areas may actually be higher than what was observed. Species observed in the marsh areas included chestnut-backed chickadee, Canada goose, great blue heron, mallard, and song sparrow, all of which appeared to be foraging. Mallards were observed in the marsh areas during the August, October, and December visits. The remaining species were observed using the marsh areas during spring visits. Great blue heron was observed stalking prey in the marsh areas in both spring and late summer. Bird use of the site was highest in summer (44 species) and lowest in winter (four species). These trends generally follow migratory and breeding seasons for the region.

Figure 3-14. Total number of bird species observed at Hylebos Creek Off-Channel (Jordan) and Sha Dadx, Year 7 (2008)

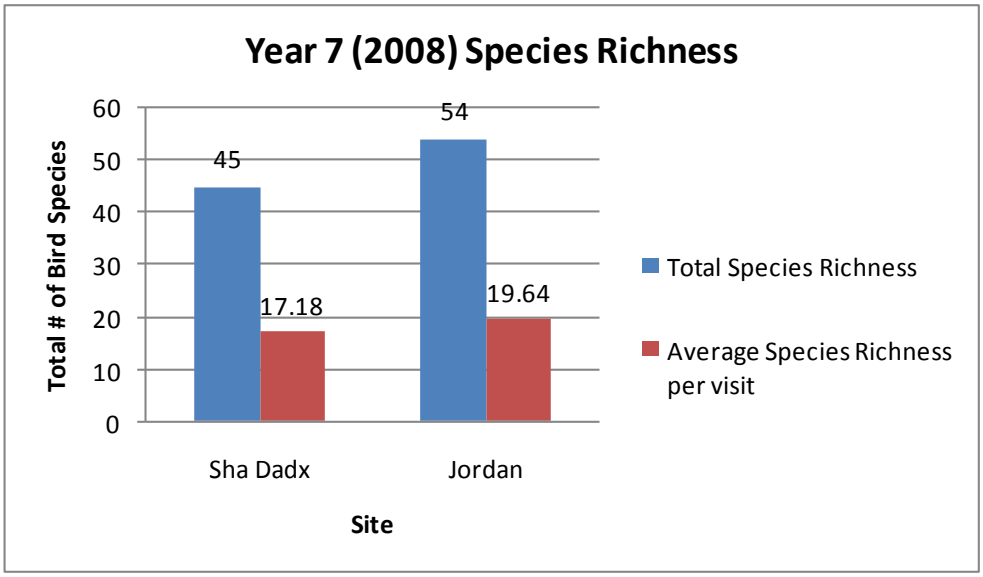
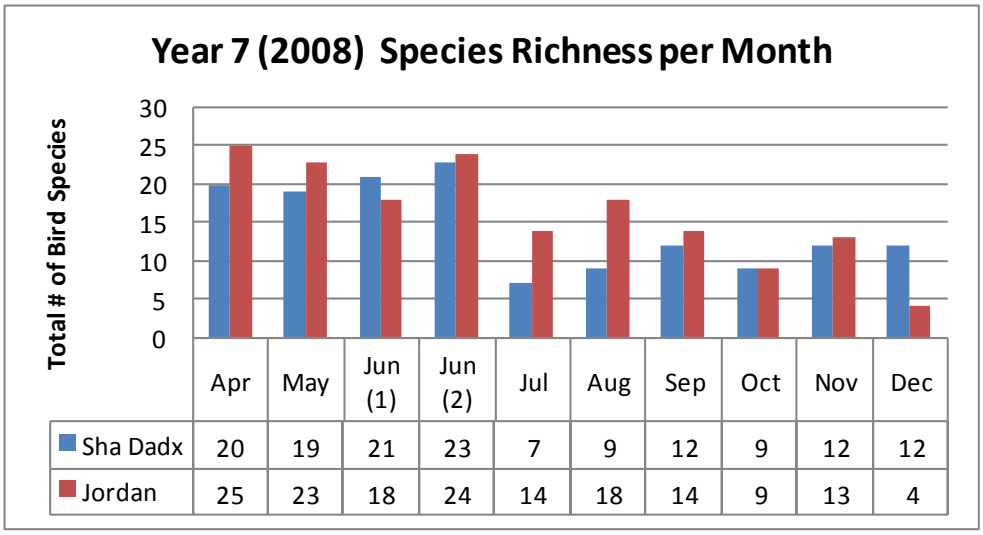


Figure 3-15. Total number of bird species observed at Hylebos Creek Off-Channel (Jordan) and Sha Dadx per sampling event, Year 7 (2008)



	Apr	May	Jun (1)	Jun (2)	Jul	Aug	Sep	Oct	Nov	Dec
Sha Dadx	20	19	21	23	7	9	12	9	12	12
Jordan	25	23	18	24	14	18	14	9	13	4

Song sparrow was the sole species observed during all 10 field visits. American robin was observed during nine of 10 field visits, and mallards were present during eight field visits.

Waterfowl species included mallard, Canada goose, common goldeneye, and gadwall. Mallards were observed during every season (with no observations in July and September).

Common goldeneye was observed foraging in the creek near the bridge in spring and summer. Canada goose and gadwall were observed in April and June, respectively. Great blue heron was observed in May, July, and November. During each of these visits, one heron was seen stalking prey in the marsh areas. Belted kingfisher was observed stalking and foraging along the creek during spring, summer, and fall. During the September visit, one female kingfisher was observed catching and consuming fish near the bridge. Shorebird species were not observed at the site, possibly because the majority of the shoreline is obstructed from view.

Five raptor species were observed during spring, summer, and fall. No raptors were observed in winter. Bald eagle, Cooper's hawk, peregrine falcon, red-tailed hawk, and sharp-shinned hawk were observed engaging in various behaviors, including soaring, calling, diving, foraging, and perching; all five species engaged in these activities during spring. During the October field visit, the site was fairly quiet and lacked bird activity. This observation may be attributed to the presence of a Cooper's hawk and a sharp-shinned hawk that were seen soaring over the site and perching in the riparian canopy. Red-tailed hawks were heard calling, indicating territorial behavior; although no nest was observed, potential nest sites exist on the wooded hillside above the restoration site.

Obvious evidence of breeding (singing, fighting, or pursuit; "broken-wing" distraction technique; gathering of nesting material; presence of young) was observed for 16 species: American robin, black-headed grosbeak, common yellowthroat, house finch, olive-sided flycatcher, song sparrow, willow flycatcher, American goldfinch, marsh wren, warbling vireo, western tanager, barn swallow, black-capped chickadee, mourning dove, red-winged blackbird, and spotted towhee.

Many bird species migrate seasonally to areas that will supply them with sufficient food sources to support them during their breeding season. Generally, bird species are characterized by four basic migratory types: complete migrators, partial migrators, irruptive migrators, and non-migrators, as described below (Tekiela, 2001):

- Complete migrators travel at set times and along set patterns each year, varying little from their migration patterns.
- Partial migrators travel seasonally, but not at set times or in set patterns. Partial migrators initiate movement when food supplies become insufficient to support their life cycle. They will generally travel south, east, or west until they find sufficient food sources and will remain in those areas while the food sources last.
- Irruptive migrators have erratic migration patterns that may include seasonal migrations. These seasonal migration patterns depend on the availability of food sources. If food sources are plentiful, irruptive migrators will not move.
- Non-migrators or resident species typically do not migrate out of their regions.

Many species use a combination of these migration patterns to fulfill their life cycles.

The majority of bird species observed at the site migrate south in some combination of patterns to wintering grounds in the southern United States, Mexico, Central America, and South America. Use of the site by complete migrator bird species was greatest in summer and lowest in winter. Twelve species considered partial migrators were observed in various combinations, the majority in spring and summer. One irruptive migratory species, pine siskin, was observed in November. Over 55 pine siskins were seen flying and foraging over the site. Twenty-two non-migrators or resident bird species were observed during spring, summer, and fall. Two non-migrating species and one complete migrating species were observed during the December field event. Mallard, a partial to non-migrator species, was also present at the site during the winter sampling event.

3.4.1.1 Success Criterion Evaluation

Based on the presence of resident and migratory bird species, BSC 9 appears to be met for indigenous and native bird species at the Hylebos Creek Off-Channel (Jordan) site. A bird use reference site has not been selected for comparison purposes.

3.4.2 Sha Dadx

Introduction. The Sha Dadx site was monitored for bird assemblage composition during ten field visits conducted from April through December. Visits occurred on a monthly basis, excepting June, when two field visits were performed because June typically coincides with seasonal migratory and breeding patterns in the area. Monitoring coincided with restoration construction, which began in June and continued through mid-November, generally one of the periods of greatest SR for this region. Bird monitoring was conducted as described in Section 2.4.

Descriptive Analysis. Forty-five bird species were recorded at the Sha Dadx site during 10 field visits. The number of species observed between April and December ranged from nine to 23 (Figure 3-14). The greatest number of bird species was observed in late June, and the lowest number was observed in July (Figure 3-15). Because of the heavy construction noise and disturbances, SR was low at the site during the summer and fall months.

Birds were observed during every field visit, primarily in the site's riparian and meadow habitat zones. Six species were observed in the marsh or wetland areas during the spring, summer, and fall sampling events. All of these species, including common yellowthroat, mallard, northern shoveler, red-winged blackbird, song sparrow, and willow flycatcher, were observed in the wetland area in the western portion of the site. This area experienced the least amount of disturbance during construction and seemed to be providing a refuge for the displaced birds. Post-construction, waterfowl, including bufflehead, hooded merganser, and mallard, were observed foraging throughout the site in the newly constructed open-water pools.

European starling, pine siskin, and song sparrow were all observed in large numbers. Forty-five of the 74 European starlings observed at the site were seen during the fall and winter sampling events, perching in the large trees bordering the newly constructed pools. Pine siskin was the second most abundant species at the site. Fifty birds were observed flying and perching among the large trees on a single day in December. Over 50 song sparrows were observed, the majority during the spring and summer sampling events. Other species observed at the site in large numbers (40 or more individuals) were American robin, Canada goose, and mourning dove.

Black-capped chickadee, mourning dove, and song sparrow were observed at the site on eight of 10 field visits. Black-capped chickadee and song sparrow were present in spring, summer, and fall. Mourning dove were documented using the site in spring, summer, fall, and winter.

Waterfowl species observed using open water at the Sha Dadx site included bufflehead (one female), hooded merganser (one male, one female), mallard (six males, six females), and northern shoveler (one male). Waterfowl use of the open-water areas was observed only in November and December, when waterfowl were seen foraging in the newly constructed pools and channels.

No shorebird species were observed using the site. This is to be expected because the shoreline was under heavy construction during the majority of the sampling season. Prior to construction, the shoreline was heavily vegetated and did not necessarily provide sufficient access to shallow mudflat habitats that shorebird species require for foraging. Populations of waterfowl and shorebird species should increase over time at the site as the shoreline habitat establishes and matures.

Great blue heron were present at the site in spring and summer. Four of the five herons observed were seen flying over the site and one was perched in a large tree.

Raptor species observed included red-tailed hawk, osprey, and barn owl. Red-tailed hawk were observed foraging, calling, and soaring over the site during spring, summer, and fall. One osprey was observed soaring over the site during a June field visit. A barn owl was observed during the first (April) sampling event, prior to construction. The owl was observed flying through the forested portion of the site and roosting in what appeared to be an established roosting area. White-wash was present, also indicating a roost location. The grove of trees used by the barn owl was cut down early in the construction work to develop the large open-water pools.

Obvious evidence of breeding (singing, fighting, or pursuit; “broken-wing” distraction technique; gathering of nesting material; presence of young) was observed for 17 species: American goldfinch, American robin, common yellowthroat, mourning dove, song sparrow, spotted towhee, Steller’s jay, red-tailed hawk, downy woodpecker, western scrub jay, western tanager,

black-capped chickadee, olive-sided flycatcher, willow flycatcher, Bewick's wren, black-headed grosbeak, and house finch.

The majority of the bird species migrate south in some combination of patterns to wintering grounds in the southern United States, Mexico, Central America, and South America. Use of the site by complete migrator bird species was greatest in summer and lowest in fall. Fifteen complete migrator species were observed using the site. Ten species considered partial migrators were observed in various combinations, with the majority seen in spring and summer. One irruptive migrator species, pine siskin, was observed in November and December. Fifty pine siskin were seen flying and foraging over the site on a single visit in December. Nineteen non-migrators or resident bird species were observed during all four seasons.

3.4.2.1 Success Criterion Evaluation

Based on the presence of resident and migratory bird species, BSC 9 appears to be met for indigenous and native bird species at the Sha Dadx site. A bird use reference site has not been selected for comparison purposes.

3.5 Physical Success: Aerial Photography

Walker and Associates of Seattle, Washington, shot aerial photographs at the Yowkwala, Squally Beach, Mowitch, Hylebos Creek Off-Channel (Jordan), Middle Waterway (Simpson/Trustees), Middle Waterway (City of Tacoma), Olympic View, and Sha Dadx sites. Those photographs are used in Section 1 of this report as the base for figures that display site features at these locations and were presented as prints in a separate deliverable in fall 2008.

3.6 Baseline Chemical Conditions: Surface Water Chemistry

Introduction. Ridolfi performed surface water sampling at the Squally Beach, Mowitch, Hylebos Creek Off-Channel (Jordan), and Middle Waterway sites. Sampling locations are shown on Figures 1-4, 1-5, 1-6, and 1-7. The samples were submitted to ARI for analysis of dissolved metals and nutrients and to SPECTRA for fecal coliform analysis. Table 3-17 presents the analytical results and compares them to appropriate screening levels, as summarized below.

Descriptive Analysis. The samples were analyzed for dissolved arsenic, cadmium, chromium, copper, lead, mercury, silver, and zinc. Only arsenic, copper, and zinc were detected at concentrations above the sample detection limit. Copper was detected at concentrations exceeding the relevant screening level at all sampling stations excepting the Hylebos Creek Off-Channel (Jordan) site, where copper was detected at a concentration below the screening level. The maximum copper concentration, which was detected in sample SW-01 from the Squally Beach site, exceeded the screening level by a factor of four; the copper concentration detected in SW-02 from the Squally Beach site exceeded the screening level by a factor of approximately 3.5. The concentration of copper detected in the sample from the Middle Waterway site exceeded the screening level by a factor of just over three, and copper detected in the sample from the Mowitch site slightly exceeded the screening level. Arsenic and zinc were detected in the sample from the Hylebos Creek Off-Channel (Jordan) site, but at concentrations below their screening levels. Arsenic was also detected in the Mowitch sample, again at a concentration below the screening level.

Total nitrogen was calculated by summing the results of nitrite + nitrate and total Kjeldahl nitrogen analyses. Total nitrogen was detected in surface water from all of the sampling stations at concentrations exceeding the relevant screening level. The maximum concentration of total nitrogen, which exceeded the screening level by more than an order of magnitude, was detected at the Hylebos Creek Off-Channel (Jordan) site. Total nitrogen concentrations at the Mowitch and Middle Waterway sites were slightly lower, but also exceeded the screening level by an order of magnitude. Total nitrogen detected in the sample from Squally Beach station SW-01 exceeded the screening level by a factor of eight, while the concentration at Squally Beach station SW-02 was almost three times the screening level.

Total phosphorous was also detected in surface water from all of the sampling stations at concentrations exceeding the relevant screening level. The maximum concentration of total phosphorous was detected at the Middle Waterway site; this concentration exceeded the screening level by more than an order of magnitude.

Table 3-17. Surface water analytical results for the Commencement Bay restoration sites, Year 7 (2008)

Sample Location:			Hylebos Creek Off-Channel (Jordan)		Squally Beach				Mowitch		Middle Waterway			
Station Identification			SW-01		SW-01		SW-02		SW-01		SW-01			
Comments:													Field Duplicate	
Compound	**CAS No.**	**Screening Levels[a]**												
	Sample ID:		08102101		08102102		08102103		08102104		08102105		08102106[b]	
Dissolved Metals (µg/L)														
Arsenic	7440-38-2	36	3.3		5	U	5	U	3		5	U	5	U
Cadmium	7440-43-9	9	0.2	U	2	U	2	U	0.5	U	2	U	2	U
Chromium	7440-47-3	5	0.5	U	5	U	5	U	1	U	5	U	5	U
Copper	7440-50-8	3	1.6		**12**		**11**		**4**		**10**		**10**	
Lead	7439-92-1	8	1	U	10	U	10	U	2	U	10	U	10	U
Mercury	7439-97-6	0.025	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Silver	7440-22-4	1.9[c]	0.2	U	2	U	2	U	0.5	U	2	U	2	U
Zinc	7440-66-6	81	6		40	U	40	U	10	U	40	U	40	U
Nutrients														
Nitrate + Nitrite (mg-N/L)	NA	NA	0.68		0.332		0.348		0.518		0.234		0.233	
Total Kjeldahl Nitrogen (mg-N/L)	NA	NA	0.8		0.63		0.6	U	0.84		0.97		1.21	
Total Nitrogen[e]	NA	0.12[d]	**1.48**		**0.962**		**0.348**		**1.358**		**1.204**		**1.443**	
Total Phosphorous (mg-P/L)	NA	0.01[d]	**0.3**		**0.16**		**0.08**		**0.18**		**0.34**		**0.16**	
	Sample ID:		08102006		08102003		08102004		08102005		08102001		08102002[f]	
Fecal Coliform (CFU/100mL)	NA	43	**12,800**		**160**		**440**		**300**		**220**		**120**	

Notes:

Contaminant values in **bold** exceed screening guidelines.

a: Washington State Water Quality Standards - Marine chronic criteria (Ecology, 2006)

b: Sample 08102106 is a field duplicate of 08102105.

2006)

d: USEPA National Recommended Nutrient Criteria for Rivers and Streams in Ecoregion 2 (USEPA, 2000).

e: Total nitrogen is the sum of the value for nitrate +nitrite and the value for total Kjeldahl nitrogen.

f: Sample 08102001 is a field duplicate of 08102002.

sw = surface water

mL = milliliter

CFU = colony forming units

mg-N/L = milligrams nitrogen for liter

µg/L = microgram per liter

mg-P/L = milligrams phosphorous per liter

U: The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

The concentrations of total phosphorous detected in the Hylebos Creek Off-Channel (Jordan), Mowitch, and Squally Beach (SW-01) samples were slightly lower, but all exceeded the screening level by an order of magnitude. In the Squally Beach SW-02 sample, the concentration of total phosphorous exceeded the screening level by a factor of eight.

Fecal coliform concentrations in all five surface water samples exceeded the screening level. The maximum concentration, which was detected at the Hylebos Creek Off-Channel (Jordan) site, exceeded the screening level by more than two orders of magnitude. The fecal coliform concentration detected in the sample from Squally Beach station SW-02 exceeded the screening level by one order of magnitude. Fecal coliform concentrations in the Mowitch, Middle Waterway, and Squally Beach SW-01 samples exceeded the screening level by factors of approximately seven, five, and four, respectively.

Discussion. Fish and other aquatic species may be adversely affected by elevated levels of metals, nutrients, and fecal coliform in surface water. Copper in surface water harms salmon and other fish in estuarine environments by interfering with their olfactory nervous systems (Baldwin et al., 2003). Copper inhibits the sense of smell and ability to sense vibration, which can prevent salmon from finding safe spawning locations and cause the fish to stray to areas for which they are not adapted and may not be able to sense predators. These changes in migratory and spawning behavior may cause low survival rates. Copper can also impair breathing, brain function, blood chemistry, enzyme activity, and metabolic activities in salmon and other fish species, causing stress. Increases in stress may cause higher susceptibility to disease. Furthermore, copper interferes with osmoregulation, the process by which cells maintain fluid and electrolyte balance with their surroundings (Woody, 2007). The combined effects of copper on fish and other aquatic species can inhibit reproduction and cause death in individuals.

Nitrogen and phosphorous are harmful to fish because they fertilize algae and create an overgrowth known as an algae bloom. This is called cultural eutrophication, “the process whereby human activity increases the amount of nutrients entering an aquatic ecosystem causing excessive biological growth and depletion of dissolved oxygen concentrations” (Ku, 2007).

When an algae bloom decays, microbes consume the dissolved oxygen (DO) supply, causing fish to suffocate. Nitrogen and phosphorous create an excellent environment for the algae *Pfiestera piscicida* to thrive in coastal waters. "Known as the killer alga, *P. piscicida* can emit a strong neurotoxin when in the presence of schools of fish. It feasts, reproduces, and then settles back into the sediment" (Pew, 2003). Beyond causing fish kills and bottom water hypoxia, algae blooms can also lead to loss of perennial vegetation (Peterson et al., 2008). Thus, nutrient loading of nitrogen and phosphorous in aquatic ecosystems creates multiple negative impacts to fish and other aquatic species.

Fecal coliform bacteria in estuarine environments can be an indicator or an indirect cause of harm to fish and other aquatic species. The bacteria come from the intestines and fecal matter of warm-blooded animals (including humans) and indicate the presence of disease-causing bacteria and viruses. The likely presence of waterborne pathogens creates an exposure risk to humans engaging in recreational activities and makes shellfish toxic for consumption. It also causes unpleasant views and odors. Fecal coliform causes harm to fish by changing pH levels, contributing nutrients to the system, and subsequently decreasing already low supplies of oxygen (Ecology, 2005). Nutrients carried in animal waste include nitrogen and phosphorous, which fertilize algae and create harmful algae blooms. When the algae or the bacteria decompose aerobically, the process uses DO, which is already low in southern Puget Sound. By creating excessive biological oxygen demand in estuaries, fecal coliform bacteria threaten fish health by creating the risk of suffocation.

4.0 DISCUSSION OF MONITORING TO DATE AND COMPARISON OF SITES

4.1 Biological Success Criterion 2 – Marsh Development/Species Composition

The Squally Beach, Mowitch, and Middle Waterway (Simpson/Trustees) sites were monitored for BSC 2 in Years 1, 3, and 5 as well as in Year 7.[2] The Spearman's rank test was performed on the monitoring results to determine the statistical significance of any changes in marsh plant development and species composition observed from Year 1 (2002) to Year 7 (2008). Detailed results of this analysis are presented in Appendix C.

Figure 4-1 displays summary information for BSC 2 at Squally Beach for native species along two transects and for non-native invasive species. The trend line for the native species is positive and the line for the NNI trends slightly downward. However, the trends were not statistically significant. Figure 4-2 displays summary information for BSC 2 at Mowitch for native species along two transects and for non-native invasive species. The trend line for the native species is positive and the line for the NNI trends slightly downward. The trend in one of the two transects for native plants was statistically significant. Figure 4-3 displays summary information for BSC 2 at Squally Beach for native species along two transects. The trend line for the one of the transects is positive and statistically significant. The trend line for the other transect is nearly flat and the result is not statistically significant.

[2] The Hylebos Creek Off-Channel (Jordan) site was also monitored in Year 7, which was the newly built site's first monitoring year; results from Year 7 monitoring at the Hylebos Creek Off-Channel (Jordan) site will serve as the baseline for comparison to future years and are not included in the current discussion.

Figure 4-1. Total percent cover of non-native and native plant species at the Squally Beach site from 2002 through 2008 with trendlines

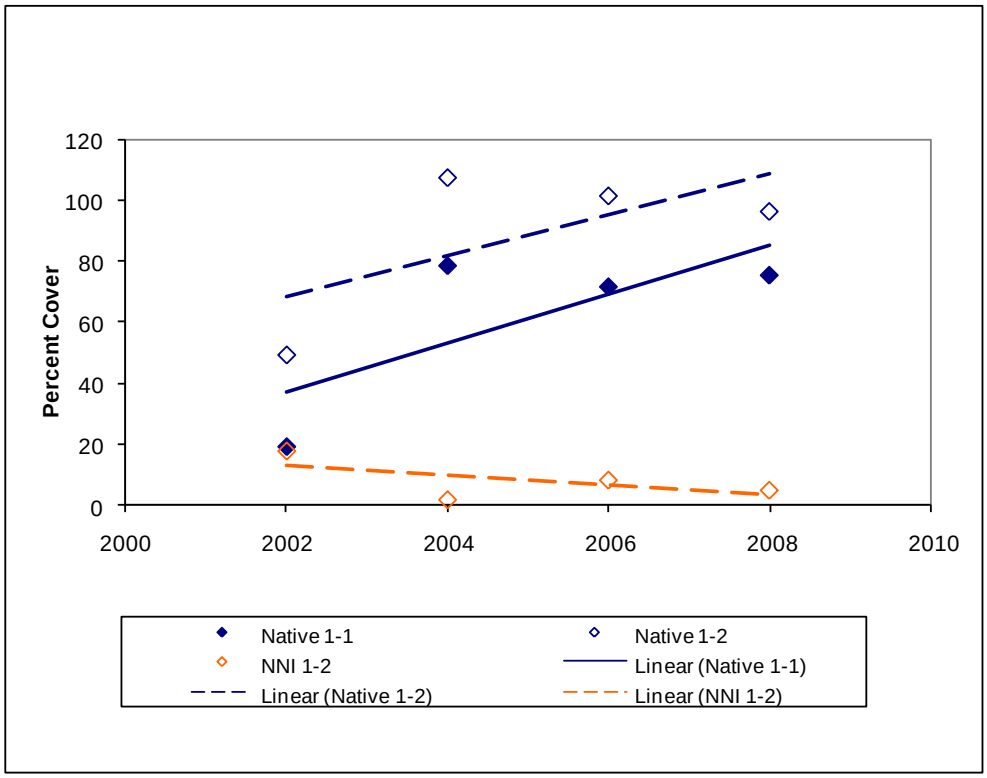


Figure 4-2. Total percent cover of non-native and native plant species at the Mowitch site from 2002 through 2008 with trendlines

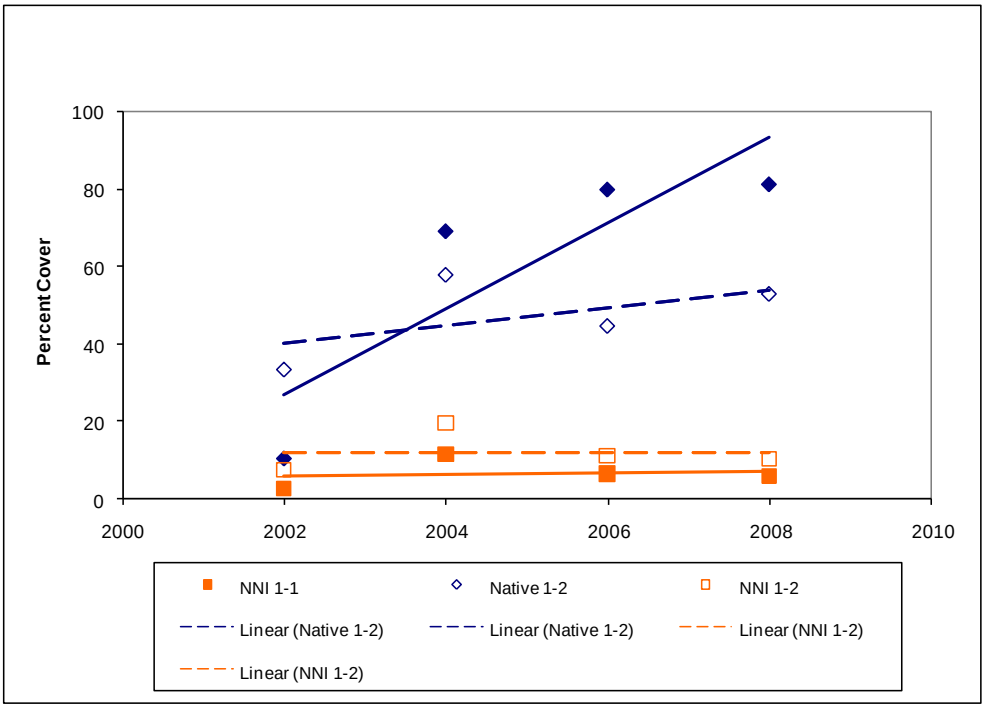
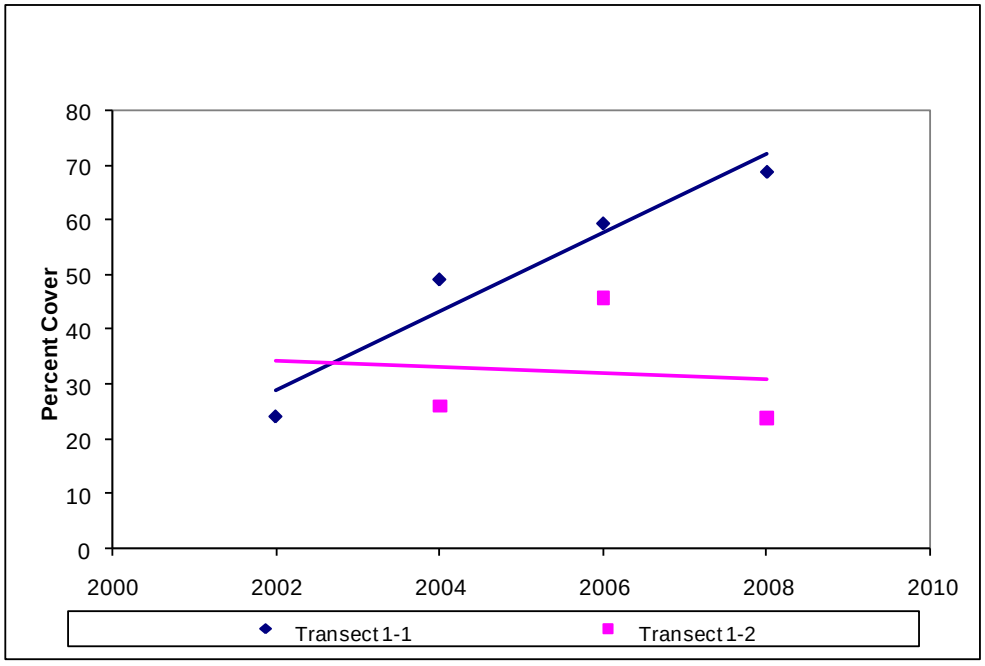


Figure 4-3. Total percent cover of native plant species at the Middle Waterway (Simpson/Trustees) site from 2002 through 2008 with trendlines



4.1.1 Discussion – BSC 2

The Year 7 data and general site observations indicate several trends occurring within the marsh at the three sites. As in Year 5, pickleweed was a dominant species in terms of percent cover in Year 7 and one of the most frequently occurring native species in the quadrats along most of the transects. There was no statistically significant change in NNI species by Year 7 at the Squally Beach, Mowitch, and Middle Waterway (Simpson/Trustees) sites. Brass buttons remained the dominant NNI species during Year 7.

At Mowitch Transect 1-2, pickleweed and fleshy jaumea were dominant. This may be due to the location of this transect on top of "lobes" within the Hylebos Creek channel with high exposure to sun and tidal flows and where much of the herbivory avoidance fencing had deteriorated by Year 5. Signs of scouring were also noted along portions of Mowitch Transect 1-2, indicating that debris may be carried under the deteriorated fencing by the tides, resulting in damage to the substrate and herbaceous vegetation. In 2008, Citizens for a Healthy Bay (CHB), a local environmental community group, repaired the herbivory avoidance fencing along this transect, which may allow pickleweed and other native marsh species to establish along the lobes. Additionally, CHB planted over 1,000 marsh plants along these lobes, which will help the cover to increase.

Squally Beach Transect 1-2 is located along the base of a riparian slope. The dominant herbaceous species along this transect was Lyngby's sedge. Hooker's willow was observed rooted in the adjacent slope and overhanging the marsh. It seems possible that the shading provided by the willow, along with freshwater inflows from upland areas, could make this area more suitable for sedge instead of pickleweed.

Herbivory avoidance fencing has been removed from the Squally Beach and Middle Waterway (Simpson/Trustees) sites. This does not appear to have impacted the Squally Beach site, where the marsh plants are well established and diverse. The marsh plants along Middle Waterway (Simpson/Trustees) Transect 1-1 are also well established. Middle Waterway (Simpson Trustees) Transect 1-2 runs along a low-elevation beach area where sand is the predominant substrate. In Year 5, only a small portion of this area was situated within herbivory avoidance

fencing, and the fenced area contained dense vegetation cover, while the surrounding unfenced area had very little vegetation cover. This may help explain why native cover did not significantly increase along Middle Waterway (Simpson/Trustees) Transect 1-2 by Year 5 as it did on all the other transects sampled: suitable area for native species growth is limited to the fenced area. Herbivory avoidance fencing appears to be a necessity here, and it appears that the fencing would need to remain on site indefinitely for the area to develop established marsh plant populations.

As in Year 5, the cover of fat-hen saltbush declined at the sites in Year 7. Statistical analysis indicates a significant decline in cover of this species along Mowitch Transect 1-1 and Squally Beach Transect 1-2. The reason for this decline is not readily apparent, but it could be influenced by drought conditions the previous summer, early senescence, or competition from other, faster-growing herbaceous species.

As in Year 5, field crews observed that the herbaceous marsh plant communities seem to be quite dynamic, with some species (e.g., pickleweed, seashore saltgrass) spreading to colonize new areas since Year 3, and other species (e.g., fat-hen saltbush) declining. This was apparent when comparing photos of the sampling quadrats over time, as well as observations at areas where pin flags marking changes in vegetation communities were still present from field work conducted in previous years.

4.2 Biological Success Criterion 6 – Riparian Vegetation/Areal Coverage

The Squally Beach, Mowitch, and Middle Waterway (Simpson/Trustees) sites were monitored for BSC 6 in Year 5 (2006) and Year 7 (2008).[3] Although it is difficult to assess trends at the sites based on only two sampling seasons, the results show that numerous native plant species are present at the restored sites, but BSC 6 is being only partially met at all three sites.

[3] The Hylebos Creek Off-Channel (Jordan) site was also monitored in Year 7, which was the newly built site's first monitoring year; results from Year 7 monitoring at the Hylebos Creek Off-Channel (Jordan) site will serve as the baseline for comparison to future years and are not included in the current discussion. Although numerous native plant species were observed at the site, BSC 6 is being only partially met.

4.2.1 Squally Beach

As observed in Year 5, several very dense willow and alder thickets are present in portions of the riparian area at the Squally Beach site. Shrubs were not observed growing beneath the willows, and shrub cover was also reduced beneath the alder canopy. Therefore, even though much of the riparian zone contains high shrub cover, overall mean shrub cover is relatively low because the tree canopy reduces shrub growth in some areas. NNI species noted at Squally Beach included field bindweed, Himalayan blackberry, reed canarygrass, pea vine, thistle, and bitter nightshade. The adjacent property immediately east of the riparian area is infested with field bindweed, which provides an ongoing source for this species to spread into the Squally Beach site. Himalayan blackberry was also noted in dense patches, particularly in the riparian areas closest to the roadway. Japanese knotweed is prevalent to the north of the site. A buffer created between the site and the Japanese knotweed infestation appears to be keeping this NNI species from spreading to the Squally Beach site. The buffer was created in 2007 by CHB.

Native plant species have significantly increased along transects between Year 5 and Year 7 at the Squally Beach site. There was no significant increase in cover by NNI species (Appendix B).

4.2.2 Mowitch

As observed in Year 5, shrub and tree cover was notably higher at the north end of the site and sparse in much of the southern portion. The southern part of the site experiences heavier foot traffic than does the rest of the riparian area, because pedestrian access is available only at the southern end. The riparian area at Mowitch is exposed to direct summer sunlight, and crews noted that several red alder trees had died, apparently due to drought. NNI species noted at Mowitch included reed canarygrass, Scot's broom, thistle, and fennel. The NNI species were observed to be scattered in small to large patches. Additionally, a small black locust tree (an NNI species) was observed in the northern portion of the site along the fence.

Native plant species have significantly increased along transects at the Mowitch site between Year 5 and Year 7. There was no significant increase in cover by NNI species (Appendix B).

4.2.3 Middle Waterway (Simpson/Trustees)

As observed in Year 5, much of the shrub cover at the Middle Waterway (Simpson/Trustees) site was concentrated in the southern and northern portions of the riparian zone. Areas with sparse shrub cover were present along East 11th Street and along the gravel access road into the Simpson log yard. Tree cover was particularly dense in the northern part of the riparian zone. This area consists of established forest vegetation, which may explain the dense tree cover observed. Black cottonwood is widespread in the eastern riparian area, and patches of Douglas fir also provide tree cover along the access road. This riparian zone is exposed to direct sunlight as well as exhaust and dust from adjacent roads, and soils appeared to be generally quite sandy. In Year 5, field crews noted several dead western red cedar trees along the gravel access road that may have been stressed by these conditions. Parts of the slope between the riparian area and the marsh were bare and eroding. These observations were not made in Year 7, likely because CHB conducted numerous work parties, which removed NNI species; planted native tree, shrub, and groundcover species; and spread mulch to control weeds. NNI species at the site included scattered butterfly bush, English ivy, Himalayan blackberry, Scot's broom, pampas grass, and thistle. Of the three sites monitored in 2007 for BSC 6, Middle Waterway (Simpson/Trustees) is the only one observed to contain English ivy, which was climbing trees in the northern part of the riparian zone. Butterfly bush was abundant along the gravel access road.

Between Year 5 and Year 7, total native plant species showed significant increases in 100 percent of the sampled transects. Overall NNI species cover significantly decreased in 80 percent of sampled transects (Appendix B).

4.2.4 Discussion – BSC 6

Two years of sampling at these three sites allowed paired comparisons of the data for riparian zone vegetation. The Squally Beach, Mowitch, and Middle Waterway (Simpson/Trustees) sites all showed significant increases in overall native plant vegetation sampled along the line intercept transects. The Mowitch and Middle Waterway (Simpson/Trustees) sites also showed significant decreases in NNI species, and the Squally Beach site showed no measurable change

in NNI species cover.[4] Native roses and non-native Himalayan blackberry are forming dense shrub thickets in portions of all three sites.

Of the three sites monitored for BSC 6 during Year 7[5], the Mowitch site had the highest mean cover of shrubs (Appendix B). The Squally Beach site had the highest mean cover of overall native vegetation (Appendix B), which is comprised of grass, herb, shrub, and tree species, and the highest mean cover of NNI species. Reed canarygrass and Himalayan blackberry are prevalent at all of the sites. Field bindweed and white sweet-clover are other NNI species that appear to show extensive growth at the sites. Additionally, native rose species are forming impenetrable thickets at all three sites. These thickets make human access difficult and provide refuge for numerous bird and small mammal species. Native rose species also provide a plentiful food source for birds using the sites.

The tree species red alder was present along the sampled line intercept transects, often in thick groves, at the Squally Beach and Mowitch. Red alder is one of the first species to recruit to newly disturbed riparian areas and it is a nitrogen-fixing species. Dense groves of red alder help to shade out competing NNI species such as reed canarygrass and Himalayan blackberry, allowing other native species to establish. At the Middle Waterway (Simpson/Trustees) site, the dominant tree species along sampled line intercept transects was Douglas fir, which was observed along the line intercept transects at all four of the sampled sites.

4.3 Biological Success Criterion 7 – Fish Access/Presence

Data from sites that were monitored using beach seine and block nets to sample fish assemblage in Years 1–3 were compared to data collected in Year 7 (Section 4.3.1). In Year 7, the beach seine/block net sites were Yowkwala, Skookum Wulge, Middle Waterway (Simpson/Trustees), Middle Waterway (City of Tacoma), Olympic View, and Puget Creek. In Years 1–3, the

[4] Note that species with fewer than three transects with non-zero changes in percent cover could not be tested.

[5] Excluding the fourth site, Hylebos Creek Off-Channel (Jordan), from the comparison because data are available only for Year 7 monitoring.

Mowitch site had also been sampled, but it was deleted from the program in Year 7 (discussed in Appendix A). Puget Creek was added to the program and sampled for the first time in Year 7.

Data from the Hylebos Creek Off-Channel (Jordan) site, where snorkel surveys were used to sample fish assemblage in Year 7, were compared to data collected in Year 5 (Section 4.3.2).

All four sampling seasons showed fish abundance and assemblage at all seven of the restoration sites studied. Juvenile salmonids, flat fish, forage fish, and resident fish were observed at the restoration sites.

4.3.1 Beach Seine and Block Net Results

The sampling schedule was modified in Year 7. Sampling had occurred biweekly in Year 1 and Year 2 and approximately weekly from late April through October in Year 3. In Year 7, sampling took place approximately weekly from mid-February through July. This shift helped to better define the peak of salmonid outmigration by capturing the late winter months, allowing for more frequent sampling during the peak outmigration for juvenile salmonids, and providing a clearer picture of the abundance and assemblage of juvenile salmonids. Because of differences in habitats, the gear used, and the areas sampled, it is important to be cautious when comparing catch results among sites and from year to year.

The Year 7 data were analyzed and compared to data from Years 1–3 to determine trends in fish abundance and assemblage over time and to compare species richness across all four seasons. The CPUE and mean average length for salmonids (Chinook, coho, chum, and pink) provided a means of comparing salmonid use of the restoration sites over time.

A total of 329 sets were completed in Year 7, compared to 108 sets in Year 1, 128 sets in Year 2, and 232 sets in Year 3.[6]

[6] During Year 3, sampling at the Mowitch site was conducted with block nets, which required almost a full day to complete the work. This task was discontinued in Year 7, allowing for more sampling events at the other sites and more time to process fish catches.

Table 4-1 presents some highlights of the fish monitoring results for Years 1–3 and 7; these highlights are discussed below.

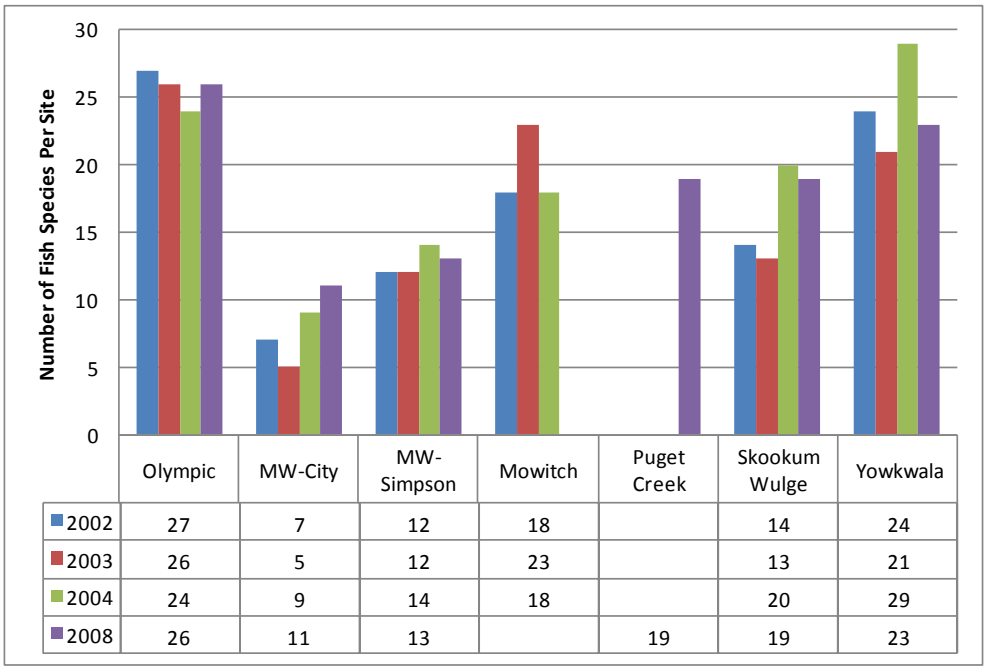
Table 4-1. Highlights of Commencement Bay fish monitoring, Years 1–3 and 7

Parameter	Year 1	Year 2	Year 3	Year 7
Number of species observed (species richness, SR)				
Total SR	36	31	31	31
Site with highest SR	Olympic View	Olympic View	Yowkwala	Olympic View
Site with second highest SR	Yowkwala	Mowitch	Olympic View	Yowkwala
Site with third highest SR	Mowitch	Yowkwala	Skookum Wulge	Skookum Wulge/Puget Creek
Site with lowest SR	Middle Waterway (City of Tacoma)	Middle Waterway (City of Tacoma)	Middle Waterway (City of Tacoma)	Middle Waterway (City of Tacoma)
Individual species abundance				
Most abundant species	Shiner perch	Shiner perch	Shiner perch	Pink salmon
Second most abundant species	Coho salmon	Pacific staghorn sculpin	Pacific staghorn sculpin	Chum salmon
Third most abundant species	Pacific staghorn sculpin	Surf smelt	Pacific herring	Coho salmon
Salmonid species				
Peak period of salmon	Early May	Late May	Late April	Late April
Greatest abundance of cutthroat trout	Yowkwala and Skookum Wulge	Yowkwala and Skookum Wulge	Yowkwala and Skookum Wulge	Yowkwala and Skookum Wulge
Greatest abundance of coho salmon	Yowkwala	Yowkwala	Yowkwala	Yowkwala
Greatest abundance of Chinook salmon	Yowkwala	Yowkwala	Yowkwala	Yowkwala
Greatest abundance of salmon	Yowkwala	Yowkwala	Olympic View	Puget Creek
Percentage of coho checked for hatchery marks	4%	54%	95%	20%
Percentage of wild fish among coho checked for hatchery marks	25%	24%	38%	7%
Percentage of Chinook checked for hatchery marks	89%	84%	91%	87%
Percentage of wild fish among Chinook checked for hatchery marks	12%	23%	18%	30%

4.3.1.1 Species Richness

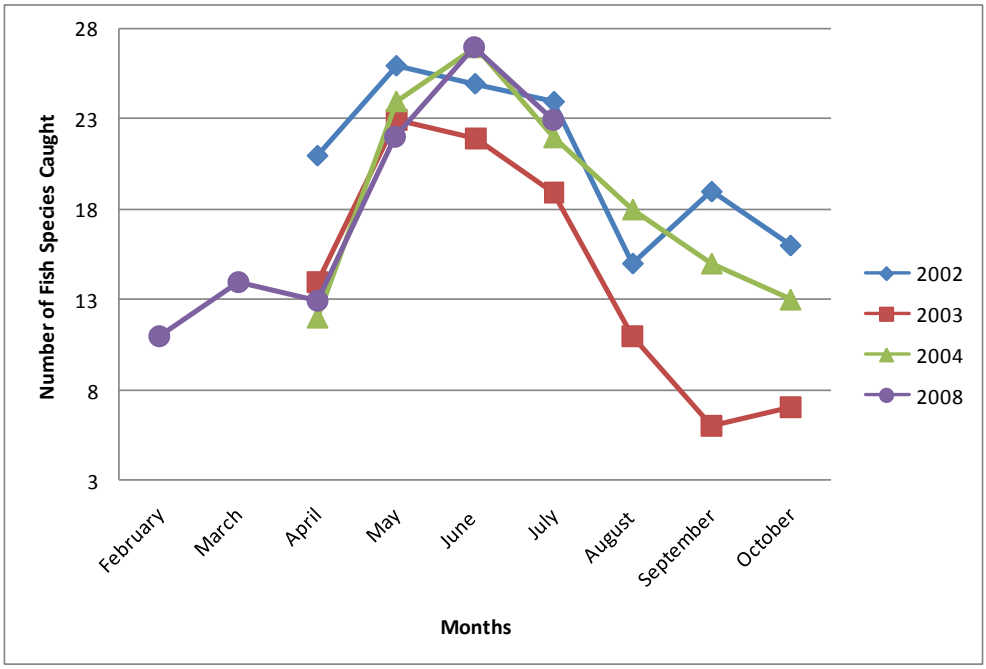
Data from Years 1–3 and 7 show a similar trend in overall SR for each site (Figure 4-4). Species richness was slightly higher during Year 1, with a total of 36 species observed at the sites over time, compared to 31 species in Year 2, Year 3, and Year 7 (Table 4-1). The total number of species peaked in late spring/early summer (Figure 4-5).

Figure 4-4. Total number of fish species caught per site, Years 1–3 and 7



	Olympic	MW-City	MW-Simpson	Mowitch	Puget Creek	Skookum Wulge	Yowkwala
2002	27	7	12	18		14	24
2003	26	5	12	23		13	21
2004	24	9	14	18		20	29
2008	26	11	13		19	19	23

Figure 4-5. Total number of fish species caught per month (all sites), Years 1–3 and 7



The Olympic View site had the highest SR in Years 1, 2, and 7 and ranked second in SR in Year 3. The site's species richness likely reflects the presence of adjacent eelgrass beds, which provide nursery habitat and feeding grounds for a wide variety of fish species and provide shelter and food for numerous invertebrate and plant species.

The Yowkwala site ranked first in SR in Year 3, second in SR in Years 1 and 7, and third in SR in Year 2 (Table 4-1). The reason for species richness at the Yowkwala site is unknown, but may be related to the site's location within Commencement Bay. The Yowkwala site is on historical and modern outmigration routes (Graeber, 1999, as cited in Simenstad, 2000) and is an undeveloped beach in a protected area with little marine traffic. The site is characterized by a gently sloping cobble beach with a highly vegetated buffer and headland. LWD predominates on the upper edges of the beach. Calm waters and the undeveloped beach may provide a significant food source and habitat for numerous species.

The Skookum Wulge site ranked third in SR in Year 3 and tied with the Puget Creek site for third in Year 7 (Table 4-1). The lower elevations of the intertidal zones are similar at both sites, consisting of fine, wet, brown sand. Both sites are entirely inundated by water during high tides.

The Skookum Wulge and Puget Creek sites both experience high wave action from boats and seasonal storms.

The Middle Waterway (City of Tacoma) site had the lowest SR in all four monitoring years (Table 4-1), although SR increased in Year 7, when SR was just two species less than the Year 7 SR for the Middle Waterway (Simpson/Trustees) site. Again, differences in SR among sites may be related to their locations in Commencement Bay. The Middle Waterway (City of Tacoma) and Middle Waterway (Simpson/Trustees) sites are farther inland than the others, which are on historical and modern outmigration routes, and situated in a highly industrialized area. Although the upper portions of the Middle Waterway have been restored, large ships docking in the waterway's lower portions create overwater structures that might interfere with fish migration. Other industrial activities occurring in the lower Middle Waterway may be disruptive to fish as well. In addition, the Middle Waterway is dry for a few hours twice per day because of elevation and changes in tide height; sampling generally occurred around high tide, and fish may not have reached or may have left the upper end of the waterway by the time sampling was completed.

4.3.1.2 Species Abundance

Shiner perch was the most abundant species in Years 1–3 and was observed at all sites during all four monitoring years (Table 4-1). This was expected, as shiner perch are resident fish in the Puget Sound region, have one of the broadest distributions of all perch species found along the Pacific coast, and use bays and estuaries as nurseries (Froese and Pauly, 2003). Shiner perch was not the most abundant species in Year 7; this may be because the Mowitch site, which had large numbers of shiner perch during the summer months in Years 1–3, was not sampled in Year 7.

Pink salmon were observed in record numbers and was the most abundant species in Year 7. The majority were caught at the Puget Creek site on two consecutive days in mid-April and on one day in mid-May. The abundance of pink salmon may be related to the record number of adult pink salmon that returned to the Puyallup River basin in the 2007 spawning season, which was estimated in advance by the Puyallup Tribe at over 770,000 (NWIFC, 2007) and anecdotally said to have been even greater. In addition, pink salmon fry migrate directly to estuarine waters

immediately after emergence. Once in the estuary, the young fry form large schools and remain close to shore to avoid predators and to feed for several weeks before continuing their migration to open waters (Croot and Margolis, 2003). The tendency for juvenile pink salmon to form large schools and remain close to shore in relatively shallow water makes them an easy target for the beach seine net.

The second most abundant species in Years 1–3 and Year 7 has varied between salmon and Pacific staghorn sculpin. In Year 1, coho salmon ranked second in SR. In Years 2 and 3, Pacific staghorn sculpin ranked second in SR. In Year 7, chum salmon ranked second in SR.

The majority of the coho observed in Year 1 were caught during mid-May on two consecutive days at the Yowkwala site. Coho was also the third most abundant species in Year 7, with the highest numbers occurring at the Yowkwala site. The large coho numbers probably relate to hatchery releases from the Puyallup River basin. In a study of the Duwamish estuary in 1995, it was found that a large pulse of juvenile Chinook observed in May was related to a hatchery release from the Green River basin (Warner and Fritz, 1995, as cited in King County Department of Natural Resources, 2001). Coho likely congregate at the Yowkwala site because of food availability, protection from predators, and the site's location within Commencement Bay.

The majority of chum salmon observed in Year 7 were caught on two consecutive days in April and on one day in May, the majority at the Yowkwala site. The large chum salmon numbers may be related to mass outmigration from the Puyallup River basin due to spring melt in the upper watershed, which may have flushed the chum salmon downstream en masse. Like pink salmon, juvenile chum salmon immediately begin downstream migration once they emerge from gravel. The total brood year outmigration from fresh water to estuarine water is generally completed in 30 days (WDFW, 2009). As with pink salmon, the tendency for chum salmon to form large schools in shallow water near the shore makes them an easy target for the beach seine net.

The Yowkwala site's geometry, structure, and location on historical and modern outmigration paths may be factors in the higher catches of coho and chum salmon. Among the six beach seine/block net sites, the Yowkwala site has the least industrial development and a highly

vegetated beach and headlands. In addition, the Yowkwala site experiences some of the strongest currents among the sites during tidal cycles. These currents provide food and well-oxygenated water and likely carry outmigrating salmonids into the area of the Yowkwala site.

Pacific staghorn sculpin, a resident fish, was the second most abundant species in Year 2 and Year 3 and the third most abundant in Year 1. The largest quantities of Pacific staghorn sculpin were caught at the Middle Waterway (Simpson/Trustees) site in Year 2 and Year 3 and at the Mowitch site in Year 1. Both sites have fine, light substrates, creating mudflat habitat with calm waters.

Forage fish, including surf smelt, Pacific herring, and Pacific sand lance, were observed at all the sites in Years 1–3 and Year 7. The presence of forage fish indicates overall favorable site conditions and is a good sign for the sites' health and function, as forage fish provide an important food source for salmon.

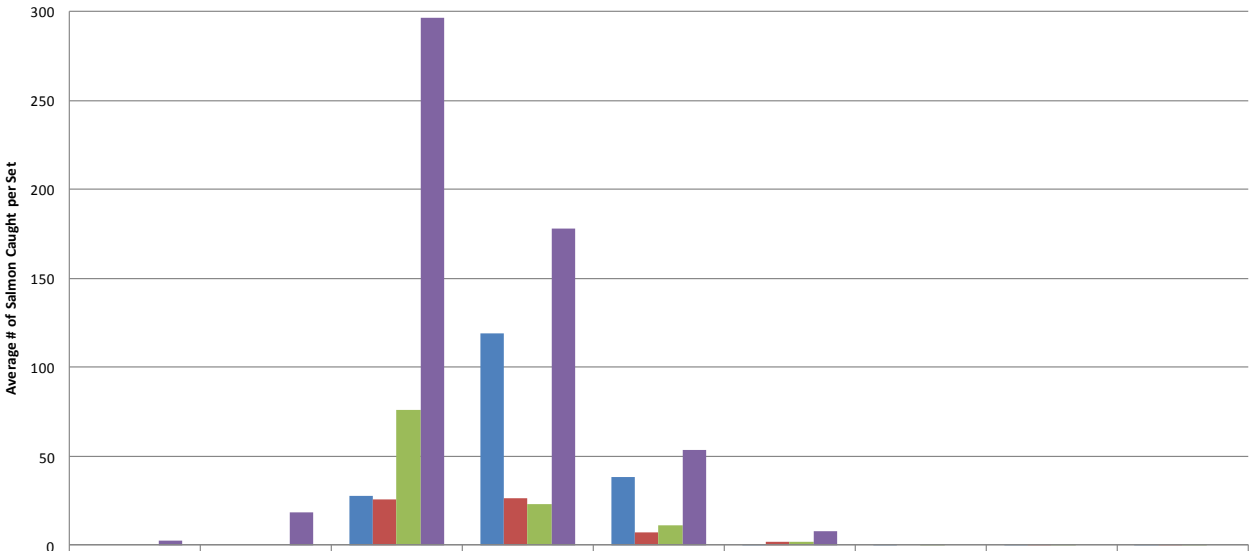
The third most abundant species in Year 2 was surf smelt, with the highest numbers observed at the Middle Waterway (Simpson/Trustees) site. The surf smelt at the Middle Waterway (Simpson/Trustees) site were generally smaller than those encountered elsewhere, indicating the smelt were using the site as a nursery. In Year 3, the third most abundant species was Pacific herring, with the highest numbers occurring at the Olympic View site. In general, forage fish numbers increased at all the sites in Year 3, with a 66 percent increase in total forage fish catches from Year 1 to Year 3 and a 73 percent increase in total forage fish catches from Year 2 to Year 3. However, forage fish numbers decreased by 60 percent in Year 7 as compared to Year 3. This may be because the sampling season ended in the first half of July in Year 7; large numbers of the forage fish observed in Year 3 were captured from mid-July through October. Just over 60 percent of the total forage-fish catch for Year 3 was captured from mid-July through October.

4.3.1.3 Salmonid Abundance

The majority of salmon were caught at the Yowkwala, Skookum Wulge, and Olympic View sites in Years 1–3 and Year 7. Puget Creek, which was added to the monitoring program in Year 7, had the largest number of salmon observed in that year at a single site. Figures 4-6 and 4-7 depict the average number of salmon observed by month and per set by site, respectively.

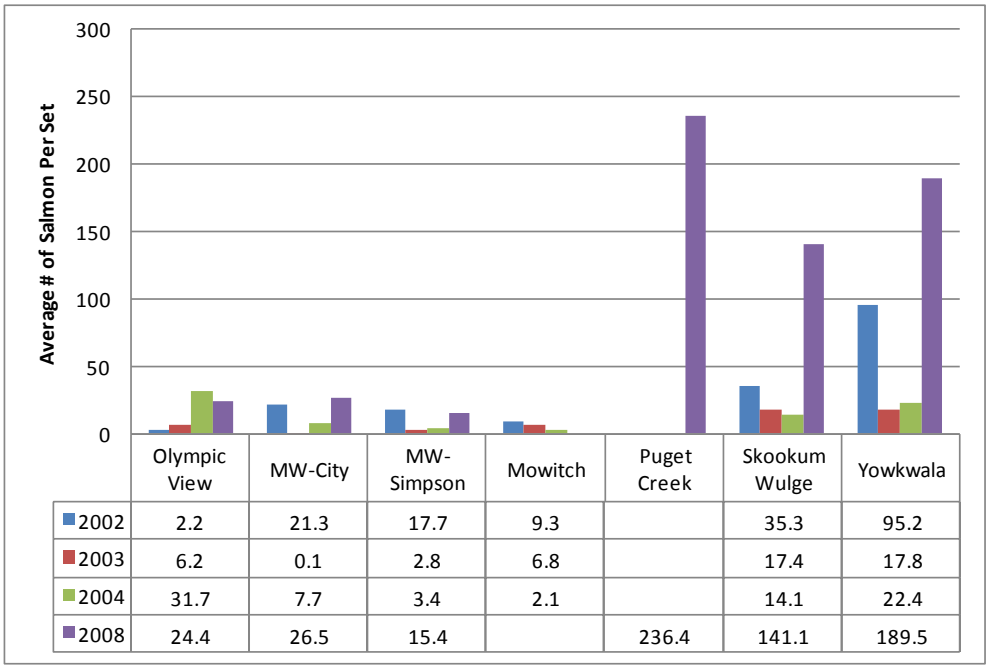
Juvenile Chinook, coho, chum, and pink salmon were encountered at all sites during Years 1–3 and Year 7 monitoring, with the exception of pink salmon at the Mowitch site in Year 3. Peak abundance of salmon occurred in late spring/early summer in all monitoring years (Figure 4-6). In Year 3 and Year 7, the peak numbers of salmon were observed in late April; in Year 1, in early May; in Year 2, in late May. In Years 1, 2, and 7, the peak catch occurred over a two- to three-day period; in Year 3, the peak catch occurred on one day. Overall, greater numbers of juvenile salmon were observed in Year 7 at all sites combined (Figure 4-7), estimated to be more than 40,000 salmonids, the majority of them pink and chum salmon. The greatest numbers of coho and Chinook salmon were also observed at the Yowkwala site in Years 1–3 and Year 7. Data for all four monitoring years show a definite decline in salmon observed after late June (Figure 4-6). In Years 1–3, salmon were observed through the last sampling event in mid-October.

Figure 4-6. Average number of salmon caught per month, Years 1–3 and 7



	February	March	April	May	June	July	August	September	October
2002			27.8	119.3	38.1	0.6	0.4	0.3	0.2
2003			25.8	26.2	6.8	2.1		0.04	0.1
2004			76.1	22.9	11.2	2	0.7	0.4	0.2
2008	2.4	18.7	296.3	177.9	53.5	7.9			

Figure 4-7. Average number of salmon caught per set by site, Years 1–3 and 7



	Olympic View	MW-City	MW-Simpson	Mowitch	Puget Creek	Skookum Wulge	Yowkwala
2002	2.2	21.3	17.7	9.3		35.3	95.2
2003	6.2	0.1	2.8	6.8		17.4	17.8
2004	31.7	7.7	3.4	2.1		14.1	22.4
2008	24.4	26.5	15.4		236.4	141.1	189.5

The larger numbers of juvenile salmon seen in Year 7 may reflect the sampling methods employed. When large numbers of juvenile salmon were caught, approximately 40 fish of each species were removed for identification and measurement and to determine whether they were hatchery or wild salmon. The numbers and species of the remaining fish were then estimated based on the approximately 40-fish subsample, allowing the fish to be released as soon as possible. This method promotes the survival of fragile juvenile salmon, but may elevate the estimates. In addition, constraints inherent to the study design mean that fish monitoring does not always occur concurrent with the peak runs; for Year 2, salmon numbers may be lower because of less frequent sampling. In Year 7, more frequent sampling events were scheduled during the peak outmigration; the Year 7 data may therefore provide a more accurate picture of salmon abundance and assemblage at the sites.

Trout observed at the sites included bull trout/Dolly Varden and cutthroat and steelhead trout. The majority of trout sampled in Years 1–3 and Year 7 were caught at the Yowkwala and Skookum Wulge sites, with Year 7 having the highest counts. Steelhead trout were observed only at the Yowkwala site in Years 2, 3, and 7. No steelhead were caught in Year 1. In Year 3, one bull trout/Dolly Varden was encountered at the Yowkwala site, and one was observed at the

Olympic View site in Year 7. Bull trout/Dolly Varden and Puget Sound steelhead are listed as threatened species by the U.S. Fish and Wildlife Service and NOAA, respectively (USFWS, 2008; NOAA Fisheries, 2008). Bull trout/Dolly Varden are rarely encountered in Commencement Bay; it is likely that these particular fish were foraging at the Yowkwala site as they migrated through the area, possibly to spawn in the Puyallup River. Both fish were approximately 185 mm in length, indicating they were from a similar age group.

4.3.2 Snorkel Survey Results

The snorkel survey methods used at the Hylebos Creek Off-Channel (Jordan) site in Year 5 were continued in Year 7. Salmonids, flat fish, sculpin, and stickleback were observed in both sampling seasons. Table 4-2 summarizes the fish species and numbers for both years. Although it is difficult to compare data for only two sampling seasons, overall the results were similar.

Table 4-2. Summary of fish species and numbers observed at the Hylebos Creek Off-Channel (Jordan) site, Year 5 (2006) and Year 7 (2008)

Common Name	Scientific Name	Year 5	Year 7
Chinook salmon	*Oncorhynchus tshawytscha*	6	5
chum salmon	*Oncorhynchus keta*	0	3
coho salmon	*Oncorhynchus kisutch*	44	33
cutthroat trout	*Oncorhynchus clarki*	7	1
rainbow trout	*Oncorhynchus mykiss*	10	3
flat fish	*Pleuronectidae spp./Pleuronectiformes spp.*	107	8
sculpin	*Cottidae spp.*	97	10
shiner perch	*Cymatogaster aggregata*	135	0
stickleback	*Gasterosteus aculeatus*	2430	258
other	*Centrarchidae spp./Hexagrammidae spp.*	2	0

In both the off-channel habitat area and the Hylebos Creek area, juvenile salmonids were observed holding in deeper water in and around root wads or other woody cover in both sampling seasons. In Year 7, a total of five juvenile Chinook, 33 juvenile coho, and three chum salmon were observed at the site, the majority of them in Hylebos Creek. In Year 5, a total of six juvenile Chinook, 44 juvenile coho, and no chum salmon were observed in similar areas. All the observed salmon had intact adipose fins.

The salmon were similar in size in Year 5 and Year 7, ranging from 65 mm to 150 mm in length for Chinook and 65 mm to 200 mm in length for coho; in Year 7, chum ranged from 45 mm to 50 mm in length. These sizes indicate the salmon were feeding, rearing, and migrating through the system. The salmon were observed at the site during both sampling seasons in the months of May, June, and July. For both seasons, all of the juvenile salmon were observed in Hylebos Creek in the deeper portions of Reaches 3 and 4 and a root wad in Reach 1 of the off-channel habitat area. This root wad is one of the larger ones found in the site and provides refuge.

Cutthroat and rainbow trout were observed during May and July in Year 7 and May through July in Year 5. The observed trout ranged from 150 mm to 350 mm in length, with the larger trout being observed in Year 5. The trout were observed in the Hylebos Creek area in the deeper portions of Reaches 3 and 4. The areas where the trout were observed had good flow and were downstream of submerged woody debris or a feature in the channel that created some turbulence. The trout appeared to be feeding in these areas. During both monitoring years, juvenile salmon and trout were observed together in these areas. Trout were also observed top-feeding on terrestrial insects in Reaches 1, 2, and 3 of the Hylebos Creek area during every monitoring event.

Other fish observed throughout the entire Hylebos Creek Off-Channel (Jordan) site were juvenile flat fish, sculpin, shiner perch, and stickleback. These species were encountered in the off-channel habitat area and Reaches 1 and 2 of the Hylebos Creek area during each month of both sampling seasons. Shiner perch were observed at the site in Year 5, but not in Year 7. The Year 7 sampling season ended in mid-July, while the Year 5 sampling season ended in early August. The majority of the shiner perch observed in Year 5 were sampled later in the season.

Additionally, stickleback were observed at the site in Year 5, with numbers ninefold greater in Year 5 than in Year 7.

Starry flounder was one of the flat fish species observed at the site. Starry flounder commonly rear in estuarine habitats and can tolerate a wide range of salinities, including fresh water (Ralston, 2006). Adult and juvenile stickleback were also observed during this time, indicating that spawning may be occurring at the site. Stickleback are a food source for trout and salmon (Wydoski and Whitney, 2003).

During the Year 5 and Year 7 sampling seasons, the five pools within the off-channel habitat area consistently had poor to zero visibility, and snorkel surveys were therefore not performed in these pools. Factors contributing to poor visibility included algae blooms, unstable fine substrate, and people working or recreating at the site. The pools also appear to be quite shallow as a result of the settling of fine sediments.

For both sampling seasons, it was not possible to snorkel Reach 3 of the off-channel habitat area or the upper portions of Reach 4 and all of Reach 5 in Hylebos Creek because water depths were generally less than 8 inches (20 cm). Sand from Hylebos Creek settled out in Reach 3, causing the shallow depths. The openings or mouths of the channels connecting Hylebos Creek to Reach 3 of the off-channel habitat area were at times completely blocked by sand and sediments, thus restricting water flow from Hylebos Creek. The source of the sand is unknown. Visual surveys from the bank were conducted in the reaches that were too shallow for snorkeling. No fish were observed.

In Year 7, water temperatures at the site ranged from approximately 12.5 degrees Celsius (^{o}C) to 18.2 ^{o}C. In Year 5, large algae blooms occurred at the site. During these blooms, the highest temperatures were recorded in Pool 3 (19.3 ^{o}C) and Pool 5 (24.3 ^{o}C) in the off-channel habitat area. These measurements were recorded in late May. In Year 7, temperatures recorded in Hylebos Creek in mid- and late June ranged from 12.5 ^{o}C to 14.3 ^{o}C.

Juvenile salmonids will occupy waters with temperatures of approximately 13 ^{o}C to 18 ^{o}C. Water temperatures of approximately 23 ^{o}C to 25 ^{o}C can be lethal (Ecology, 2000). It is assumed

that the water temperatures in the off-channel habitat area will be more consistent with the temperatures in Hylebos Creek once the newly planted riparian vegetation is established and has grown to a height that creates sufficient shade and cover. Additionally, the large algae blooms did not occur in Year 7, which may have contributed to the lower temperatures.

Concurrent with the highest temperatures recorded in Year 5 during the algae blooms, the highest salinities were also recorded in late May in Pool 3 (15.5 parts per thousand [ppt]) and Pool 5 (11 ppt) in the off-channel habitat area. Both Pool 3 and Pool 5 have sills at their entrances that may have blocked water from flowing in and out of the pools, thus resulting in the higher salinity readings. In Year 7, salinities ranged from approximately 0.1 to 0.2 ppt in the off-channel habitat area. They were slightly higher in Year 5, measuring 0.4 ppt.

In Year 7, beaver dams were observed in the channels of the Reach 3 off-channel habitat area. The dams are present at the connections between Reach 5 of Hylebos Creek and the Reach 3 off-channel habitat area. The dams appear to be forming pools above them in Hylebos Creek and pour-overs or small waterfalls downstream in Reach 3 of the off-channel habitat area. The continued presence of the dams would provide benefits to juvenile salmonids in the form of deep pools, trapped nutrients, increased water quality, and habitat complexity.

4.4 Biological Success Criterion 9 – Bird Use

Data on bird species assemblage were collected in Year 5 and Year 7 at the Sha Dadx and Hylebos Creek Off-Channel (Jordan) sites. Although it is difficult to discuss trends based on results from just two sampling seasons, the results show that numerous bird species are using the restored sites.

Migratory and resident bird species were observed at both sites during Year 5 and Year 7. Bird species are tabulated in Appendix C. Both sites supported obvious evidence of breeding (singing, fighting, or pursuit; “broken-wing” distraction technique; gathering of nesting material; presence of young) during both sampling years. Additionally, numerous species were observed foraging at the sites. Both sites supported bird species that exhibit four migratory patterns in various combinations to achieve their life cycles. Twenty-eight complete migrator bird species

were observed over the course of Years 5 and 7 at the Hylebos Creek Off-Channel (Jordan) site, and 26 complete migrator species were observed over the two years at the Sha Dadx site. The Hylebos Creek Off-Channel (Jordan) site supported 13 partial migrator species, while the Sha Dadx site supported 16. Both sites supported the same irruptive migrator (pine siskin) and 23 non-migrator species over the two sampling years.

The Hylebos Creek Off-Channel (Jordan) site had similar SR in both years (Figure 4-8). Fifty-six bird species were observed at the site during Year 5; 54 species were observed in Year 7. There were slight differences in the bird species observed between Year 5 and Year 7. When the Year 5 and Year 7 data are combined, the site has been observed to support 70 bird species over the sampling period (Appendix C). For both years, SR was greatest during the spring and summer months (Figure 4-9), consistent with local migration and breeding patterns.

The Sha Dadx site also had total SR of 56 bird species in Year 5 (Figure 4-8). In Year 7, however, the total SR dropped to 45 species because of ongoing noise and activities related to construction of the restoration site. When the Year 5 and Year 7 data are combined, the site has been observed to support 67 bird species over the sampling period (Appendix C). Overall SR was greatest at the Sha Dadx site during the spring and summer months (Figure 4-9).

It is assumed that overall SR will grow at the Sha Dadx site once the new habitat created by the restoration project is established and the site no longer experiences intense human disturbances. The bird species that use the site are also expected to change slightly with the reduction in forested areas and the addition of open water and marsh vegetation. More waterfowl and shorebird species are expected to use the site once it is established.

Figure 4-8. Total number of bird species observed at the Hylebos Creek Off-Channel (Jordan) and Sha Dadx sites, Year 5 (2006) and Year 7 (2008)

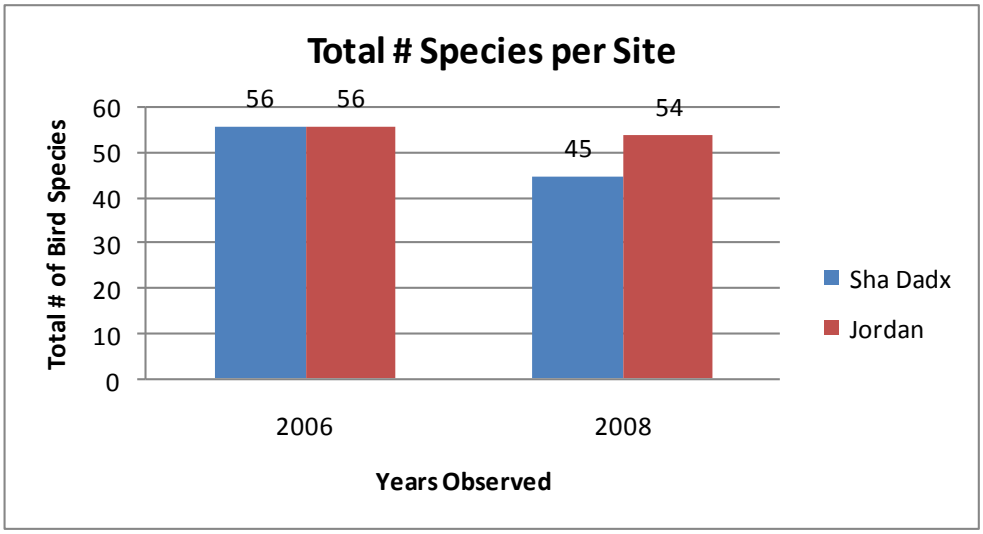
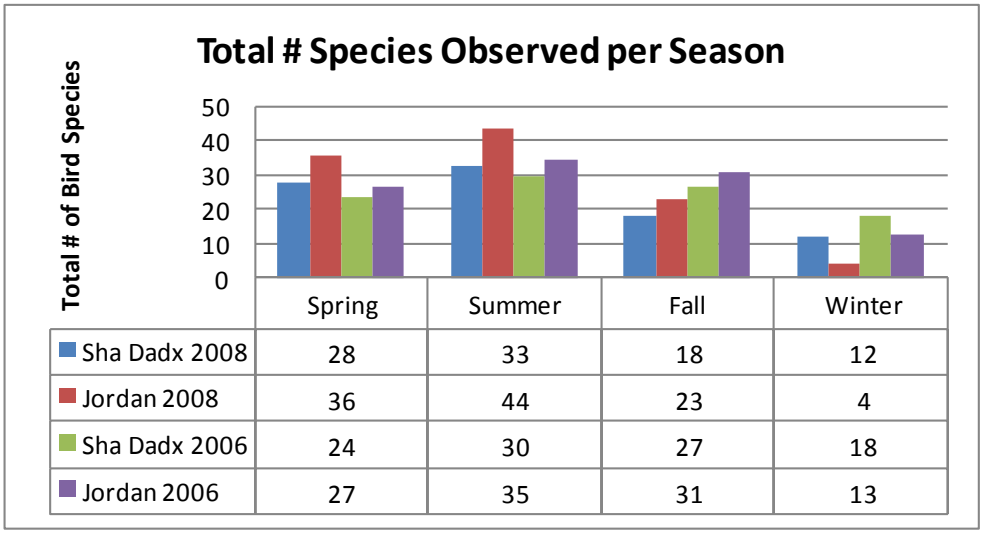


Figure 4-9. Total number of bird species observed at the Hylebos Creek Off-Channel (Jordan) and Sha Dadx sites by season, Year 5 (2006) and Year 7 (2008)



	Spring	Summer	Fall	Winter
Sha Dadx 2008	28	33	18	12
Jordan 2008	36	44	23	4
Sha Dadx 2006	24	30	27	18
Jordan 2006	27	35	31	13

5.0 SUMMARY AND RECOMMENDATIONS

5.1 Monitoring Summary

Table 5-1 summarizes performance at the 10 restoration sites during Year 7 for BSCs 2, 6, 7, and 9, as well as for surface water baseline chemistry.

5.1.1 Yowkwala

The Yowkwala site was monitored for BSC 7. Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the Yowkwala site.

5.1.2 Skookum Wulge

The Skookum Wulge site was monitored for BSC 7. Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the Skookum Wulge site.

5.1.3 Squally Beach

The Squally Beach site was monitored for BSC 2 and BSC 6, as well as surface water baseline chemistry. Percent cover of native species has increased along Transect 1-1 and Transect 1-2 and meets BSC 2 for percent cover of native species. Year 7 will serve as the new baseline year for Transect 1-3; as a result no assumptions can be made about the success of Transect 1-3 for this round of monitoring. Non-native plant cover along all three transects was less than 5 percent, which meets BSC 2 for non-native cover. BSC2 is being met at the Squally Beach site.

For BSC 6, the tree cover criterion is met at Squally Beach, but the shrub criterion is not met. However, for native shrubs it should be noted that the upper boundary of the 95CI exceeds the criterion. The NNI criterion is also not met. Cover by native species showed a significant increase from Year 5 to Year 7, while NNI species cover showed no significant increase. BSC 6 is being partially met at the Squally Beach site.

Table 5-1. Performance summary for Year 7 (2008) monitoring

Site Name	BSC 2 (Marsh)	BSC 6 (Riparian)	BSC 7[a] (Fish)	BSC 9[a] (Birds)	Surface Water Baseline Chemistry
Yowkwala			🟢		
Skookum Wulge			🟢		
Squally Beach	🟢[b] ↑	🟡 ↑			🔴
Mowitch	🟡[b] ↑	🟡 ↑ ↓			🔴
Hylebos Creek Off-Channel (Jordan)	🟡 ↑	🟡	🟡	🟢	🔴
Middle Waterway (Simpson/Trustees)	🟡[b] ↑	🟡 ↑ ↓	🟢		🔴[c]
Middle Waterway (City of Tacoma)			🟢		🔴[c]
Olympic View			🟢		
Puget Creek			🟢		
Sha Dadx				🟢	

LEGEND

Biological Success Criteria (BSC)

Marsh Development/Species Composition = BSC 2
Riparian Vegetation/Areal Coverage = BSC 6
Fish Access/Presence = BSC 7
Bird Use = BSC 9

Baseline Chemical Conditions

Surface Water Baseline Chemistry

🟢 = Criterion met
🟡 = Criterion partially met or improving
🔴 = Exceeds one or more screening levels for surface water quality
↑ = Total native species cover increasing
↓ = Total non-native species cover decreasing

a. Reference not available for quantitative comparison; evaluation based on site observations
b. Variability is high and one limit of the confidence interval may not meet the criterion
c. One Middle Waterway surface water sample was collected at point between the Simpson/Trustees and City of Tacoma sites.

Surface water samples were collected from four sites, including the Squally Beach site. The maximum copper concentration, which was detected in the sample from station SW-01 at the Squally Beach site, exceeded the screening level by a factor of four; the copper concentration detected in the sample from station SW-02 exceeded the screening level by a factor of just over 3.5. Total nitrogen detected at Squally Beach station SW-01 exceeded the screening level by a factor of eight, while the concentration of total nitrogen detected at station SW-02 was almost three times the screening level. The concentrations of total phosphorous at Squally Beach sampling stations exceeded the screening level by one order of magnitude (station SW-01) and a factor of approximately eight (station SW-02). The fecal coliform concentration detected at Squally Beach station SW-02 was the second highest concentration among the four sampled sites and exceeded the screening level by one order of magnitude. The fecal coliform concentration detected at Squally Beach station SW-01 exceeded the screening level by a factor of close to four.

5.1.4 Mowitch

The Mowitch site was monitored for BSC 2 and BSC 6, as well as surface water baseline chemistry. Percent cover of native species has increased along both Transect 1-1 and Transect 1-2, meeting the success criterion for percent cover of native species. Non-native cover for both transects was greater than 5 percent and therefore does not meet BSC 2 for non-native cover. BSC 2 is being partially met at the site.

For BSC 6, the shrub and tree cover criteria are not met at Mowitch. However, it should be noted that the upper boundary of the 95CI on the mean for native shrub cover exceeds the criterion. Additionally, both native shrub and tree species showed significant increases in cover between Year 5 and Year 7. Therefore, the shrub cover criterion at the site is partially met. The NNI criterion is met based on the stratified mean estimate, but the upper boundary of the 95CI on the mean is equal to the criterion. NNI species cover decreased significantly between Year 5 and Year 7. BSC 6 is being partially met at the site.

Surface water samples were collected from four sites, including the Mowitch site. The concentration of copper detected in surface water collected at the Mowitch site slightly exceeded the screening level. The concentrations of total nitrogen and total phosphorous both exceeded screening levels by one order of magnitude. The concentration of fecal coliform exceeded the screening level by a factor of close to seven.

5.1.5 Hylebos Creek Off-Channel (Jordan)

The Hylebos Creek Off-Channel (Jordan) site was monitored for BSC 2, BSC 6, BSC 7, and BSC 9, as well as surface water baseline chemistry. Based on the presence of native plant species along both transects, BSC 2 appears to be met at the site. However, percent cover of native marsh plant species remaining stable or increasing over time cannot realistically be assessed based on a single year of monitoring. Non-native cover on both transects was greater than 5 percent, and therefore does not meet BSC 2 for non-native cover. BSC 2 is being partially met at the site.

For BSC 6, the shrub cover criterion is not met at the site, but the tree cover criterion is met. The NNI criterion is not met. BSC 6 is being partially met at the site.

BSC 7 appears to be met for resident non-salmonid species at the site and partially met for salmonids.

BSC 9 appears to be met for indigenous and native bird species at the site.

Surface water samples were collected from four sites, including the Hylebos Creek Off-Channel (Jordan) site. Copper was detected in the surface water sample collected from the site, but the concentration did not exceed the screening level. The concentrations of total nitrogen and total phosphorous both exceeded screening levels by more than an order of magnitude. The maximum concentration of fecal coliform detected among the four sampled sites occurred at the Hylebos Creek Off-Channel (Jordan) site and exceeded the screening level by more than two orders of magnitude.

5.1.6 Middle Waterway (Simpson/Trustees)

The Middle Waterway (Simpson/Trustees) site was monitored for BSC 2, BSC 6, and BSC 7, as well as surface water baseline chemistry. Percent cover of native species has increased significantly along Transect 1-1, meeting the BSC 2 success criterion for percent cover of native species. Native cover along Transect 1-2 showed no statistically significant change, so it is possible, but uncertain whether, this transect also met the success criterion. Non-native cover for both transects was less than 5 percent and therefore meets the success criterion for non-native cover. BSC 2 is being partially met at the site.

For BSC 6, the shrub cover criterion is not met at the site, while the tree cover criterion is met. The NNI criterion is met on the stratified mean estimate but the upper boundary of the 95CI on the mean exceeds the NNI criterion, therefore the NNI criterion is partially met. Native shrub and tree species cover significantly increased at the site between Year 5 and Year 7, while NNI species significantly decreased. BSC 6 is being partially met at the site.

Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the site.

The concentration of copper detected in the surface water sample collected from the Middle Waterway exceeded the screening level by a factor of just over three. Total nitrogen and total phosphorous exceeded screening levels by one order of magnitude. The concentration of fecal coliform detected at the site exceeded the screening level by a factor of just over five.

5.1.7 Middle Waterway (City of Tacoma)

The Middle Waterway (City of Tacoma) site was monitored for BSC 7, as well as surface water baseline chemistry. Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the site. One surface water sample was collected to represent both Middle Waterway sites; the analytical results for that sample are discussed above.

5.1.8 Olympic View

The Olympic View site was monitored for BSC 7. Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the site.

5.1.9 Puget Creek

The Puget Creek site was monitored for BSC 7. Based on the presence of salmonid and non-salmonid fish, BSC 7 is being met at the site.

5.1.10 Sha Dadx

The Sha Dadx site was monitored for BSC 9. Based on the presence of resident and migratory bird species, BSC 9 appears to be met for indigenous and native bird species at the Sha Dadx site.

5.2 Adaptive Management Recommendations

Based on the Year 7 monitoring results presented here, we have the following recommendations:

5.2.1 Squally Beach, Mowitch, and Middle Waterway (Simpson/Trustees) Sites

- Manually remove NNI species in the riparian areas.
- Eradicate reed canarygrass from the marsh areas to prevent this highly invasive species from spreading.
- Replant native trees and shrubs in the southern portion of the riparian area at Mowitch. Consider marking a designated trail through this area for volunteers to access the site.
- Remove debris from the sites.
- Locate the marsh and riparian sampling transects and plots using GPS, which will make relocating transects and plots more efficient during future years of monitoring.
- Monitor surface water chemistry and determine the source(s) of nutrient and bacterial contamination.

5.2.2 Hylebos Creek Off-Channel (Jordan) Site

- Manually remove NNI species in the riparian areas.
- Eradicate reed canarygrass from the marsh areas to prevent this highly invasive species from spreading.
- Remove debris from the site.
- Locate the marsh and riparian sampling transects and plots using GPS, which will make relocating transects and plots more efficient during future years of monitoring.
- Monitor surface water chemistry and determine the source(s) of nutrient and bacterial contamination.
- If sand continues to be deposited in the off-channel habitat area and Hylebos Creek, efforts should be made to determine and control the source and potentially to remove some of the excess material.
- Create more cover in the off-channel habitat area by adding additional LWD, root wads, and boulders.
- Monitor depth of openings, channels, and flow in the off-channel habitat area.
- Consider modifications to the openings in Reach 3 of the off-channel habitat area to ensure continued flow of water from Hylebos Creek through the site.
- Consider conducting a benthic indicator of biological integrity (IBI) study to gain a better understanding of the condition of the aquatic habitat at the site.

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APPENDIX A

Field and Data Evaluation Procedures

LIST OF TABLES

Table A-1 Zone names and areas for each sampled site A-16

Table A-2 Sample identification, description, coordinates, analyses performed, screening criteria, and results..... A-17

LIST OF FIGURES

Figure A-1 Hylebos Creek-Off Channel (Jordan) Site Snorkel Survey Reaches..... A-18

A-1.0 BSC 2 Marsh Development/Species Composition

This section provides a detailed description of the methods that were used to collect and analyze data to evaluate current conditions and temporal trends in the marsh zone at sites where this criterion applies. It also describes the changes in monitoring protocols and transect locations that were made over the years and provides a rationale for those changes.

A-1.1 BSC 2 Field Work

This section describes the field work and data analyses procedures that were used in BSC 2 to evaluate plant conditions in the marsh zone.

A-1.1.1 Previous Monitoring Work

Most of the permanent transects sampled in Year 7 had been installed for the Year 1 (2002) monitoring and were positioned to capture the development of marsh habitat along the transects and to characterize the plant species composition at certain elevations (Ridolfi and Adolfson, 2003a). In Year 2 (2003), a new transect (Transect 1-3) was added on the Squally Beach site to capture the establishment of lower marsh vegetation. Between the Year 5 (2006) and Year 7 (2008) monitoring seasons, Squally Beach Transect 1-3 was completely eroded away by wave action due to seasonal storms. In Year 7, Squally Beach Transect 1-3 was moved to the north, just inside of the fence running along the water's edge, thus creating a new baseline for the transect. In Year 3, the portion of Squally Beach Transect 1-1 located within an existing patch of Lyngby's sedge was removed. In doing this, the total length of Transect 1-1 was reduced by 7 ft (2m) (Ridolfi and Adolfson, 2005).

In Year 2, a new transect (Transect 1-2) was added on the Mowitch site to characterize the establishment of marsh vegetation on three lobes of intertidal habitat (Ridolfi and Adolfson, 2003b). In Year 3, a new transect (Transect 1-2) was added at the Middle Waterway (Simpson/Trustees) site to capture marsh vegetation colonization on a lobe in the northern portion of the site, and three quadrat sampling locations were added to Transect 1-1 to obtain cover data that more closely reflect conditions along that transect. Reinforcing steel bars (rebar) were used to permanently mark the transect locations.

A-1.1.2 Year 7 Monitoring

Based on recommendations made at the end of Year 2 monitoring (Shelly, 2004), the original sampling locations from Year 1 (or Year 2 for Mowitch Transect 1-2 and Year 3 for Middle Waterway [Simpson/Trustees] Transect 1-2) were used to allow for paired comparisons. Paired comparisons were not made for Squally Beach Transect 1-3 (which was relocated between Year 5 and Year 7) or for the two transects at the newly built Hylebos Creek Off-Channel (Jordan) site. The Year 7 results for these three transects will serve as baseline information for future comparisons.

From September through October 2008, plant species development and composition were evaluated within the marsh area along transects using randomly placed quadrats ("quadrats" are plots, usually rectangular, used for ecological or population studies). Staff biologists with Ridolfi and Restoration Logistics recorded the presence and percent cover of marsh species within each quadrat. Monitoring of marsh development and species composition was conducted at the Squally Beach, Mowitch, Hylebos Creek Off-Channel (Jordan), and Middle Waterway (Simpson/Trustees) sites. Permanent transects had been established generally along contours at each site monitored and situated so that they covered each of the management zones. Figures 1-4, 1-5, 1-6, and 1-7, in Section 1 of this report, show the management zones for the four sites monitored for BSC 2.

At each sampling location, a 1.6-ft x 1.6-ft (0.5-m x 0.5-m) quadrat was placed on the ground. The percent cover of each plant species present within each quadrat was visually estimated (viewed from the vertical). A determination was also made as to whether a given plant species was non-native or invasive (NNI). To ensure consistency between monitoring events, observations were recorded on standardized data forms. The percent of a quadrat that occurred within the herbivory avoidance fencing was also recorded. Photographs were taken of each quadrat sampled.

During Year 7, field crews used field notes and photographs from previous years, along with previously placed rebar markers, to determine the locations of the marsh transects and sampling quadrats. However, some of the rebar was missing in Year 7, presumably having been washed

away by tides or removed to reconstruct herbivory avoidance fencing. Field crews encountered other challenges in attempting to relocate the marsh quadrats in the same locations sampled during previous years. Herbivory avoidance fencing had been removed in some areas between the Year 5 and Year 7 sampling events, and these areas had been replanted with native marsh species. In addition, it appeared that erosion or scouring of beach sediments had occurred in some areas. Finally, the ability to relocate quadrats based on vegetation presence and cover observed in previous years was limited, as it appears that the marsh vegetation is dynamic, with some species spreading rapidly to colonize new areas and other species declining.

A-1.2 BSC 2 Data Analysis

Cover values for individual species were summarized using an unbiased average percent coverage estimate for each transect. Plant species analysis was based on the estimated cover values. Percent cover is discussed in this report in terms of the unbiased average quadrat canopy percentage. The term "unbiased" is used to signify that the estimate is different from the arithmetic mean of the quadrat cover values, which would be a biased estimate for the average or expected value for these data. The unbiased estimate is calculated in a way that compensates for the patchy distribution of plant species among quadrats.

As with most scientific sampling, these averages for canopy cover contain some uncertainty. This is because only a portion of the entire population of plants along a transect (i.e., those plants within the sampling quadrats) has been measured. Therefore, it is possible that the average canopy percentage for the entire population of plants along a transect is actually somewhat higher or lower than the average based on the quadrat sampling data. To describe this uncertainty, the upper and lower bounds of the 90 percent confidence interval (90CI) are provided, i.e., there is 90 percent probability that the average canopy percentage for the entire population of plants along a transect falls somewhere between the upper and lower bounds. In addition to the analyses described below, the statistical results served as a basis for between-site comparisons.

The percentage of a quadrat that occurred within herbivory avoidance fencing was also analyzed to determine whether the fencing influences species composition in the marsh habitats.

Based on the recommendations produced at the end of Year 2 monitoring, a statistical analysis was performed to compare the Year 7 percent cover data to data from the year of origin (Year 1, 2, 3, or 5, depending on transect). The monitoring results are presented in Section 3.1of this report and Appendix B.

A-1.2.1 Statistical Estimate of Percent Cover by Species

The objective of this analysis was to provide an unbiased estimate and confidence interval for individual species and total percentage of NNI species by transect. The percent cover for individual species and total native and NNI cover by quadrat were assumed to have zero-modified log-normal distribution. In other words, the distribution is log-normal with a positive probability of zero cover (i.e., log-normal with a spike at zero).

This estimate of mean cover for a given transect is:

$$\hat{C}_{NNI} = (1-\hat{p}) * \exp(\bar{y} + \frac{s_y^2}{2})$$

where :

$\hat{p} = r / n$,

r = the number of zero quadrats,

n = the number of sampled quadrats, $i = 1,\ldots, n$,

$\bar{y} = \sum_{i=1}^{n-r} y_i /(n-r)$,

$y_i = \ln(\sum_{j=1}^{m} c_{ij})$,

m = the number of observed NNI species, $j = 1,\ldots, m$,

c_{ij} = the observed percent cover of species j in quadrat i, and

$$s_y^2 = \frac{\sum_{i=1}^{n-r}(y_i - \bar{y})^2}{(n-r-1)}.$$

Note that $\bar{y}$ and s_y^2 are the sample mean and variance of the non-zero quadrat cover estimates.

An approximate 90CI is given by:

$$\hat{C}_{NNI} \pm t_{.10(2),(n-2)} * \sqrt{\left(\frac{N-n}{N}\right)\left(\hat{\text{var}}(\hat{C}_{NNI})\right)},$$

where:

N = the total number of quadrats that could fit on the transect, and

$\hat{\text{var}}(\hat{C}_{NNI}) = \frac{1}{n}\exp(2\bar{y} + s_y^2)\cdot(1-p)\left[p + \frac{2s_y^2 + s_y^4}{2}\right]$, the asymptotic variance estimate (Owen and DeRouen, 1980).

The results of this analysis indicate the unbiased average percent cover of plant species in the marsh as well as the upper and lower bounds of the 90CI. The results also indicate the frequency with which each species was found along a transect. The determination as to whether the monitoring objectives for this BSC were met is based on these statistical analyses.

A-1.2.2 Statistical Comparison Between Years

Now that data for four years of monitoring are available for most sites, changes through time in individual species and total cover can be analyzed in several ways.

The first analysis is the same one that has been completed in previous years. A non-parametric signed-ranks test is used to compare the median percent cover for the current year to that in the baseline year for each transect. Because the same quadrats are sampled every year, the change can be determined for each quadrat, and consistent changes across quadrats indicate a significant change. Non-parametrics are used due to severe skew and a high proportion of zero changes.

This year, a second analysis for temporal trends has been added. Most transects have now been sampled for four years, so testing for monotonic trends through time is possible. Again, non-parametrics are used to avoid normality assumptions. For each species or total that has an unbiased mean estimate available for multiple years, Spearman's rank correlation coefficient test (Spearman's rank test) was applied, testing for correlation between years and mean percent cover. Years for which cover could not be estimated or was not detected were given lowest rankings in the analysis.

A-2.0 BSC 6 Riparian Vegetation/Areal Coverage

This section provides a detailed description of the methods that were used to collect and analyze data to evaluate current conditions and temporal trends in the riparian zone at sites where this criterion applies. It also describes the changes in monitoring protocols and transect locations that were made over the years and provides a rationale for those changes.

A-2.1 BSC 6 Field Work

This section describes the field work and data analyses procedures that were used in BSC 6 to evaluate plant conditions in the riparian zone.

A-2.1.1 Previous Monitoring Work

The riparian monitoring methods used in Years 1–3 differ from the methods used in Years 5 and 7 and are detailed in the Year 3 (2004) monitoring report (Ridolfi and Adolfson, 2005). The Year 5 riparian monitoring methods are detailed in the Year 5 (2006) monitoring report (Ridolfi and Adolfson, 2006) and are summarized below in the discussion of Year 7 monitoring.

A-2.1.2 Year 7 Monitoring

In Year 5, the Trustees established a new protocol for sampling riparian vegetation (Cereghino, 2006). This protocol was continued in Year 7. Instead of using randomly placed quadrats along a single transect (as in Years 1–3), line intercept transects were employed in Years 5 and 7. The objectives for this change were to produce a more representative random sample of riparian vegetation, reduce observer error, increase replicability, and reduce between-plot variation.

Riparian cover monitoring was conducted at the Squally Beach, Mowitch, Hylebos Creek Off-Channel (Jordan), and Middle Waterway (Simpson/Trustees) sites. As with the marsh areas, the riparian areas at each site were divided into management zones during Year 5. The purpose of these zones is to facilitate maintenance activities by dividing the riparian areas into smaller units. The management zone boundaries (shown on Figures 1-4, 1-5, 1-6, and 1-7 in Section 1 of this report) were initially determined by NOAA (Cereghino, 2006). In Year 5, management zone boundaries were marked in the field by Adolfson biologists based on site features that can be seen on aerial photos (e.g., changes in vegetation or the presence of structures such as fences or buildings). The management zones remained the same for Year 7.

NOAA determined the number of line intercept transects to be sampled at each site and within each riparian management zone. The Year 5 monitoring report (Ridolfi and Adolfson, 2006) documents how these transects and a baseline transect along the outer (upland) edge of the riparian area were established. The ends of each line intercept transect were marked in the field with wooden stakes and flagging.

In both Year 5 and Year 7, a total of 20 line intercept transects were sampled at Middle Waterway (Simpson/Trustees); 12 were sampled at Squally Beach; 24 were sampled at Mowitch; and 25 were sampled at Hylebos Creek Off-Channel (Jordan). Line intercept transects were 60 feet long to reduce variance (Cereghino, 2006). Using a measuring tape, field crews recorded the beginning and ending points where each woody species intercepted the tape. In portions of the transect where two or more woody species were intertwined, the starting and ending points of the intertwined group were recorded along with the relative percent cover of each species within the group. Several transects contained more than one distinct woody stratum (for example, a shrub layer beneath an overhead tree canopy or a tall shrub layer above a low shrubby species). For these transects, each stratum was recorded separately, which means that the total woody cover along the transect could total more than 100 percent. The percent cover of herbaceous and groundcover species and bare ground along each transect was visually estimated for the transect as a whole. The riparian data were recorded on standardized data forms.

A-2.2 BSC 6 Data Analysis

The riparian zones within each sampled site were stratified into sampling zones, with different numbers of random transect locations within each zone. The cover estimate for each transect comprises one independent random sample from the sampling zone. Because the zones have different areas, the combined estimate of mean cover for each site is a weighted mean based on sizes of strata. Table A-1 lists the strata and their associated sizes.

The transect cover estimates for individual species contained a high proportion of zeros for most species, and most distributions were somewhat positively skewed with very few high values. The zero-modified log-normal distribution was assumed for the marsh quadrat data and may also be appropriate for most riparian species. However, not all species conformed to this distribution. The formulas for confidence intervals on means of zero-modified log-normal distribution would also have to be modified to be used on stratified samples. In this case, the variances would have to be estimated within each strata, which consists of three to seven samples. These variance estimates are unstable, and the asymptotic properties of the estimators are in serious question.

Instead of assuming a distribution, bootstrapping[1] was used to estimate the stratified mean and confidence limits for the mean cover of each species and group totals. The bootstrapping was done within strata, with appropriate weights to estimate the stratified mean. The mean and bias-corrected 95 percent confidence interval (95CI) were estimated from 1,000 bootstrap samples using S-PLUS statistical software (S-PLUS 2000, Professional Release 3.0, ©1998-2000, MathSoft Inc.). The monitoring results are presented in Section 3.2 and Appendix B.

A-2.2.2 Changes in Riparian Cover Over Time

For the Mowitch, Middle Waterway (Simpson/Trustees), and Squally Beach sites, two years of riparian data have been collected in the same manner and can be compared to determine changes

[1] "Bootstrapping" is a non-parametric method that lets us compute estimated standard errors by resampling the empirical data distribution. For each bootstrap trial, a random sample of the same size as the original sample is selected with replacement from the empirical data. The desired statistic (e.g., the sample mean) is estimated for this bootstrap sample, then this process is repeated many times. At the end of the process, we have a distribution of the estimated statistic and we can estimate the variance directly from the bootstrap sample.

over time. A paired analysis was conducted for each site in which the median difference in percent cover (2006–2008) was tested for difference from zero. A non-parametric sign test was used because of the large number of zero differences and lack of normality. Individual species observed in both years were tested, as were total native and NNI groupings. Note that species with fewer than three transects with non-zero changes in percent cover could not be tested.

A-3.0 BSC 7 Fish Access/Presence

This section provides a detailed description of the methods that were used to collect and analyze data to evaluate current conditions and temporal trends in the fish usage at sites where this criterion applies. It describes the procedures used at each site (block netting, beach seining, and snorkel surveying) to collect the fish. At each site the fish were identified to species, the juvenile salmonid were checked to see if they were wild or hatchery bred, and the length of each salmon was also measured.

A-3.1 Field Work

This section describes the field work and data analyses procedures that were used in BSC 7 to evaluate fish access/presence at the sites.

The block net/beach seine net crew collected, identified, and measured the fork length (FL) of salmonids to the nearest millimeter (mm). If possible, hatchery fish were identified by the presence of clipped fins or coded wire tags (CWTs). The fish were then released after examination. For the snorkel surveys, the snorkeler used visual observations to identify salmonids, estimate FL, and, if possible, determine whether the fish had clipped fins, primarily clipped adipose fins.

The Puyallup River basin supports wild and hatchery Chinook, coho, chum, and pink salmon, as well as steelhead, sea-run cutthroat, and bull trout/Dolly Varden. The Puyallup Tribe of Indians, the Muckleshoot Indian Tribe, and the Washington Department of Fish and Wildlife (WDFW) have hatcheries in the basin that produce spring/fall Chinook, coho, and steelhead. Outmigration occurs from March through July, with peak use of the nearshore tidal areas occurring May through June.

In Years 1–3, fish monitoring was conducted from mid-April through October. The sampling schedule was modified in Year 7, with sampling conducted from mid-February through July to better capture the beginning of the peak outmigration of juvenile salmon in the bay. Another reason for the modification is that in Years 1–3, juvenile salmonids were generally not observed at the sites after July.

Year 7 was the first year that the Puget Creek site, on the western shore of Commencement Bay, was sampled for fish access and presence. The site was added to provide a more complete picture of fish assemblage throughout Commencement Bay. Conversely, the Mowitch site was dropped from the Year 7 fish monitoring because the block nets used in Years 1–3 were ineffective, were time-consuming, and caused unnecessary trauma and harm to the fish. The use of beach seines or snorkeling at the Mowitch site is not practical due to the site's configuration and extremely low visibility in the water.

Beach seine nets were used at the Yowkwala, Skookum Wulge, Middle Waterway (Simpson/Trustees), Middle Waterway (City of Tacoma), Olympic View, and Puget Creek sites. The approximate locations of the beach seine sets are shown by site on Figures 1-2, 1-3, 1-7, 1-8, and 1-9 in Section 1 of this report. Monitoring was also conducted at the Olympic View site using a block net when tides were high enough to fill the site with water.

Fish sampling with nets was conducted from February through July 2008. Sampling was conducted bimonthly from mid-February through March and weekly from April through July, for a total of 35 sampling events comprising 329 sets. The Olympic View site was sampled with the block net four times (once each in February, March, May, and June); the beach seine net was used for all other sampling events. Snorkel surveys were conducted at the Hylebos Creek Off-Channel (Jordan) site from April through July 2008, at a frequency of once per month in April and July and approximately weekly from May through June, for a total of 10 monitoring events.

For all sampling events, the following data were collected at each site: location, date, time of deployment, tide stage (time and height), and weather conditions, including an approximation of air temperature, wind direction, precipitation, and cloud cover. Environmental measurements taken at each site included water quality parameters such as temperature and salinity. A YSI 30

salinity-conductivity-temperature meter was used to collect water quality data. Any uncommon events or changes in the sites were noted. The Trustees have not yet identified any reference or comparison sites, so no reference sampling was performed.

A-3.1.1 Beach Seine Nets

At the Yowkwala, Skookum Wulge, Middle Waterway (Simpson/Trustees), Middle Waterway (City of Tacoma), Olympic View, and Puget Creek sites, a 17-ft (5-m) outboard skiff was used to deploy a 120-ft x 8-ft (37-m x 2.4-m) floating "Puget Sound" beach seine net of 0.4-inch (1-centimeter [cm]) mesh. The main part of the beach seine, known as the "wings," is constructed with 1-inch (2.5-cm) mesh. Between the wings is a 6-ft (1.8-m)-deep "bag" made of 0.25-inch (0.6-cm) mesh. The bag creates a deep pocket, increasing the chance that fish will be trapped as the net is dragged through the water. Seine nets are equipped with a weighted lead line attached to the bottom of the mesh that creates a seal along the topography of the substrate as the net is being pulled to shore. A cork line attached to the top of the net keeps the net from sinking below the water surface. Attached to each end of the beach seine at the cork line is approximately 50 ft (15 m) of polypropylene line (poly-line), which is used to pull the net to shore.

To conduct the sampling, a sampler stood on the beach and held one end of the net. Two people stayed in the boat to deploy the net. The driver motored backward away from shore approximately 50 ft (15 m) and then turned parallel to the shore. The deployer began releasing the net as the boat continued to travel backward about 100 ft (30 m) until the net was fully deployed and taut; the driver then turned the boat and motored forward, bringing the full length of the poly-line (boat end of the net) to shore. Once the boat reached shore, the deployer disembarked and took his/her place to begin retrieving the net. Next, the samplers slowly pulled the full length of the net toward the beach; as the samplers came together on the beach, the net formed a semicircle, allowing trapped fish to slide down the wings and into the bag.

Replicate sets were made at each site if space, time, and tide stage permitted. Care was taken to ensure that the area covered by one set was not duplicated in the replicate sets. This was achieved by moving approximately 10 to 20 ft (3 to 6 m) away from the previous set's endpoint. Generally, three sets were deployed at each site with the exception of the Middle Waterway (City

of Tacoma) and the Skookum Wulge sites, where site configuration is not conducive to more than one set. Time between sets varied between five and 30 minutes, a reflection of the time needed to process fish caught in a set. Beach seining was conducted during high to mid-tide, generally on an outgoing tide. At times, environmental factors, such as tides that were too high or too low or mass accumulations of seaweed in the net, prevented the samplers from completing the prescribed number of sets.

As the tide receded, all fish were collected from the nets, identified by genus and species, counted, examined for external anomalies, and released. Additionally, up to 40 specimens from each species of sculpin, flat fish, forage fish, and salmonids were measured before being released. Salmonid fork lengths were measured to the nearest mm (from nose to mid-fork of tail); all other species were measured full length to the nearest mm (from nose to end of tail).

Salmonids were also checked for hatchery marks. These data were used to estimate the proportion of wild to hatchery fish, as well as the hatchery origin of marked fish. Possible hatchery marks include CWTs and clipped adipose fins, right ventral fins, and left ventral fins. Sampling personnel examined salmonids for fin clips while the fish were being measured and identified. Tags were detected using a handheld CWT wand detector. Hatchery fish were assumed to originate from the Washington State and tribal hatcheries located in the Puyallup River basin.

A-3.1.2 Block Nets

At the Olympic View site, the crew was able to walk across the opening of the site and set a 120-ft x 44-ft (37-m x 13.5-m) block net made of 0.4-inch (1-cm) mesh. The catch from the block net was added to the catch from the beach seine method to create the total catch for the site. The block net was attached to a length of rebar driven into the shore on either side of the site to ensure full blockage of the outlet. The block net was equipped with a weighted lead line attached to the bottom of the net, which created a seal along the substrate of the mouth of the site. A cork line kept the top of the net from sinking below the water surface, thus creating fish blockage. The net was set during tide cycles that included a 12-ft (3.7-m) or greater high tide and a 1-ft (0.3-m) or lower low tide. The net was allowed to “soak” as the tide receded, until the

site was emptied of water; this took approximately two to three hours. Sampling personnel monitored the net as low tide approached to ensure the catch was not left without water. Captured fish were identified, measured, and counted as described for the block net sampling method.

A-3.1.3 Snorkel Surveys

Snorkel surveys were conducted at the Hylebos Creek Off-Channel (Jordan) site using an adapted monitoring approach outlined in Thurow (1994). A two-person crew, one snorkeler and one on-shore observer, conducted the surveys. For this purpose, the site was divided into two main sections: the off-channel habitat area and the Hylebos Creek area. Each area was further divided into survey reaches as shown on Figure A-1. The off-channel habitat area was subdivided into three distinct units characterized by a series of channels and five pools. Numbering of the reaches and pools begins at the downstream end of the area.

The Hylebos Creek area was divided into five distinct units, beginning at the downstream end of the site. Hylebos Creek is a straight channel with shallow to deeper pools. The entire length of Reaches 4 and 5 are characterized by shallow water flowing over a sand and gravel substrate, forming a glide. The shallow areas are estimated at less than 8 inches (20 cm) in depth. At the downstream edge of Reach 4, the creek deepens. Reaches 1, 2, and 3 are characterized by deeper water with pools, with the deepest pools estimated at just over 6 ft (2 m). Water depths in Reaches 1, 2, and 3 fluctuate with the tides.

The snorkeler was outfitted with a dark green dry suit, neoprene gloves, a wet-suit hood, snorkel and mask, and dive boots. To conduct the survey in the off-channel habitat area, the snorkeler started at the downstream end of each reach and moved slowly upstream in a zigzag pattern across the channel to complete one upstream pass for each reach. Pools were surveyed in a similar manner. In the Hylebos Creek area, the snorkeler started at the downstream end of each reach and slowly moved upstream, surveying the bank along the site. One upstream pass was conducted for each reach. The snorkeler was generally in the center of Hylebos Creek with head turned in the direction of the site. Because turbid tidal waters and shadows from the sun can hamper water clarity, the snorkel surveys were generally planned around a mid to low tide and

conducted between late morning and early afternoon when the sun was directly overhead, increasing the likelihood of good visibility for the snorkeler. All portions of the site were surveyed if conditions allowed.

Salmonids were identified to species and counted. Total lengths for salmonids were estimated to the nearest size group (e.g., 50 to 80 mm, 80 to 100 mm, and 100 to 120 mm). If possible, salmonids were also examined for hatchery marks, such as clipped adipose fins. All other species were identified to family, or species when possible, and counted. When large numbers of the same species were encountered, counts were estimated to the nearest 10. Fish data and observations were called out by the snorkeler to the on-shore observer. The on-shore observer recorded the information in a waterproof field notebook. The on-shore observer also recorded any observations made from the bank during the survey.

A-3.2 BSC 7 Data Analysis

All site-condition and fish-survey data were entered into an Excel spreadsheet to facilitate data analysis and aid in constructing the figures and tables. The monitoring results are presented in Section 3.3.

A-4.0 Baseline Chemical Conditions: Surface Water Chemistry

This section provides a detailed description of the methods that were used to collect and analyze data to evaluate current conditions and temporal trends of the surface water chemistry at sites where this criterion applies. It also describes the monitoring protocols and sample locations that were chosen to capture the surface water conditions at the sites.

A-4.1 Field Work

In all, five surface water samples were collected, where possible near potential point sources of contamination. The samples were collected near two outfalls at the Squally Beach site (Figure 1-4) and one outfall at the Middle Waterway site (Figure 1-7). There are no outfalls at the Mowitch site, so the sample was collected from the southeast end of the site where potential sources of contaminants include runoff from the adjacent road and bridge (Figure 1-5).

There are no outfalls or potential point sources of contamination at the Hylebos Creek Off-Channel (Jordan) site; therefore, the sample was collected near the middle of the site (Figure 1-6). Figures 1-4 through 1-7 are in Section 1 of this report.

Surface water samples were collected using a peristaltic pump and by dipping sample bottles under the water surface as described in the SAP (Ridolfi, 2008). On October 20, 2008, one primary sample was collected from each of the five sampling stations and submitted to SPECTRA Laboratories (SPECTRA) in Tacoma, Washington, for fecal coliform analysis. On October 21, 2008, a second sample was collected at each of the five sampling stations and submitted to Analytical Resources, Inc. (ARI) of Tukwila, Washington, for analysis of dissolved metals, total nitrogen[2], and total phosphorous. Field duplicate samples were collected at the Middle Waterway site at the same time as the primary samples.

Horizontal coordinates for each sampling location were determined using a Garmin global positioning system (GPS) unit. Location information for the sampling stations is summarized in Table A-2 and displayed on Figures 1-4, 1-5, 1-6, and 1-7 in this report.

A-4.2 Data Analysis

Samples were analyzed for dissolved metals, total nitrogen, total phosphorous, and fecal coliform in accordance with the SAP (Ridolfi, 2008) and using the analytical methods summarized in Table A-2. The sample results were reviewed for data quality; results of the data review will be provided upon request. Ridolfi compared the sample results for dissolved metals and fecal coliform to the Washington State water quality standards (Ecology, 2006) and the nutrient results to the USEPA's ambient water quality criteria (USEPA, 2000); the results of this comparison are summarized in Section 3.6 of this report

[2] The sum of total Kjeldahl nitrogen and nitrite/nitrate (NO_2/NO_3) analyses.

Table A-1. Zone names and areas for each sampled site

Zone Code	Zone Name	Area	
		sq. ft	acres
Mowitch			
F1	F1	8,580	0.197
F2	F2	4,237	0.097
F3	F3	3,798	0.087
F4	F4	5,250	0.121
F5	F5	3,941	0.09
F6	F6	5,391	0.124
F7	F7	2,953	0.068
Middle Waterway (Simpson/Trustees)			
NB	North Bank	19,280	0.443
NW	North Woods	10,487	0.241
SB	South Bank	19,622	0.45
SW	South Woods	26,047	0.598
Squally Beach			
AG	Alder Grove	5,619	0.129
EW	East Woods	10,179	0.234
WW	West Woods	5,886	0.135
Hylebos Creek Off-Channel (Jordan)			
NB	North Bank	54,655	1.255
CB	Central Bank	33,240	0.763
SB	South Bank	112,327	2.579
NI	North Island	16,669	0.383
NCI	North Central Island	24,015	0.551
SCI	South Central Island	10,631	0.244
SI	South Island	15,214	0.349

Table A-2. Sample identification, description, coordinates, analyses performed, screening criteria, and results

Sample Location	Station Identification	GPS Coordinates		Date Collected	Sample ID	Analyses	Sample Description
		Latitude	Longitude				
Middle Waterway	SW-1	47.255640	-122.427160	10/21/2008	08102105	Dissolved Metals*/Nutrients**	
				10/21/2008	08102106 (Duplicate)	Dissolved Metals*/Nutrients**	
				10/20/2008	08102001	Fecal Coliform***	high tide, water clear to slightly turbid, no smell
				10/20/2008	08102002 (Duplicate)	Fecal Coliform***	
Squally Beach	SW-1	47.281420	-122.392970	10/21/2008	08102102	Dissolved Metals*/Nutrients**	
	SW-2	47.281190	-122.392070	10/21/2008	08102103	Dissolved Metals*/Nutrients**	
	SW-1	47.281420	-122.392970	10/20/2008	08102003	Fecal Coliform***	high tide, water clear to slightly turbid, no smell
	SW-2	47.281190	-122.392070	10/20/2008	08102004	Fecal Coliform***	
Mowitch	SW-1	47.259770	-122.358350	10/21/2008	08102104	Dissolved Metals*/Nutrients**	
				10/20/2008	08102005	Fecal Coliform***	high tide, water clear to slightly turbid, no smell
Hylebos Creek Off-Channel (Jordan)	SW-1	47.252440	-122.349270	10/21/2008	08102101	Dissolved Metals*/Nutrients**	
				10/20/2008	08102006	Fecal Coliform***	high tide, water clear to slightly turbid, no smell

NOTES:

SW = surface water

* Dissolved metals analysis was performed by USEPA Method 6010 for cadmium, chromium, copper, and zinc; 200.8 for silver, arsenic, and lead; and 7470/7471 low reporting limit method for mercury.

** Nutrient analyses were performed by Standard Methods 4500-Norg and D4500-NO_3 I for TKN and NO_2/NO_3 and by standard method 4500-P B for phosphorous.

*** Fecal coliform analyses was performed using standard method 9222D.

Legend

Creek Reach

- Creek Reach 1
- Creek Reach 2
- Creek Reach 3
- Creek Reach 4
- Creek Reach 5

Off-Channel Reach

- Off-Channel Reach 1
- Off-Channel Reach 2
- Off-Channel Reach 3

Note:
Airphoto Date - August 2008

N

0 100
Feet

Figure A-1
Hylebos Creek Off-Channel (Jordan)
Site Snorkel Survey Reaches

Year 7 (2008) Monitoring Report
Commencement Bay
Habitat Restoration Sites

April 2009

RIDOLFI Inc.

APPENDIX B

Monitoring Results

LIST OF TABLES

Table B-1 Marsh development at Squally Beach, Transect 1-1 .....B-12

Table B-2 Squally Beach Marsh Transect 1-1: Change in percent cover 2002 to 2008.....B-13

Table B-3 Marsh development at Squally Beach, Transect 1-2 .....B-14

Table B-4 Squally Beach Marsh Transect 1-2: Change in percent cover, 2002 to 2008.....B-15

Table B-5 Marsh development at Squally Beach, Transect 1-3 .....B-16

Table B-6 Marsh development at Mowitch, Transect 1-1 .....B-17

Table B-7 Mowitch marsh Transect 1-1: Change in percent cover, 2002 to 2008.....B-18

Table B-8 Marsh development at Mowitch, Transect 1-2 .....B-19

Table B-9 Mowitch Marsh Transect 1-2: Change in percent cover, 2003 to 2008.....B-20

Table B-10 Marsh development at Hylebos Creek Off-Channel (Jordan), Transect 1-1 .....B-21

Table B-11 Marsh development at Hylebos Creek Off-Channel (Jordan), Transect 1-2 .....B-22

Table B-12 Marsh development at Middle Waterway (Simpson/Trustees), Transect 1-1 .....B-23

Table B-13 Middle Waterway (Simpson/Trustees) Marsh Transect 1-1: Change in percent cover, 2002 to 2008.....B-24

Table B-14 Marsh development at Middle Waterway (Simpson/Trustees), Transect 1-2 .....B-25

Table B-15 Middle Waterway (Simpson/Trustees) marsh Transect 1-2: Change in percent cover, 2002 to 2008.....B-26

Table B-16 Riparian development at Squally Beach, Year 7 (2008).....B-27

Table B-17 Change in riparian cover at the Squally Beach site, Year 5 (2006) to Year 7 (2008) B-28

Table B-18 Riparian development at Mowitch, Year 7 (2008) B-29

Table B-19 Change in riparian cover at the Mowitch site, Year 5 (2006) to Year 7 (2008) B-30

Table B-20 Year 7 (2008) Riparian development at Hylebos Creek Off-Channel (Jordan), Year 7 (2008) B-31

Table B-21 Year 7 (2008) Riparian development at Middle Waterway (Simpson/Trustees), Year 7 (2008).....B-32

Table B-22 Change in riparian cover at the Middle Waterway (Simpson/Trustees) site, Year 5 (2006) to Year 7 (2008).....B-33

Table B-23 Summary of bird species and numbers observed at the Hylebos Creek Off-Channel (Jordan) site, Year 7 (2008) B-34

Table B-24 Summary of bird species and numbers observed at the Sha Dadx site, Year 7 (2008) B-35

B-1.0 BSC 2 Marsh Development/Species Composition Detailed Results

This section describes monitoring results for BSC 2 observed during the Year 7 (2008) monitoring season. It also compares current conditions in the marsh habitat zones to the baseline conditions that were observed at each site. Marsh management zone locations for each site are shown on Figures 1-4, 1-5, 1-6, and 1-7 in this report. Detailed tables showing the results are provided at the end of Appendix B.

B-1.1 Squally Beach

The Squally Beach site was sampled for marsh plant development and species composition in September 2008. Three marsh transects containing 55 quadrats were sampled. Marsh management zone locations are shown on Figure 1-4 in this report.

B-1.1. Transect 1-1

Description of Results. Of the 24 marsh quadrats sampled along Squally Beach Transect 1-1, 22 quadrats contained vegetation in Year 7. Eleven plant species were found along Transect 1-1, all identified as native plant species. Native species represented approximately 75 percent cover along Squally Beach Transect 1-1 in Year 7 and the remainder of the ground was bare. The most prevalent native species, based on the average unbiased cover estimate (Table B-1), was pickleweed at 21.4 percent. The next two most frequently observed species were fleshy jaumea (20.8 percent) and seashore saltgrass (11 percent). The percent cover for NNI species was 0 percent, below the target of 5 percent.

The diversity of native plant species and the average percent native cover among quadrats significantly increased in Year 7 (Table B-2), with 78 percent of quadrats showing a significant increase in cover by native plant species. Four native plant species showed a significant increase in cover in sampled quadrats from Year 1 to Year 7: seashore saltgrass (48 percent), entire-leaved gumweed (52 percent), seaside plantain (35 percent), and pickleweed (83 percent). Although 13 percent of the sampled quadrats showed an increase in cover by the native plant species fat-hen saltbush from Year 1 to Year 7, 43 percent of quadrats saw a decrease of that plant species.

During Year 1, seven native plant species were observed along Transect 1-1, with a total unbiased average cover of 19.1 percent. Both the diversity of native plant species and the percent cover of native species have increased along Transect 1-1 from Year 1 to Year 7. There was no significant change in the percent cover of NNI species, which were not found along this transect in Year 3, Year 5, or Year 7.

B-1.1.2 Transect 1-2

Description of Results. All 15 marsh quadrats sampled along Transect 1-2 contained vegetation in Year 7. Of the 13 species found, 10 were native, representing approximately 96 percent cover. The most prevalent native species, based on the average unbiased cover estimate (Table B-3), was Lyngby's sedge at 33.2 percent, followed by fleshy jaumea (25.4 percent) and seashore saltgrass (12.8 percent). The percent cover for NNI species was 4.8 percent, below the target of 5 percent and a decrease since Year 1.

The average percent native cover across this transect showed a significant increase in Year 7 (Table B-4), with 87 percent of quadrats sampled showing an increase in cover by native plant species. Three species showed the greatest significant increase in cover: seashore saltgrass and fleshy jaumea cover both increased in 60 percent of the quadrats, and Lyngby's sedge cover increased in 53 percent of quadrats (Table B-4). The native plant species fat-hen saltbush significantly decreased in cover, with 80 percent of the sampled quadrats showing a decrease (Table B-4).

Thirteen native plant species were observed along Transect 1-2 at the Squally Beach site during the Year 1 monitoring, with a total unbiased average cover of approximately 49.5 percent (90CI of 14.8 to 84.1 percent). During Year 7, 10 native species were observed, with a total average cover of 96.4 percent (90CI of 69.3 to 123.5 percent) (Table B-3). Although the diversity of native plant species slightly decreased along the transect between Year 1 and Year 7, the average percent cover of native species has shown a statistically significant increase from Year 1 to Year 7.

In Year 7, the total unbiased average percent cover of NNI species for Squally Beach Transect 1-2 was 4.8 percent (Table B-3). Both the total number of NNI species observed and the average percent cover of NNI species along Transect 1-2 decreased from Year 1 to Year 7. However, statistical analysis indicates the NNI average percent cover did not significantly change from Year 1 to Year 7 (Table B-4).

B-1.1.3 Transect 1-3

Description of Results. Of the 16 marsh quadrats sampled along Transect 1-3, 14 quadrats contained vegetation in Year 7. Eight plant species were found along Transect 1-3, all identified as native plant species. Native species represented approximately 58 percent cover along Squally Beach Transect 1-3 in Year 7, and the remainder of the ground was bare. The most prevalent native species observed, based on the average unbiased cover estimate (Table B-5), was seashore saltgrass at 22.7 percent. The next two most frequently observed species were pickleweed at 16.9 percent and fleshy jaumea at 12.1 percent. The percent cover for NNI species was 0 percent, below the target of 5 percent (Table B-5).

Squally Beach Transect 1-3 was established during the Year 2 (2003) sampling season. Between Year 5 and Year 7, the transect was completely eroded away by wave action from seasonal storms. To continue to capture the lower marsh vegetation establishment at the site, Transect 1-3 was moved to the north just inside the fence that runs along the water's edge of the site. The Year 7 results for Transect 1-3 will serve as baseline information for future paired comparisons.

B-1.2 Mowitch

The Mowitch site was sampled for marsh plant development and species composition in Ocober 2008. Two marsh transects containing 69 quadrats were sampled. Marsh management zone locations are shown on Figure 1-5 in this report.

B-1.2. Transect 1-1

Description of Results. All of the 46 marsh quadrats sampled along Transect 1-1 contained vegetation in Year 7. Fourteen plant species were found along Transect 1-1, with 12 of those species identified as native (Table B-6). Native species represented approximately 80 percent cover in Year 7, while NNI species represented approximately 5.8 percent and the remainder of the ground was bare. The most prevalent native species observed was pickleweed at 14.6 percent, followed by seaside plantain at 13.3 percent and fleshy jaumea at 13.2 percent (Table B-6). Although the percent cover for NNI species remained above the target of 5 percent, it has decreased since Year 3.

Both the diversity of native plant species and the average percent cover of native species have increased along the transect between Year 1 and Year 7 (Table B-7). In Year 7, 98 percent of quadrats showed a significant increase in cover by native plant species. Seven of the 12 native plant species observed along Transect 1-1 showed significant increase in cover per quadrat, with pickleweed showing the greatest increase (70 percent of quadrats sampled) (Table B-7). Fat-hen saltbush significantly decreased in cover, with 43 percent of the sampled quadrats showing a decrease in cover (Table B-7).

Of the 46 quadrats along Transect 1-1, 10.5 quadrats were entirely within herbivory avoidance fencing. The quadrats falling within the fenced area generally had the greatest plant species diversity and greatest overall percent cover of native plant species. In general, areal coverage along this transect was greatest within the areas protected with herbivory avoidance fencing. Native plant species typically occurred more frequently and appeared to have higher percent cover inside the herbivory avoidance devices. The exception was native spike-rush, which had greater cover outside of the avoidance fencing.

In Year 1, a total of eight native plant species were observed along Transect 1-1, with a total unbiased average cover of 10.5 percent. During Year 7, 12 native plant species were observed, with a total unbiased average percent cover of 81.2 percent (Table B-6). The results for the non-parametric sign test indicate that the total of native species has shown a statistically significant increase along the transect since Year 1 (Table B-7). Therefore, both the diversity of native plant

species and the average percent cover of native species increased from Year 1 to Year 7. The total unbiased average percent cover of non-native species had increased along Transect 1-1 from 2.7 percent in Year 1 to 16.8 percent in Year 3 (Ridolfi and Adolfson, 2005), but decreased to 5.8 percent in Year 7 (Table B-6).

B-1.2.2 Transect 1-2

Description of Results. All of the 23 marsh quadrats sampled along Transect 1-2 at the Mowitch site contained vegetation in Year 7. Eleven plant species were found along Transect 1-2, with nine of those species identified as native (Table B-8). Native species represented approximately 53 percent cover in Year 7, while NNI species represented approximately 10 percent and the remainder of the ground was bare. The most prevalent native species observed, based on the average unbiased cover estimate, was spike-rush at 23.3 percent, followed by pickleweed at 9.9 percent and Canadian sandspurry at 7.1 percent (Table B-8). Although the percent cover for NNI species remained above the target of 5 percent, it has decreased since Years 2, 3, and 5. Despite this overall decrease in NNI species cover, brass buttons showed a significant increase of 65 percent along the transect in Year 7 (Table 3-10).

Both the diversity of native plant species and the average percent cover of native species have increased along the transect between Year 2 and Year 7 (Table B-9). Seven native plant species were observed along Transect 1-2 during the Year 2 monitoring, with a total unbiased average cover of 20.3 percent. During Year 7, nine native species were observed, with a total average percent cover of 52.9 percent (Table B-8). In Year 7, 91 percent of quadrats showed a significant increase in cover by native plant species, with pickleweed showing an increase in 52 percent of sampled quadrats and, although not statistically significant, spike-rush increasing in 57 percent of quadrats (Table B-9). An increase in average total cover by native species, statistically significant at the 95CI, was observed between Years 2 and 7 (Table B-9).

Of the 23 quadrats along Transect 1-2, 12 quadrats were entirely within herbivory avoidance fencing and 11 were entirely outside the fencing. The quadrats falling within the fenced areas generally had the greatest species diversity and greatest overall percent cover of native plants.

Native plant species such as pickleweed, Canadian sandspurry, and seaside arrowgrass generally showed a higher percent cover in fenced areas than in unfenced areas.

The total unbiased average percent cover of non-native species, which had increased along Mowitch Transect 1-2 from 20.4 percent in Year 2 to 87.9 percent in Year 3 (Ridolfi and Adolfson, 2005), decreased to 11.0 percent in Year 5 and decreased again to 10.2 percent in Year 7 (Table B-8).

B-1.3 Hylebos Creek Off-Channel (Jordan)

The Hylebos Creek Off-Channel (Jordan) site was sampled for marsh plant development and species composition in October 2008. Two marsh transects containing 54 quadrats were sampled. Marsh management zone locations are shown on Figure 1-6 in this report.

B-1.3.1 Transect 1-1

Description of Results. Of the 29 marsh quadrats sampled along Transect 1-1, 27 quadrats contained vegetation in Year 7. Seventeen of the 25 plant species found along Transect 1-1 were identified as native species. Native species represented approximately 38 percent cover in Year 7, while NNI species represented 10.2 percent cover and the remainder of the ground was bare. The most prevalent native species observed, based on the average unbiased cover estimate, was common rush at 13.2 percent (Table B-10). The next two most frequently observed species were softstem bulrush at 6 percent and Lyngby's sedge at 5.4 percent. The percent cover for NNI species was 10.2 percent, above the target of 5 percent (Table B-10). Reed canarygrass was the predominant NNI observed at 8.1 percent.

B-1.3.2 Transect 1-2

Description of Results. Of the 25 marsh quadrats sampled along Transect 1-2, 24 quadrats contained vegetation in Year 7. Thirteen of the 21 plant species found were identified as native species. Native species represented 34.5 percent cover in Year 7, while NNI species represented 21.7 percent cover and the remainder of the ground was bare. The most prevalent native species observed, based on the average unbiased cover estimate, was common rush at 17 percent.

The next three most frequently observed species were slough sedge at 8.1 percent and willowherb and Pacific willow, both at 1.6 percent. The percent cover for NNI species was 21.7 percent, above the target of 5 percent (Table B-11). Reed canarygrass was the predominant NNI observed at 11.2 percent.

B-1.4 Middle Waterway (Simpson/Trustees)

The Middle Waterway (Simpson/Trustees) site was sampled for marsh plant development and species composition in October 2008. Two marsh transects containing 33 quadrats were sampled. Marsh management zone locations are shown on Figure 1-7 in this report.

B-1.4.1 Transect 1-1

Description of Results. Of the 26 marsh quadrats sampled along Transect 1-1, 24 quadrats contained vegetation in Year 7. Six of the seven species observed were identified as native species. Native species represented approximately 68 percent cover in Year 7, with the remainder of the ground bare. Based on the average unbiased cover estimate, NNI species were present but insignificant. An unclassified-grass observed in two of the quadrats was assumed to be an NNI species. The most prevalent native species observed, based on the average unbiased cover estimate, was pickleweed at 38.3 percent, followed by seashore saltgrass at 23.5 percent and Canadian sandspurry at 1.9 percent (Table B-12).

Both the diversity of native plant species and the average percent cover of native species have increased along the transect in Year 7 (Table B-13). In Year 7, 87 percent of quadrats showed a significant increase in cover by native plant species. Two native plant species, seashore saltgrass and pickleweed, showed a significant increase in sampled quadrats from Year 1 to Year 7. Pickleweed cover increased in 87 percent of sampled quadrats and seashore saltgrass cover increased in 39 percent of sampled quadrats (Table B-13). An unclassified-grass, assumed to be an NNI, was observed in two quadrats along Transect 1-1. It was estimated to cover 10 percent of quadrat 4 and 5 percent of quadrat 5. Because the plant is patchy and rare along the transect, it was not possible to calculate a sufficient estimate of the mean.

In Year 1, a total of five native plant species was observed, with a total average cover of 24.2 percent. Both the diversity of native plant species and the percent cover by native species showed a statistically significant increase from Year 1 to Year 7 (Table B-13).

Year 7 saw a significant increase for both diversity of native plant species and percent cover of native plant species along Transect 1-1, suggesting the native plants are well established at the site and are not affected by the lack of herbivory avoidance fencing. The percent cover for NNI species was under 0.5 percent, well below the target of 5 percent.

B-1.4.2 Transect 1-2

Description of Results. Of the seven marsh quadrats sampled along Transect 1-2, five quadrats contained vegetation in Year 7. The four plant species observed along Transect 1-2 were all identified as native species. Native species represented approximately 23.8 percent cover in Year 7, with the remainder of the ground bare. The most prevalent native species observed, based on the average unbiased cover estimate, was pickleweed at 18.7 percent, followed by Canadian sandspurry at 5.4 percent (Table B-14). Although seashore saltgrass and seaside plantain were also observed, it was not possible to calculate a sufficient estimate of the mean for these plants because they were observed in such low percentages. In Year 7, the percent cover for NNI species was 0 percent, below the target of 5 percent (Table B-14).

In Year 3, three native species were observed along Transect 1-2 with a total unbiased average percent cover of 26.1 percent. In Year 7, four native species were identified within the transect with an unbiased average percent cover of 23.8 percent (Table B-14). While the number of native species increased between Year 3 and Year 7, the percent cover of native species decreased between the two years. The decrease may be because there is no herbivory avoidance fencing along the transect. In addition, the transect may cover an area having elevations too low to support saltmarsh vegetation. Neither the increase nor the decrease was statistically significant (Table B-15).

B-2.0 BSC 6 Riparian Vegetation/Areal Coverage Detailed Results

This section describes monitoring results for BSC 6 observed during the Year 7 (2008) monitoring season. It also compares current conditions in the riparian habitat zones to the baseline conditions that were observed at each site. Riparian management zone locations for each site are shown on Figures 1-4, 1-5, 1-6, and 1-7 in this report. Detailed tables showing the results are provided at the end of Appendix B.

B-2.1 Squally Beach

The Squally Beach site was sampled for riparian vegetation and areal coverage in September 2008. A total of 12 line intercepts were sampled. Riparian management zone locations are shown on Figure 1-4 in this report.

Table B-16 shows the stratified mean standard, bootstrap cover estimates, and 95CIs calculated by species. The stratified mean bootstrap estimate is used for this analysis because it has been statistically corrected for the skewed distribution of the riparian data.

Table B-17 compares the change in riparian cover for native and NNI species between Years 5 and 7 at the Squally Beach site, where native plant species have significantly increased along transects over the time period. Ten native shrub species and three native tree species were observed during both sampling seasons. Of these, Nootka rose and common snowberry showed significant increases in cover in 75 percent and 58 percent of the transects sampled, respectively. Douglas fir increased significantly in 58 percent of sampled transects. According to the paired analysis results, the increase in cover by NNI species was not statistically significant. Statistical analysis indicates a mean cover of 45 percent native shrubs, 89 percent native trees, and 31 percent NNI species (Table B-16).

B-2.2 Mowitch

The Mowitch site was sampled for riparian vegetation and areal coverage in September and October 2008. A total of 24 line intercepts were sampled. Riparian management zone locations are shown on Figure 1-5 in this report.

Table B-18 shows the stratified mean standard, bootstrap cover estimates, and 95CIs calculated by species. The stratified mean bootstrap estimate is used for this analysis because it has been statistically corrected for the skewed distribution of the riparian data.

Table B-19 compares the change in riparian cover for native and NNI species between Years 5 and 7 at the Mowitch site, where native plant species have significantly increased along transects. Nine native shrub species and ten native tree species were observed during both sampling seasons. Of these, the native shrubs rose, common snowberry, and red-osier dogwood showed significant increases in cover in 79 percent, 58 percent, and 42 percent of transects sampled, respectively. The native trees red alder and shore pine increased significantly in 63 percent and 42 percent of sampled transects, respectively. According to the paired analysis results, there was a significant decrease in cover by NNI species. Statistical analysis indicates a mean cover of 48 percent native shrubs, 28 percent native trees, and 1.9 percent NNI species (Table B-18).

B-2.3 Hylebos Creek Off-Channel (Jordan)

The Hylebos Creek Off-Channel (Jordan) site was sampled for riparian vegetation and areal coverage in October 2008. A total of 25 line intercepts were sampled. Riparian management zone locations are shown on Figure 1-6 in this report.

Table B-20 shows the stratified mean standard, bootstrap cover estimates, and 95CIs calculated by species from the data. The stratified mean bootstrap estimate is used for this analysis because it has been statistically corrected for the skewed distribution of the riparian data.

Statistical analysis indicates a mean cover of 20 percent native shrubs, 101 percent native trees, and 28 percent NNI species (Table B-20). NNI species, including Himalayan blackberry, reed canarygrass, pea vine, white sweet-clover, Japanese knotweed, and field bindweed, were also observed in areas surrounding the transects. The majority of these NNI species were observed on the islands, as well as in the northern portion of the site. Ten native shrub, four native herb, one native grass, and 13 native tree species were observed along the transects. The mean cover of native herbs was 3.3 percent; native herbs included American skunkcabbage, common horsetail, lady fern, and western swordfern.

B-2.4 Middle Waterway (Simpson/Trustees)

The Middle Waterway (Simpson/Trustees) site was sampled for riparian vegetation and areal coverage in October 2008. A total of 20 line intercepts were sampled. Riparian management zone locations are shown on Figure 1-7 in this report.

Table B-21 shows the stratified mean standard, bootstrap cover estimates, and 95CIs calculated by species. The stratified mean bootstrap estimate is used for this analysis because it has been statistically corrected for the skewed distribution of the riparian data.

Table B-22 compares the change in riparian cover for native and NNI species between Years 5 and 7 at the Middle Waterway (Simpson/Trustees) site. Eleven native shrub species, 10 native tree species, and three NNI species were observed at the site in both Year 5 and Year 7. Total native plant cover has significantly increased at the site since Year 5 sampling was conducted, while total cover by NNI species has significantly decreased. Forty-five percent of transects showed a significant increase in cover of Nootka rose, a native shrub. Among native tree species, cover by black cottonwood and Douglas fir significantly increased in 55 percent of transects sampled, while cover by madrone significantly increased in 30 percent of transects sampled. Between Year 5 and Year 7, total native plant species showed significant increases in 100 percent of the sampled transects. Cover by Himalayan blackberry, an NNI species, significantly decreased across 75 percent of the sampled transects, and overall NNI species cover significantly decreased in 80 percent of sampled transects. Statistical analysis indicates a mean cover of 30 percent native shrubs, 61 percent native trees, and 4.1 percent NNI species (Table B-21).

B-3.0 BSC 9 Bird Use Detailed Results

Detailed tables showing the monitoring results for BSC 9 observed during the Year 7 (2008) monitoring season are provided at the end of Appendix B. Table B-23 and Table B-24 provide the following information for bird species observed during the sampling season at the Hylebos Creek Off-Channel (Jordan) and Sha Dadx sites, respectively: general migratory patterns, common names, scientific names, and total number of each bird species observed by season.

Table B-1. Marsh development at Squally Beach, Transect 1-1

Common Name	Scientific Name	Exact Method - Continuous				Unbiased Average Quadrat Canopy Cover (%)	90% Confidence Interval	
		Actual Total Canopy (%)	Average Quadrat Canopy Cover (%)	Frequency (%)	Species Composition (%)		Lower Bound	Upper Bound
Native								
orache, fat-hen saltbush	*Atriplex patula*	25.0	1.0	12.5	0.06	1.1	0.1	2.1
Lyngby's sedge	*Carex lyngbyei*	55.0	2.3	16.7	0.13	2.5	0.1	4.8
tufted hairgrass	*Deschampsia cespitosa*	30.0	1.3	12.5	0.07	1.3	0.2	2.3
seashore saltgrass	*Distichlis spicata*	260.0	10.8	50.0	0.62	11.0	6.4	15.7
sea milkwort	*Glaux maritima*	10.0	0.4	4.2	0.02	n/a	n/a	n/a
entire-leaved gumweed	*Grindelia integrifolia*	215.0	9.0	54.2	0.51	9.1	5.4	12.8
fleshy jaumea	*Jaumea carnosa*	475.0	19.8	70.8	1.14	20.8	13.3	28.3
American dunegrass	*Leymus mollis*	15.0	0.6	8.3	0.04	n/a	n/a	n/a
seaside plantain	*Plantago maritima*	135.0	5.6	37.5	0.32	5.7	3.0	8.4
pickleweed	*Salicornia virginica*	510.0	21.3	83.3	1.22	21.4	15.0	27.7
saltmarsh chickweed	*Stellaria humifusa*	10.0	0.4	4.2	0.02	n/a	n/a	n/a
Canopy Cover, Native		*1,740.0*	*72.5*		*4.17*	75.2	58.9	91.6
Non-Native or Invasive (NNI)								
(None)								
Canopy Cover, NNI		*0.0*	*0.0*		*0.00*			
TOTAL		**1,740**	**72.5**		**4.17**	**75.2**	**58.9**	**91.6**
Proportion of non-native or invasive plants (%):			**0.0%**			**0.0%**		

Actual Total Canopy: Obtained by summing the percent cover of all quadrats on the transect.

Average Quadrat Canopy Cover: Obtained by dividing the total canopy by the total number of quadrats sampled on the transect.

Frequency: Obtained by dividing the number of occurrences of a plant species (the number of quadrats in which a plant species was observed) by the total number of quadrats sampled along the transect.

Species Composition: Obtained by dividing the percent canopy cover of each plant species by the total canopy cover of all plant species.

Table B-1. Marsh development at Squally Beach, Transect 1-1

Common Name	Scientific Name	Exact Method - Continuous				Unbiased Average Quadrat Canopy Cover (%)	90% Confidence Interval	
		Actual Total Canopy (%)	Average Quadrat Canopy Cover (%)	Frequency (%)	Species Composition (%)		Lower Bound	Upper Bound
Native								
orache, fat-hen saltbush	*Atriplex patula*	25.0	1.0	12.5	0.06	1.1	0.1	2.1
Lyngby's sedge	*Carex lyngbyei*	55.0	2.3	16.7	0.13	2.5	0.1	4.8
tufted hairgrass	*Deschampsia cespitosa*	30.0	1.3	12.5	0.07	1.3	0.2	2.3
seashore saltgrass	*Distichlis spicata*	260.0	10.8	50.0	0.62	11.0	6.4	15.7
sea milkwort	*Glaux maritima*	10.0	0.4	4.2	0.02	n/a	n/a	n/a
entire-leaved gumweed	*Grindelia integrifolia*	215.0	9.0	54.2	0.51	9.1	5.4	12.8
fleshy jaumea	*Jaumea carnosa*	475.0	19.8	70.8	1.14	20.8	13.3	28.3
American dunegrass	*Leymus mollis*	15.0	0.6	8.3	0.04	n/a	n/a	n/a
seaside plantain	*Plantago maritima*	135.0	5.6	37.5	0.32	5.7	3.0	8.4
pickleweed	*Salicornia virginica*	510.0	21.3	83.3	1.22	21.4	15.0	27.7
saltmarsh chickweed	*Stellaria humifusa*	10.0	0.4	4.2	0.02	n/a	n/a	n/a
Canopy Cover, Native		*1,740.0*	*72.5*		*4.17*	75.2	58.9	91.6
Non-Native or Invasive (NNI)								
(None)								
Canopy Cover, NNI		*0.0*	*0.0*		*0.00*			
TOTAL		**1,740**	**72.5**		**4.17**	**75.2**	**58.9**	**91.6**
Proportion of non-native or invasive plants (%):			**0.0%**			**0.0%**		

Actual Total Canopy: Obtained by summing the percent cover of all quadrats on the transect.

Average Quadrat Canopy Cover: Obtained by dividing the total canopy by the total number of quadrats sampled on the transect.

Frequency: Obtained by dividing the number of occurrences of a plant species (the number of quadrats in which a plant species was observed) by the total number of quadrats sampled along the transect.

Species Composition: Obtained by dividing the percent canopy cover of each plant species by the total canopy cover of all plant species.

Table B-2. Squally Beach Marsh Transect 1-1: Change in percent cover 2002 to 2008

Common Name	Scientific Name [a]	Percent of Quadrats with Decreased Cover	Percent of Quadrats with No Change	Percent of Quadrats with Increased Cover	Statistical Result [b]
Native					
orache, fat-hen saltbush	*Atriplex patula*	43%	43%	13%	
seashore saltgrass	*Distichlis spicata*	9%	43%	48%	+
entire-leaved gumweed	*Grindelia integrifolia*	0%	48%	52%	+
seaside plantain	*Plantago maritima*	4%	61%	35%	+
pickleweed	*Salicornia virginica*	0%	17%	83%	+
Native Total		9%	13%	78%	+
Non-Native or Invasive Total		9%	91%	0%	No Test [c]
Total (All Species)		9%	13%	78%	+

a: Displayed species are species observed in both years - NNI and native totals include species observed in either year.

b: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05)

"-" indicates a significant decrease

If blank, there is no significant change

c: Species with less than three non-zero changes could not be statistically tested.

Table B-3. Marsh development at Squally Beach, Transect 1-2

Common Name	Scientific Name	Exact Method - Continuous				Unbiased Average Quadrat Canopy Cover (%)	90% Confidence Interval	
		Actual Total Canopy (%)	Average Quadrat Canopy Cover (%)	Frequency (%)	Species Composition (%)		Lower Bound	Upper Bound
Native								
orache, fat-hen saltbush	*Atriplex patula*	20.0	1.3	13.3	0.10	n/a	n/a	n/a
Lyngby's sedge	*Carex lyngbyei*	395.0	26.3	53.3	1.88	33.2	0.0	67.3
red-osier dogwood	*Cornus stolonifera*	0.0	0.0	6.7	0.00	n/a	n/a	n/a
seashore saltgrass	*Distichlis spicata*	190.0	12.7	66.7	0.90	12.8	5.1	20.5
entire-leaved gumweed	*Grindelia integrifolia*	16.0	1.1	20.0	0.08	1.5	0.0	4.1
fleshy jaumea	*Jaumea carnosa*	335.0	22.3	60.0	1.60	25.4	2.4	48.4
seaside plantain	*Plantago maritima*	40.0	2.7	20.0	0.19	2.7	0.1	5.4
Hooker's willow	*Salix hookeriana*	24.0	1.6	13.3	0.11	n/a	n/a	n/a
pickleweed	*Salicornia virginica*	115.0	7.7	33.3	0.55	7.5	0.0	15.2
seacoast bulrush	*Scirpus maritimus*	200.0	13.3	13.3	0.95	n/a	n/a	n/a
Canopy Cover, Native		*1,335.00*	*89.0*		*6.36*	96.4	69.3	123.5
Non-Native or Invasive (NNI)								
Himalayan blackberry	*Rubus discolor*	10.0	0.7	6.7	0.05	n/a	n/a	n/a
unclassified-composite	*unclassified-composite*	25.0	1.7	20.0	0.12	1.7	0.0	3.4
unclassified-grass	*unclassified-grass*	30.0	2.0	6.7	0.14	n/a	n/a	n/a
Canopy Cover, NNI		*65*	*4*		*0.31*	4.8	0.0	9.9
TOTAL		**1,400**	**93.3**		**6.67**	**101.6**	**72.7**	**130.4**
Proportion of non-native or invasive plants (%):			**4.6%**			**4.7%**		

Actual Total Canopy: Obtained by summing the percent cover of all quadrats on the transect.

Average Quadrat Canopy Cover: Obtained by dividing the total canopy by the total number of quadrats sampled on the transect.

Frequency: Obtained by dividing the number of occurrences of a plant species (the number of quadrats in which a plant species was observed) by the total number of quadrats sampled along the transect.

Species Composition: Obtained by dividing the percent canopy cover of each plant species by the total canopy cover of all plant species.

Table B-4. Squally Beach Marsh Transect 1-2: Change in percent cover, 2002 to 2008

Common Name	Scientific Name [a]	Percent of Quadrats with Decreased Cover	Percent of Quadrats with No Change	Percent of Quadrats with Increased Cover	Statistical Result [b]
Native					
orache, fat-hen saltbush	*Atriplex patula*	80%	13%	7%	-
Lyngby's sedge	*Carex lyngbyei*	7%	40%	53%	+
seashore saltgrass	*Distichlis spicata*	0%	40%	60%	+
fleshy jaumea	*Jaumea carnosa*	7%	33%	60%	+
pickleweed	*Salicornia virginica*	7%	60%	33%	
American bulrush	*Scirpus americanus*	20%	67%	13%	
Hooker's willow	*Salix hookeriana* [c]	20%	73%	7%	
Native Total		13%	0%	87%	+
Non-Native or Invasive Total		40%	40%	20%	
Total (All Species)		13%	7%	80%	+

a: Displayed species are species observed in both years - NNI and native totals include species observed in either year.

b: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05)

"-" indicates a significant decrease

If blank, there is no significant change

c: Species with less than three non-zero changes could not be statistically tested.

Table B-5. Marsh development at Squally Beach, Transect 1-3

Common Name	Scientific Name	Exact Method - Continuous				Unbiased Average Quadrat Canopy Cover (%)	90% Confidence Interval	
		Actual Total Canopy (%)	Average Quadrat Canopy Cover (%)	Frequency (%)	Species Composition (%)		Lower Bound	Upper Bound
Native								
orache, fat-hen saltbush	*Atriplex patula*	20.0	1.3	12.5	0.09	n/a	n/a	n/a
seashore saltgrass	*Distichlis spicata*	335.0	20.9	68.8	1.50	22.7	10.6	34.8
entire-leaved gumweed	*Grindelia integrifolia*	15.0	0.9	18.8	0.07	0.9	0.1	1.7
fleshy jaumea	*Jaumea carnosa*	185.0	11.6	56.3	0.83	12.1	5.8	18.3
seaside plantain	*Plantago maritima*	5.0	0.3	6.3	0.02	n/a	n/a	n/a
pickleweed	*Salicornia virginica*	265.0	16.6	43.8	1.18	16.9	6.9	26.8
seacoast bulrush	*Scirpus maritimus*	10.0	0.6	6.3	0.04	n/a	n/a	n/a
saltmarsh chickweed	*Stellaria humifusa*	10.0	0.6	6.3	0.04	n/a	n/a	n/a
Canopy Cover, Native		*845*	*52.8*		*3.77*	58.2	28.9	87.4
Non-Native or Invasive (NNI)								
(None)								
Canopy Cover, NNI		*0*	*0.0*		*0.00*			
TOTAL		**845**	**52.8**		**3.77**	**58.2**	**28.9**	**87.4**
Proportion of non-native or invasive plants (%):			**0.0%**			**0.0%**		

Actual Total Canopy: Obtained by summing the percent cover of all quadrats on the transect.

Average Quadrat Canopy Cover: Obtained by dividing the total canopy by the total number of quadrats sampled on the transect.

Frequency: Obtained by dividing the number of occurrences of a plant species (the number of quadrats in which a plant species was observed) by the total number of quadrats sampled along the transect.

Species Composition: Obtained by dividing the percent canopy cover of each plant species by the total canopy cover of all plant species.

Table B-6. Marsh development at Mowitch, Transect 1-1

Common Name	Scientific Name	Exact Method - Continuous				Unbiased Average Quadrat Canopy Cover (%)	90% Confidence Interval	
		Actual Total Canopy (%)	Average Quadrat Canopy	Frequency (%)	Species Composition (%)		Lower Bound	Upper Bound
Native								
Pacific silverweed	*Potentilla pacifica*	5.0	0.1	2.2	0.00	n/a	n/a	n/a
Douglas aster	*Aster subspicatus*	5.0	0.1	2.2	0.00	n/a	n/a	n/a
orache, fat-hen saltbush	*Atriplex patula*	35.0	0.8	4.3	0.02	n/a	n/a	n/a
Lyngby's sedge	*Carex lyngbyei*	210.0	4.6	26.1	0.14	4.7	1.8	7.6
tufted hairgrass	*Deschampsia cespitosa*	111.0	2.4	15.2	0.07	3.3	0.0	6.8
seashore saltgrass	*Distichlis spicata*	448.0	9.7	52.2	0.29	11.6	5.3	18.0
spike-rush	*Eleocharis sp.*	327.0	7.1	39.1	0.21	8.9	3.2	14.7
fleshy jaumea	*Jaumea carnosa*	562.5	12.2	45.7	0.36	13.2	6.7	19.7
seaside plantain	*Plantago maritima*	585.0	12.7	50.0	0.38	13.3	8.9	17.7
pickleweed	*Salicornia virginica*	603.5	13.1	69.6	0.39	14.6	9.7	19.5
Canadian sandspurry	*Spergularia canadensis*	101.0	2.2	21.7	0.07	2.4	0.7	4.2
seaside arrowgrass	*Triglochin maritimum*	159.0	3.5	0.2	0.10	3.5	1.6	5.4
Canopy Cover, Native		*3,142.0*	*68.3*		*2.02*	81.2	*59.8*	*102.6*
Non-Native or Invasive (NNI)								
brass buttons	*Cotula coronopifolia*	197.0	4.3	141.3	0.13	5.0	2.0	8.0
unclassified-grass	*unclassified-grass*	35.0	0.8	106.5	0.02	0.8	0.0	1.8
Canopy Cover, NNI		*232.0*	*5.0*		*0.15*	5.8	*2.8*	*8.7*
TOTAL		**3,374**	**73.3**		**2.17**	**77.5**	**64.5**	**90.5**
Proportion of non-native or invasive plants (%):			**6.9%**			**6.6%**		

Actual Total Canopy: Obtained by summing the percent cover of all quadrats on the transect.

Average Quadrat Canopy Cover: Obtained by dividing the total canopy by the total number of quadrats sampled on the transect.

Frequency: Obtained by dividing the number of occurrences of a plant species (the number of quadrats in which a plant species was observed) by the total number of quadrats sampled along the transect.

Species Composition: Obtained by dividing the percent canopy cover of each plant species by the total canopy cover of all plant species.

Table B-7. Mowitch marsh Transect 1-1: Change in percent cover, 2002 to 2008

Common Name	Scientific Name [a]	Percent of Quadrats with Decreased Cover	Percent of Quadrats with No Change	Percent of Quadrats with Increased Cover	Statistical Result [b]
Native					
orache, fat-hen saltbush	*Atriplex patula*	43%	54%	2%	-
Lyngby's sedge	*Carex lyngbyei*	2%	72%	26%	+
tufted hairgrass	*Deschampsia cespitosa*	0%	85%	15%	+
seashore saltgrass	*Distichlis spicata*	0%	48%	52%	+
spike-rush	*Eleocharis sp.*	2%	59%	39%	+
seaside plantain	*Plantago maritima*	0%	50%	50%	+
pickleweed	*Salicornia virginica*	0%	30%	70%	+
seaside arrowgrass	*Triglochin maritimum*	4%	78%	17%	
fleshy jaumea	*Jaumea carnosa* [c]	9%	54%	37%	+
Native Total		2%	0%	98%	+
Non-Native or Invasive (NNI)					
brass buttons	*Cotula coronopifolia*	17%	48%	35%	
NNI Total		26%	33%	41%	
Total (All Species)		2%	0%	98%	+

a: Displayed species are species observed in both years - NNI and native totals include species observed in either year.

b: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05)

"-" indicates a significant decrease

If blank, there is no significant change

c: This comparison is between 2004 and 2008; species was not observed in 2002.

Table B-8. Marsh development at Mowitch, Transect 1-2

Common Name	Scientific Name	Exact Method - Continuous				Unbiased Average Quadrat Canopy Cover (%)	90% Confidence Interval	
		Actual Total Canopy (%)	Average Quadrat Canopy Cover (%)	Frequency (%)	Species Composition (%)		Lower Bound	Upper Bound
Native								
orache, fat-hen saltbush	*Atriplex patula*	10.0	0.4	8.7	0.03	n/a	n/a	n/a
Lyngby's sedge	*Carex lyngbyei*	5.0	0.2	4.3	0.02	n/a	n/a	n/a
seashore saltgrass	*Distichlis spicata*	25.0	1.1	17.4	0.08	1.1	0.2	2.0
spike-rush	*Eleocharis sp.*	515.0	22.4	73.9	1.61	23.3	15.0	31.7
fleshy jaumea	*Jaumea carnosa*	50.0	2.2	13.0	0.16	2.2	0.0	4.4
seaside plantain	*Plantago maritima*	120.0	5.2	30.4	0.37	5.5	1.7	9.3
pickleweed	*Salicornia virginica*	225.0	9.8	52.2	0.70	9.9	3.9	15.9
Canadian sandspurry	*Spergularia canadensis*	165.0	7.2	47.8	0.51	7.1	4.0	10.3
seaside arrowgrass	*Triglochin maritimum*	60.0	2.6	21.7	0.19	2.7	0.6	4.8
Canopy Cover, Native		*1,175*	*51.1*		*3.66*	52.9	39.3	*66.4*
Non-Native or Invasive (NNI)								
brass buttons	*Cotula coronopifolia*	220.0	9.6	69.6	0.69	9.7	6.4	13.1
unclassified-sedge	*unclassified-sedge*	10.0	0.4	8.7	0.03	n/a	n/a	n/a
Canopy Cover, NNI		*220*	9.6		*0.69*	10.2	6.7	*13.8*
TOTAL		**1,395**	**60.7**		**4.35**	**63.0**	**50.5**	**75.6**
Proportion of non-native or invasive plants (%):			**15.8%**			**16.2%**		

Actual Total Canopy: Obtained by summing the percent cover of all quadrats on the transect.

Average Quadrat Canopy Cover: Obtained by dividing the total canopy by the total number of quadrats sampled on the transect.

Frequency: Obtained by dividing the number of occurrences of a plant species (the number of quadrats in which a plant species was observed) by the total number of quadrats sampled along the transect.

Species Composition: Obtained by dividing the percent canopy cover of each plant species by the total canopy cover of all plant species.

Table B-9. Mowitch Marsh Transect 1-2: Change in percent cover, 2003 to 2008

Common Name	Scientific Name [a]	Percent of Quadrats with Decreased Cover	Percent of Quadrats with No Change	Percent of Quadrats with Increased Cover	Statistical Result [b]
Native					
orache, fat-hen saltbush	*Atriplex patula*	17%	78%	4%	
seashore saltgrass	*Distichlis spicata*	4%	83%	13%	
spike-rush	*Eleocharis sp.*	22%	22%	57%	
seaside plantain	*Plantago maritima*	9%	61%	30%	
pickleweed	*Salicornia virginica*	0%	48%	52%	+
seaside arrow-grass	*Triglochin maritimum*	13%	65%	22%	
Native Total		9%	0%	91%	+
Non-Native or Invasie (NNI)					
brass buttons	*Cotula coronopifolia*	26%	9%	65%	+
NNI Total		48%	9%	43%	
Total (All Species)		17%	4%	78%	+

a: Displayed species are species observed in both years - NNI and native totals include species observed in either year.

b: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05)

"-" indicates a significant decrease

If blank, there is no significant change

Table B-10. Marsh development at Hylebos Creek Off-Channel (Jordan), Transect 1-1

Common Name	Scientific Name	Exact Method - Continuous				Unbiased Average Quadrat Canopy Cover (%)	90% Confidence Interval	
		Actual Total Canopy (%)	Average Quadrat Canopy Cover (%)	Frequency (%)	Species Composition (%)		Lower Bound	Upper Bound
Native								
Pacific silverweed	*Potentilla pacifica*	10.0	0.3	6.9	0.03	n/a	n/a	n/a
Douglas aster	*Aster subspicatus*	5.0	0.2	3.4	0.01	n/a	n/a	n/a
orache, fat-hen saltbush	*Atriplex patula*	5.0	0.2	3.4	0.01	n/a	n/a	n/a
Lyngby's sedge	*Carex lyngbyei*	155.0	5.3	24.1	0.40	5.4	2.2	8.7
slough sedge	*Carex obnupta*	35.0	1.2	6.9	0.09	n/a	n/a	n/a
sedge	*Carex sp.*	45.0	1.6	10.3	0.12	1.8	0.0	4.1
ovate spike-rush	*Eleocharis ovata*	15.0	0.5	6.9	0.04	n/a	n/a	n/a
creeping spike-rush	*Eleocharis palustris*	85.0	2.9	17.2	0.22	3.0	0.7	5.3
willowherb	*Epilobium sp.*	31.0	1.1	17.2	0.08	1.3	0.0	2.7
common rush	*Juncus effusus*	365.0	12.6	48.3	0.95	13.2	6.6	19.7
rush	*Juncus sp.*	15.0	0.5	6.9	0.04	n/a	n/a	n/a
water parsely	*Oenanthe sarmentosa*	10.0	0.3	3.4	0.03	n/a	n/a	n/a
Pacific willow	*Salix lasiandra*	15.0	0.5	6.9	0.04	n/a	n/a	n/a
bulrush	*Scirpus sp.*	55.0	1.9	6.9	0.14	n/a	n/a	n/a
softstem bullrush	*Scirpus tabernaemontani*	170.0	5.9	24.1	0.44	6.0	1.2	10.8
soft-stemmed bulrush	*Scirpus validus*	10.0	0.3	3.4	0.03	n/a	n/a	n/a
broadleaf cattail	*Typha latifolia*	10.0	0.3	3.4	0.03	n/a	n/a	n/a
Canopy Cover, Native		*1,036.0*	*35.7*		*2.68*	*37.8*	*27.6*	*48.0*
Non-Native or Invasive (NNI)								
duckweed	*Lemna sp.*	5.0	0.2	158.6	0.01	n/a	n/a	n/a
white sweet-clover	*Melilotus alba*	20.0	0.7	155.2	0.05	n/a	n/a	n/a
reed canarygrass	*Phalaris arundinacea*	235.0	8.1	151.7	0.61	8.1	2.6	13.7
buttercup	*Ranunculus sp.*	10.0	0.3	117.2	0.03	n/a	n/a	n/a
Himalayan blackberry	*Rubus discolor*	1.0	0.0	113.8	0.00	n/a	n/a	n/a
unclassified-composite	*unclassified-composite*	5.0	0.2	110.3	0.01	n/a	n/a	n/a
unclassified-grass	*unclassified-grass*	4.0	0.1	106.9	0.01	n/a	n/a	n/a
unclassified-herb	*unclassified-herb*	15.0	0.5	103.4	0.04	n/a	n/a	n/a
Canopy Cover, NNI		*295.0*	*10.2*		*0.76*	*10.2*	*4.3*	*16.1*
TOTAL		**1,331**	**45.9**		**3.45**	**47.9**	**36.9**	**58.9**
Proportion of non-native or invasive plants (%):			**22.2%**			**21.2%**		

Actual Total Canopy: Obtained by summing the percent cover of all quadrats on the transect.

Average Quadrat Canopy Cover: Obtained by dividing the total canopy by the total number of quadrats sampled on the transect.

Frequency: Obtained by dividing the number of occurrences of a plant species (the number of quadrats in which a plant species was observed) by the total number of

Species Composition: Obtained by dividing the percent canopy cover of each plant species by the total canopy cover of all plant species.

Table B-11. Marsh development at Hylebos Creek Off-Channel (Jordan), Transect 1-2

Common Name	Scientific Name	Exact Method - Continuous				Unbiased Average Quadrat Canopy Cover (%)	90% Confidence Interval	
		Actual Total Canopy (%)	Average Quadrat Canopy Cover (%)	Frequency (%)	Species Composition (%)		Lower Bound	Upper Bound
Native								
Douglas aster	*Aster subspicatus*	20.0	0.8	12.0	0.05	0.8	0.0	1.6
Lyngby's sedge	*Carex lyngbyei*	20.0	0.8	4.0	0.05	n/a	n/a	n/a
slough sedge	*Carex obnupta*	190.0	7.6	36.0	0.49	8.1	3.1	13.1
sedge	*Carex sp.*	30.0	1.2	8.0	0.08	n/a	n/a	n/a
willowherb	*Epilobium sp.*	40.0	1.6	28.0	0.10	1.6	0.7	2.5
common horsetail	*Equisetum arvense*	10.0	0.4	4.0	0.03	n/a	n/a	n/a
Oregon ash	*Fraxinus latifolia*	5.0	0.2	4.0	0.01	n/a	n/a	n/a
common rush	*Juncus effusus*	425.0	17.0	60.0	1.09	17.0	9.2	24.7
twinberry honeysuckle	*Lonicera involucrata*	5.0	0.2	4.0	0.01	n/a	n/a	n/a
salmonberry	*Rubus spectabilis*	10.0	0.4	4.0	0.03	n/a	n/a	n/a
Pacific willow	*Salix lasiandra*	40.0	1.6	12.0	0.10	1.6	0.0	3.3
softstem bullrush	*Scirpus tabernaemontani*	15.0	0.6	8.0	0.04	n/a	n/a	n/a
common snowberry	*Symphoricarpos albus*	10.0	0.4	4.0	0.03	n/a	n/a	n/a
Canopy Cover, Native		*820*	*32.8*		*2.10*	*34.5*	*23.3*	*45.6*
Non-Native or Invasive (NNI)								
field bindweed	*Convolvulus arvensis*	20.0	0.8	12.0	0.05	0.8	0.0	1.6
yellow iris	*Iris pseudacorus*	20.0	0.8	4.0	0.05	n/a	n/a	n/a
yellow sweetclover	*Melilotus officinalis*	190.0	7.6	36.0	0.49	n/a	n/a	n/a
reed canarygrass	*Phalaris arundinacea*	30.0	1.2	8.0	0.08	11.2	6.3	16.1
buttercup	*Ranunculus sp.*	40.0	1.6	28.0	0.10	n/a	n/a	n/a
Himalayan blackberry	*Rubus discolor*	10.0	0.4	4.0	0.03	n/a	n/a	n/a
unclassified-composite	*unclassified-composite*	5.0	0.2	4.0	0.01	n/a	n/a	n/a
unclassified-grass	*unclassified-grass*	425.0	17.0	60.0	1.09	7.4	1.4	13.4
Canopy Cover, NNI		*740*	*29.6*		*1.90*	*21.7*	*13.6*	*29.7*
TOTAL		**1,560**	**62.4**		**4.00**	**53.9**	**45.3**	**62.5**
Proportion of non-native or invasive plants (%):			**47.4%**			**38.6%**		

Actual Total Canopy: Obtained by summing the percent cover of all quadrats on the transect.

Average Quadrat Canopy Cover: Obtained by dividing the total canopy by the total number of quadrats sampled on the transect.

Frequency: Obtained by dividing the number of occurrences of a plant species (the number of quadrats in which a plant species was observed) by the total number of quadrats sampled along the transect.

Species Composition: Obtained by dividing the percent canopy cover of each plant species by the total canopy cover of all plant species.

Table B-12. Marsh development at Middle Waterway (Simpson/Trustees), Transect 1-1

Common Name	Scientific Name	Exact Method - Continuous				Unbiased Average Quadrat Canopy Cover (%)	90% Confidence Interval	
		Actual Total Canopy (%)	Average Quadrat Canopy Cover (%)	Frequency (%)	Species Composition (%)		Lower Bound	Upper Bound
Native								
orache, fat-hen saltbush	*Atriplex patula*	40.0	1.5	26.9	0.10	1.6	0.4	2.7
seashore saltgrass	*Distichlis spicata*	530.0	20.4	46.2	1.26	23.5	6.8	40.2
seaside plantain	*Plantago maritima*	30.0	1.2	7.7	0.07	n/a	n/a	n/a
pickleweed	*Salicornia virginica*	950.0	36.5	84.6	2.26	38.3	25.1	51.5
American bulrush	*Scirpus americanus*	5.0	0.2	3.8	0.01	n/a	n/a	n/a
Canadian sandspurry	*Spergularia canadensis*	45.0	1.7	15.4	0.11	1.9	0.0	3.8
Canopy Cover, Native		*1600.0*	*61.5*		*3.81*	*67.9*	*45.4*	*90.4*
Non-Native or Invasive (NNI)								
unclassified-grass	unclassified-grass	15.0	7.5	7.7	0.46	n/a	n/a	n/a
Canopy Cover, NNI		*15.0*	*7.5*		*0.46*			
TOTAL		**1615**	**69.0**		**4.27**	**68.7**	**45.9**	**91.5**
Proportion of non-native or invasive plants (%):			**10.9%**			**0.0%**		

Actual Total Canopy: Obtained by summing the percent cover of all quadrats on the transect.

Average Quadrat Canopy Cover: Obtained by dividing the total canopy by the total number of quadrats sampled on the transect.

Frequency: Obtained by dividing the number of occurrences of a plant species (the number of quadrats in which a plant species was observed) by the total number of quadrats sampled along the transect.

Species Composition: Obtained by dividing the percent canopy cover of each plant species by the total canopy cover of all plant species.

Table B-13. Middle Waterway (Simpson/Trustees) Marsh Transect 1-1: Change in percent cover, 2002 to 2008

Common Name	Scientific Name [a]	Percent of Quadrats with Decreased Cover	Percent of Quadrats with No Change	Percent of Quadrats with Increased Cover	Statistical Result [b]
Native					
orache, fat-hen saltbush	*Atriplex patula*	30%	52%	17%	
seashore saltgrass	*Distichlis spicata*	4%	57%	39%	+
pickleweed	*Salicornia virginica*	0%	13%	87%	+
American bulrush	*Scirpus americanus*	4%	91%	4%	No Test [c]
Canadian sandspurry	*Spergularia canadensis*	35%	57%	9%	
seaside plantian	*Plantago maritima* [d]	9%	87%	4%	
Native Total		9%	4%	87%	+
Total (All Species)		9%	4%	87%	+

a: Displayed species are species observed in both years - NNI and native totals include species in either year.

b: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05)

"-" indicates a significant decrease; other species are not significantly changed

If blank, there is no significant change

c: Species with less than three non-zero changes could not be statistically tested.

d: This comparison is between 2004 and 2006; species was not observed in 2002.

Table B-14. Marsh development at Middle Waterway (Simpson/Trustees), Transect 1-2

Common Name	Scientific Name	Exact Method - Continuous				Unbiased Average Quadrat Canopy Cover (%)	90% Confidence Interval	
		Actual Total Canopy (%)	Average Quadrat Canopy Cover (%)	Frequency (%)	Species Composition (%)		Lower Bound	Upper Bound
Native								
seashore saltgrass	*Distichlis spicata*	1.0	0.1	14.3	0.09	n/a	n/a	n/a
seaside plantain	*Plantago maritima*	10.0	1.4	14.3	0.95	n/a	n/a	n/a
pickleweed	*Salicornia virginica*	105.0	15.0	57.1	9.93	18.7	0.0	47.0
Canadian sandspurry	*Spergularia canadensis*	35.0	5.0	42.9	3.31	5.4	0.0	12.1
Canopy Cover, Native		*151*	*21.6*		*14.29*	23.8	0.0	50.1
Non-Native or Invasive (NNI)								
Canopy Cover, NNI		*0*	*0.0*		*0.00*			
TOTAL		**151**	**21.6**		**14.29**	**23.8**	**0.0**	**50.1**
Proportion of non-native or invasive plants (%):			**0.0%**			**0.0%**		

Actual Total Canopy: Obtained by summing the percent cover of all quadrats on the transect.

Average Quadrat Canopy Cover: Obtained by dividing the total canopy by the total number of quadrats sampled on the transect.

Frequency: Obtained by dividing the number of occurrences of a plant species (the number of quadrats in which a plant species was observed) by the total number of

Species Composition: Obtained by dividing the percent canopy cover of each plant species by the total canopy cover of all plant species.

Table B-15. Middle Waterway (Simpson/Trustees) marsh Transect 1-2: Change in percent cover, 2002 to 2008

Common Name	Scientific Name [a]	Percent of Quadrats with Decreased Cover	Percent of Quadrats with No Change	Percent of Quadrats with Increased Cover	Statistical Result [b]
Native					
pickleweed	*Salicornia virginica*	0%	57%	43%	
Canadian sandspurry	*Spergularia canadensis*	14%	57%	29%	
Native Total		14%	43%	43%	
Total (All Species)		14%	43%	43%	

a: Displayed species are species observed in both years - NNI and native totals include species in either year.

b: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05)

"-" indicates a significant decrease; other species are not significantly changed

If blank, there is no significant change

Table B-16. Riparian development at Squally Beach, Year 7 (2008)

Cover Class	Common Name	Scientific Name	Standard Estimate	Bootstrap Estimate		
			Stratified Mean	Stratified Mean	Lower 95% CI	Upper 95% CI
Native						
Graminoid	common rush	*Juncus effusus*	2.5%	2.4%	0%	5.1%
Herb	common horsetail	*Equisetum arvense*	0.78%	0.8%	0%	1.6%
Shrub	vine maple	*Acer circinatum*	0.027%	0.028%	0%	0.054%
	red-osier dogwood	*Cornus stolonifera*	4.4%	4.4%	2.0%	7.7%
	beaked hazelnut	*Corylus cornuta*	0.63%	0.64%	0.012%	1.8%
	oceanspray	*Holodiscus discolor*	2.8%	2.7%	0.23%	5.6%
	twinberry honeysuckle	*Lonicera involucrata*	1.0%	1.0%	0%	2.0%
	dull Oregon-grape	*Mahonia nervosa*	0.17%	0.17%	0%	0.35%
	Oregon crabapple	*Malus fusca*	0.090%	0.091%	0%	0.18%
	Indian plum	*Oemleria cerasiformis*	0.55%	0.54%	0%	1.1%
	Pacific ninebark	*Physocarpus capitatus*	0.63%	0.63%	0%	1.3%
	prickly currant	*Ribes lacustre*	0.32%	0.32%	0%	0.63%
	red-flowering currant	*Ribes sanguineum*	0.71%	0.68%	0%	1.4%
	nootka rose	*Rosa nutkana*	24%	24%	15%	36%
	trailing blackberry	*Rubus ursinus*	1.3%	1.4%	0%	2.7%
	rose spirea	*Spiraea douglasii*	0.72%	0.71%	0%	2.2%
	common snowberry	*Symphoricarpos albus*	7.7%	7.7%	2.4%	14%
	Total Native Shrubs		45%	45%	28%	59%
Trees	red alder	*Alnus rubra*	56%	55%	39%	73%
	Sitka spruce	*Picea sitchensis*	0.10%	0.10%	0%	0.30%
	Douglas fir	*Pseudotsuga menziesii*	6.3%	6.4%	2.2%	11%
	cascara	*Rhamnus purshiana*	0.26%	0.26%	0%	0.61%
	Hooker's willow	*Salix hookeriana*	27%	27%	13%	50%
	Total Native Trees		89%	89%	80%	101%
	Total Native		138%	137%	118%	156%
Non-native or Invasive (NNI)						
Graminoid	reed canarygrass	*Phalaris arundinacea*	5.4%	5.5%	0%	11%
Herb	pea vine	*Lathyrus sp.*	0.43%	0.43%	0.063%	1.5%
Shrub	Himalayan blackberry	*Rubus discolor*	23%	23%	11%	36%
Vine	field bindweed	*Convolvulus arvensis*	2.2%	2.2%	0.27%	6.1%
	Total NNI		31%	31%	18%	45%
	Total All Species		169%	168%	144%	187%

Table B-17. Change in riparian cover at the Squally Beach site, Year 5 (2006) to Year 7 (2008)

Cover Class	Common Name	Scientific Name [a]	Percent of Transects with Decreased Cover	Percent of Transects with No Change	Percent of Transects with Increased Cover	Statistical Result [b]
Native						
Shrubs	red-osier dogwood	*Cornus stolonifera*	8%	42%	50%	
	beaked hazelnut	*Corylus cornuta*	8%	67%	25%	
	oceanspray	*Holodiscus discolor*	8%	75%	17%	
	twinberry honeysuckle	*Lonicera involucrata*	0%	92%	8%	No Test [c]
	dull Oregon-grape	*Mahonia nervosa*	0%	92%	8%	No Test [c]
	Indian plum	*Oemleria cerasiformis*	0%	92%	8%	No Test [c]
	Pacific ninebark	*Physocarpus capitatus*	0%	92%	8%	No Test [c]
	red-flowering currant	*Ribes sanguineum*	8%	83%	8%	No Test [c]
	nootka rose	*Rosa nutkana*	8%	17%	75%	+
	common snowberry	*Symphoricarpos albus*	0%	42%	58%	+
	Total Native Shrubs		0%	8%	92%	+
Trees	red alder	*Alnus rubra*	17%	25%	58%	
	Douglas fir	*Pseudotsuga menziesii*	0%	42%	58%	+
	Hooker's willow	*Salix hookeriana*	50%	8%	42%	
	Total Native Trees		8%	0%	92%	+
	Total Native Species		0%	0%	100%	+
Non-Native Species (NNI)						
Graminoids	reed canarygrass	*Phalaris arundinacea*	17%	75%	8%	
Herbs	pea vine	*Lathyrus sp.*	25%	58%	17%	
Shrubs	Himalayan blackberry	*Rubus discolor*	42%	17%	42%	
	Total NNI Species		25%	17%	58%	

a: Displayed species are species observed in both years - NNI and native totals include species observed in either year.

b: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05)

"-" indicates a significant decrease

If blank, there is no significant change.

c: Species with less than three non-zero changes could not be statistically tested.

Table B-18. Riparian development at Mowitch, Year 7 (2008)

Cover Class	Common Name	Scientific Name	Standard Estimate	Bootstrap Estimate		
			Stratified Mean	Stratified Mean	Lower 95% CI	Upper 95% CI
Native						
Graminoid	common rush	*Juncus effusus*	3.0%	3.1%	1.0%	6.1%
Herb	lupine	*Lupinus sp.*	3.2%	3.2%	1.7%	5.3%
Shrub	vine maple	*Acer circinatum*	0.051%	0.051%	0%	0.10%
	red-osier dogwood	*Cornus stolonifera*	6.9%	6.9%	4.5%	11%
	beaked hazelnut	*Corylus cornuta*	0.78%	0.77%	0.35%	1.5%
	oceanspray	*Holodiscus discolor*	0.28%	0.28%	0.013%	0.61%
	twinberry honeysuckle	*Lonicera involucrata*	2.5%	2.5%	1.3%	3.7%
	Oregon crabapple	*Malus fusca*	0.68%	0.69%	0.13%	1.4%
	Pacific ninebark	*Physocarpus capitatus*	1.0%	1.0%	0.31%	2.4%
	red-flowering currant	*Ribes sanguineum*	2.1%	2.1%	0.51%	6.1%
	Nootka rose	*Rosa nutkana*	28%	28%	19%	38%
	rose spirea	*Spiraea douglasii*	0.43%	0.42%	0.076%	1.2%
	common snowberry	*Symphoricarpos albus*	5.0%	5.0%	3.1%	6.8%
	Total Native Shrubs		48%	48%	39%	61%
Tree	red alder	*Alnus rubra*	15%	15%	11%	21%
	Oregon ash	*Fraxinus latifolia*	2.5%	2.5%	1.6%	3.8%
	Sitka spruce	*Picea sitchensis*	0.45%	0.45%	0.14%	0.95%
	shore pine	*Pinus contorta*	2.9%	2.9%	1.6%	4.9%
	black cottonwood	*Populus balsamifera*	0.49%	0.48%	0.31%	0.83%
	bitter cherry	*Prunus emarginata*	0.12%	0.13%	0%	0.32%
	Douglas fir	*Pseudotsuga menziesii*	0.92%	0.91%	0.56%	1.3%
	Pacific willow	*Salix lasiandra*	0.38%	0.39%	0%	0.77%
	Scouler's willow	*Salix scouleriana*	3.8%	3.8%	1.8%	7.3%
	western red cedar	*Thuja plicata*	0.90%	0.90%	0.27%	1.5%
	Total Native Trees		28%	28%	22%	34%
	Total Native		82%	82%	70%	96%
Non-Native or Invasive (NNI)						
Graminoid	reed canarygrass	*Phalaris arundinacea*	1.9%	1.9%	0%	4.4%
Tree	black locust	*Robinia pseudoacacia*	0.0066%	0.0067%	0%	0.013%
	Total NNI		1.9%	1.9%	0.0066%	5.0%
	Total All Species		84%	84%	72%	99%

Table B-19. Change in riparian cover at the Mowitch site, Year 5 (2006) to Year 7 (2008)

Cover Class	Common Name	Scientific Name [a]	Percent of Transects with Decreased Cover	Percent of Transects with No Change	Percent of Transects with Increased Cover	Statistical Result [b]
Native						
Shrubs	red-osier dogwood	*Cornus stolonifera*	8%	50%	42%	+
	beaked hazelnut	*Corylus cornuta*	13%	67%	21%	
	twinberry honeysuckle	*Lonicera involucrata*	13%	54%	33%	
	Oregon crabapple	*Malus fusca*	0%	83%	17%	
	Pacific ninebark	*Physocarpus capitatus*	4%	75%	21%	
	red-flowering currant	*Ribes sanguineum*	4%	75%	21%	
	rose	*Rosa sp.*	8%	13%	79%	+
	rose spirea	*Spiraea douglasii*	4%	83%	13%	
	common snowberry	*Symphoricarpos albus*	4%	38%	58%	+
Total Native Shrubs			0%	0%	100%	+
Trees	red alder	*Alnus rubra*	17%	21%	63%	+
	Oregon ash	*Fraxinus latifolia*	13%	50%	38%	
	Sitka spruce	*Picea sitchensis*	4%	83%	13%	
	shore pine	*Pinus contorta*	0%	58%	42%	+
	black cottonwood	*Populus balsamifera*	4%	88%	8%	
	bitter cherry	*Prunus emarginata*	0%	92%	8%	No Test[c]
	Douglas fir	*Pseudotsuga menziesii*	8%	67%	25%	
	Pacific willow	*Salix lasiandra*	13%	88%	0%	
	Scouler's willow	*Salix scouleriana*	33%	33%	33%	
	western red cedar	*Thuja plicata*	0%	88%	13%	
Total Native Trees			25%	0%	75%	+
Total Native Species			0%	0%	100%	+
Non-Native or Invasive (NNI)						
Graminoid	reed canarygrass	*Phalaris arundinacea*	21%	71%	8%	
Trees	black locust	*Robinia pseudoacacia*	4%	96%	0%	No Test [c]
Total NNI			63%	29%	8%	-

a: Displayed species are species observed in both years - NNI and native totals include species observed in either year.

b: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05)

"-" indicates a significant decrease

If blank, there is no significant change

c: Species with less than three non-zero changes could not be statistically tested.

Table B-20. Year 7 (2008) Riparian development at Hylebos Creek Off-Channel (Jordan), Year 7 (2008)

Cover Class	Common Name	Scientific Name	Standard Estimate	Bootstrap Estimate		
			Stratified Mean	Stratified Mean	Lower 95% CI	Upper 95% CI
Native						
Graminoids	common rush	*Juncus effusus*	0.51%	0.50%	0.0%	1.5%
Herbs	lady fern	*Athyrium filix-femina*	0.021%	0.022%	0%	0.043%
	common horsetail	*Equisetum arvense*	2.9%	3.059%	0%	7.171%
	American skunkcabbage	*Lysichiton americanus*	0.26%	0.28%	0%	0.77%
	western swordfern	*Polystichum munitum*	0.090%	0.088%	0%	0.27%
Total Native Herbs			3.3%	3.3%	0.56%	7.6%
Shrubs	red-osier dogwood	*Cornus stolonifera*	6.8%	6.8%	5.7%	9.3%
	oceanspray	*Holodiscus discolor*	0.89%	0.91%	0%	1.4%
	twinberry honeysuckle	*Lonicera involucrata*	2.2%	2.3%	0.10%	3.9%
	Indian plum	*Oemleria cerasiformis*	3.5%	3.5%	0.33%	15%
	Pacific ninebark	*Physocarpus capitatus*	1.8%	1.8%	n/a	n/a
	Nootka rose	*Rosa nutkana*	0.61%	0.62%	0.25%	1.3%
	thimbleberry	*Rubus parviflorus*	0.10%	0.10%	0%	0.28%
	salmonberry	*Rubus spectabilis*	1.3%	1.3%	0%	2.2%
	red elderberry	*Sambucus racemosa*	0.39%	0.40%	0%	1.2%
	common snowberry	*Symphoricarpos albus*	1.9%	1.9%	1.4%	3.0%
Total Native Shrubs			20%	20%	14%	31%
Trees	grand fir	*Abies grandis*	0.36%	0.35%	0%	0.76%
	big leaf maple	*Acer macrophyllum*	4.6%	4.5%	0.18%	17%
	red alder	*Alnus rubra*	83%	83%	69%	91%
	black hawthorn	*Crataegus douglasii*	0.064%	0.065%	0%	0.19%
	Oregon ash	*Fraxinus latifolia*	1.1%	1.1%	1.0%	1.3%
	Sitka spruce	*Picea sitchensis*	1.4%	1.4%	0.38%	2.4%
	black cottonwood	*Populus balsamifera*	6.1%	6.2%	2.4%	16%
	Douglas fir	*Pseudotsuga menziesii*	1.4%	1.4%	0.44%	2.5%
	cascara	*Rhamnus purshiana*	0.24%	0.25%	0%	0.83%
	Hooker's willow	*Salix hookeriana*	1.9%	1.8%	0.45%	5.6%
	Pacific willow	*Salix lasiandra*	0.32%	0.32%	n/a	n/a
	Sitka willow	*Salix sitchensis*	0.86%	0.88%	0%	1.7%
	western red cedar	*Thuja plicata*	0.064%	0.062%	0%	0.17%
Total Native Trees			101%	101%	96%	105%
Total Native Species			125%	125%	117%	134%
Non-Native or Invasive (NNI)						
Graminoids	reed canarygrass	*Phalaris arundinacea*	18%	18%	11%	26%
Herbs	white sweet-clover	*Melilotus alba*	0.13%	0.12%	0%	0.38%
Shrubs	Himalayan blackberry	*Rubus discolor*	4.9%	4.8%	2.3%	8.0%
Vines	field bindweed	*Convolvulus arvensis*	5.1%	5.1%	2.5%	7.3%
Total NNI Species			28%	28%	18%	41%
Total All Species			153%	153%	139%	167%

Table B-21. Year 7 (2008) Riparian development at Middle Waterway (Simpson/Trustees), Year 7 (2008)

Cover Class	Common Name	Scientific Name	Standard Estimate	Bootstrap Estimate		
			Stratified Mean	Stratified Mean	Lower 95% CI	Upper 95% CI
Native						
Shrubs	vine maple	*Acer circinatum*	1.9%	1.9%	0%	4.2%
	Saskatoon serviceberry	*Amelanchier alnifolia*	0.45%	0.46%	0%	1.5%
	kinnikinnick	*Arctostaphylos uva-ursi*	4.0%	4.1%	0%	8.4%
	red-osier dogwood	*Cornus stolonifera*	0.12%	0.12%	0%	0.37%
	oceanspray	*Holodiscus discolor*	0.74%	0.74%	0%	2.1%
	Oregon crabapple	*Malus fusca*	1.2%	1.2%	0%	2.4%
	Indian plum	*Oemleria cerasiformis*	0.39%	0.41%	0%	0.77%
	red-flowering currant	*Ribes sanguineum*	0.72%	0.70%	0%	1.4%
	nootka rose	*Rosa nutkana*	12%	12%	6.3%	22.2%
	cluster rose	*Rosa pisocarpa*	4.7%	4.7%	0%	13.6%
	rose spirea	*Spiraea douglasii*	0.49%	0.48%	0%	1.5%
	common snowberry	*Symphoricarpos albus*	2.6%	2.6%	1.2%	5.1%
Total Native Shrubs			30%	30%	20%	41%
Trees	bigleaf maple	*Acer macrophyllum*	3.7%	3.6%	0%	9.4%
	madrone	*Arbutus menziesii*	2.7%	2.7%	1.4%	4.4%
	black hawthorn	*Crataegus douglasii*	0.29%	0.30%	0%	0.59%
	Sitka spruce	*Picea sitchensis*	0.70%	0.66%	0%	1.4%
	shore pine	*Pinus contorta*	5.6%	5.5%	3.1%	9.7%
	black cottonwood	*Populus balsamifera*	18%	18%	11%	27%
	bitter cherry	*Prunus emarginata*	1.9%	1.9%	0.76%	4.0%
	Douglas fir	*Pseudotsuga menziesii*	18%	18%	11%	28%
	Hooker's willow	*Salix hookeriana*	0.78%	0.76%	0%	2.6%
	Scouler's willow	*Salix scouleriana*	3.3%	3.3%	0.74%	8.0%
	Sitka willow	*Salix sitchensis*	1.6%	1.7%	0%	3.3%
	western red cedar	*Thuja plicata*	4.2%	4.2%	1.6%	10%
Total Native Trees			61%	61%	51%	72%
Total Native			91%	91%	81%	104%
Non-Native or Invasive (NNI)						
Shrubs	butterfly bush	*Buddleja davidii*	0.69%	0.70%	0.0%	1.4%
	Himalayan blackberry	*Rubus discolor*	2.3%	2.3%	0.0%	4.6%
	unclassified-shrub	*unclassified-shrub*	0.14%	0.14%	0.0%	0.3%
Total NNI Shrubs			3.1%	3.2%	0.2%	8.5%
Vines	English ivy	*Hedera helix*	1.0%	0.92%	0.0%	1.9%
Total NNI			4.1%	4.0%	0.3%	10.8%
Total All Species			95%	95%	85%	107%

Table B-22. Change in riparian cover at the Middle Waterway (Simpson/Trustees) site, Year 5 (2006) to Year 7 (2008)

Cover Class	Common Name	Scientific Name [a]	Percent of Transects with Decreased Cover	Percent of Transects with No Change	Percent of Transects with Increased Cover	Statistical Result [b]
Native						
Shrubs	vine maple	*Acer circinatum*	0%	85%	15%	
	Saskatoon serviceberry	*Amelanchier alnifolia*	10%	90%	0%	No Test [c]
	kinnikinnick	*Arctostaphylos uva-ursi*	10%	80%	10%	
	red-osier dogwood	*Cornus stolonifera*	0%	95%	5%	No Test [c]
	oceanspray	*Holodiscus discolor*	0%	90%	10%	No Test [c]
	Oregon crabapple	*Malus fusca*	0%	95%	5%	No Test [c]
	Indian plum	*Oemleria cerasiformis*	0%	95%	5%	No Test [c]
	red-flowering currant	*Ribes sanguineum*	0%	95%	5%	No Test [c]
	nootka rose	*Rosa nutkana*	5%	50%	45%	+
	cluster rose	*Rosa pisocarpa*	10%	80%	10%	
	common snowberry	*Symphoricarpos albus*	10%	55%	35%	
Total Native Shrubs			15%	10%	75%	+
Trees	bigleaf maple	*Acer macrophyllum*	0%	90%	10%	No Test [c]
	madrone	*Arbutus menziesii*	0%	70%	30%	+
	Sitka spruce	*Picea sitchensis*	5%	90%	5%	No Test [c]
	shore pine	*Pinus contorta*	10%	50%	40%	
	black cottonwood	*Populus balsamifera*	0%	45%	55%	+
	bitter cherry	*Prunus emarginata*	0%	75%	25%	
	Douglas fir	*Pseudotsuga menziesii*	0%	45%	55%	+
	Scouler's willow	*Salix scouleriana*	0%	85%	15%	
	Sitka willow	*Salix sitchensis*	5%	90%	5%	No Test [c]
	western red cedar	*Thuja plicata*	0%	75%	25%	
Total Native Trees			0%	0%	100%	+
Total Native Species			0%	0%	100%	+
Non Native or Invasive (NNI)						
Total NNI Herbs			35%	65%	0%	-
Shrubs	butterfly bush	*Buddleja davidii*	10%	85%	5%	
	Himalayan blackberry	*Rubus discolor*	75%	20%	5%	-
Total NNI Shrubs			80%	5%	15%	-
Vines	English ivy	*Hedera helix*	5%	90%	5%	No Test [c]
Total NNI Species			80%	5%	15%	-

a: Displayed species are species observed in both years - NNI and native totals include species observed in either year.

b: "+" indicates a significant increase (two-tailed sign test, alpha = 0.05)

"-" indicates a significant decrease; other species are not significantly changed

If blank, there is no significant change

c: Species with less than three non-zero changes could not be statistically tested.

Table B-23. Summary of bird species and numbers observed at the Hylebos Creek Off-Channel (Jordan) site, Year 7 (2008)

Migratory Pattern [a]	Common Name	Scientific Name	Total	Spring	Summer	Fall	Winter
N (PM)	American crow	*Corvus brachyrhynchos*	14	7	6	1	
PM	American goldfinch	*Carduelis tristis*	23	2	21		
N (PM)	American robin	*Turdus migratorius*	64	8	21	35	
PM	Anna's hummingbird	*Calypte anna*	1			1	
PM (N)	bald eagle	*Haliaeetus leucocephalus*	1	1			
N	band-tailed pigeon	*Patagioenas fasciata*	2			2	
C	barn swallow	*Hirundo rustica*	4	1	3		
N	belted kingfisher	*Ceryle alcyon*	6	1	2	3	
N (PM)	Bewick's wren	*Thryomanes bewickii*	2		1	1	
N	black-capped chickadee	*Poecile atricapilla*	19	4	13	2	
C	black-headed grosbeak	*Pheucticus melanocephalus*	4	1	2	1	
C	brown-headed cowbird	*Molothrus ater*	2		2		
N	bushtit	*Psaltriparus minimus*	21	3	5	13	
N (PM)	Canada goose	*Branta canadensis*	2	2			
PM	cedar waxwing	*Bombycilla cedrorum*	25	8	15	2	
N	chestnut-backed chickadee	*Poecile rufescens*	2	2			
C	common goldeneye	*Bucephala clangula*	3	1	2		
C	common yellowthroat	*Geothylpis trichas*	4	1	3		
N (PM)	Cooper's hawk	*Accipiter coopreii*	3		2	1	
N	downy woodpecker	*Picoides pubescens*	6	1	3	2	
N (PM)	European starling	*Sturnus vulgaris*	4	1	3		
N (I)	evening grosbeak	*Coccothraustes vespertinus*	2	2			
C	gadwall	*Anas strepera*	2		2		
C (PM)	glaucous-winged gull	*Larus glaucescens*	4	2	1	1	
PM	great blue heron	*Ardea herodias*	3	1	1	1	
C	hermit thrush	*Catharus guttatus*	2	1	1		
N (PM)	house finch	*Carpodacus mexicanus*	3	2	1		
PM (N)	mallard	*Anas platyrhynchos*	24	8	6	8	2
N	marsh wren	*Cistothorus palustris*	1	1			
PM	mourning dove	*Zenaida macroura*	10	2	8		
N	northern flicker	*Colaptes auratus*	15		6	7	2
C	northern rough-winged swallow	*Stelgidopteryx serripennis*	5	3	2		
PM	olive-sided flycatcher	*Contopus cooperi*	4		4		
?	peregrine falcon	*Falco peregrinus*	1	1			
I	pine siskin	*Carduelis pinus*	55			55	
C	purple martin	*Progne subis*	2		2		
N	red-breasted sapsucker	*Sphyrapicus ruber*	2	1	1		
N	red-shafted flicker	*Colaptes auratus cafer*	5	4	1		
N (PM)	red-tailed hawk	*Buteo jamaicensis*	5	2	2	1	
N (PM)	red-winged blackbird	*Agelaius phoeniceus*	3	1	2		
PM	ruby-crowned kinglet	*Regulus calendula*	1	1			
C	rufous hummingbird	*Selasphorus rufus*	3		3		
PM (C)	savannah sparrow	*Passerculus sandwichensis*	1		1		
C (N)	sharp-shinned hawk	*Accipiter striatus*	2		1	1	
N	song sparrow	*Melospiza melodia*	42	13	14	10	5
PM (N)	spotted towhee	*Pipilo maculatus*	12	3	4	5	
N	Steller's jay	*Cyanocitta stelleri*	7	1	3	3	
C	tree swallow	*Tachycineta bicolor*	5		5		
C	violet-green swallow	*Tachycineta thalassina*	32	21	11		
C	warbling vireo	*Vireo gilvus*	1		1		
C	western tanager	*Piranga ludoviciana*	2		2		
PM	willow flycatcher	*Empidonax traillii*	1		1		
C	Wilson's warbler	*Wilsonia pusilla*	1		1		
C	yellow-rumped warbler	*Dendroica coronata*	7	2	2	1	2
		Total Birds:	477				
		Species Richness:	54				

Notes:

N = non-migrator

PM = partial migrator (seasonal migration, destination varies)

I = irruptive (unpredictable migration depending on the food supply)

C = complete (consistent migration, seasonal)

a: Peterson, 1990; Tekiela, 2001

Table B-24. Summary of bird species and numbers observed at the Sha Dadx site, Year 7 (2008)

Migratory Pattern [a]	Common Name	Scientific Name	Total	Spring	Summer	Fall	Winter
N (PM)	American crow	*Corvus brachyrhynchos*	28	1	1	26	
PM	American goldfinch	*Carduelis tristis*	29	14	15		
N (PM)	American robin	*Turdus migratorius*	42	11	30	1	
N	barn owl	*Tyto alba*	1	1			
C	barn swallow	*Hirundo rustica*	7		7		
N (PM)	Bewick's wren	*Thryomanes bewickii*	7		5	2	
N	black-capped chickadee	*Poecile atricapilla*	31	6	19	6	
C	black-headed grosbeak	*Pheucticus melanocephalus*	5		5		
C	brown-headed cowbird	*Molothrus ater*	1		1		
C	bufflehead	*Bucephala albeola*	1				1
N	bushtit	*Psaltriparus minimus*	13		4	9	
N (PM)	Canada goose	*Branta canadensis*	41	24		17	
PM	cedar waxwing	*Bombycilla cedrorum*	22	4	18		
C	common yellowthroat	*Geothylpis trichas*	12	5	7		
N (PM)	Cooper's hawk	*Accipiter coopreii*	1		1		
N	downy woodpecker	*Picoides pubescens*	2			1	1
N (PM)	European starling	*Sturnus vulgaris*	74	4	25	33	12
C (PM)	glaucous-winged gull	*Larus glaucescens*	7	2	2	2	1
C	golden-crowned sparrow	*Zonotrichia atricapilla*	7				7
PM	great blue heron	*Ardea herodias*	5	3	2		
C	hooded merganser	*Lophodytes cucullatus*	2				2
N (PM)	house finch	*Carpodacus mexicanus*	25	3	3	19	
N	house sparrow	*Passer domesticus*	2		2		
PM (N)	mallard	*Anas platyrhynchos*	20	5	1	6	8
PM	mourning dove	*Zenaida macroura*	40	1	5	28	6
N	northern flicker	*Colaptes auratus*	3	1		2	
C	northern shoveler	*Anas clypeata*	3			1	2
PM	olive-sided flycatcher	*Contopus cooperi*	2		2		
PM (C)	Oregon junco	*Junco hyemalis*	6		1		5
C	osprey	*Pandion haliaetus*	1		1		
I	pine siskin	*Carduelis pinus*	56			6	50
N (PM)	red-tailed hawk	*Buteo jamaicensis*	11	1	3	7	
N (PM)	red-winged blackbird	*Agelaius phoeniceus*	2	1	1		
N	rock dove	*Columba livia*	12	12			
PM (C)	savannah sparrow	*Passerculus sandwichensis*	2	1	1		
N	song sparrow	*Melospiza melodia*	51	19	25	7	
PM (N)	spotted towhee	*Pipilo maculatus*	6	4	2		
N	Steller's jay	*Cyanocitta stelleri*	7	1	2	4	
C	tree swallow	*Tachycineta bicolor*	7	3	4		
C	violet-green swallow	*Tachycineta thalassina*	15	5	10		
N	western scrub jay	*Aphelocoma californica*	12	4	6		2
C	western tanager	*Piranga ludoviciana*	2		2		
C	white-crowned sparrow	*Zonotrichia leucophrys*	1	1			
PM	willow flycatcher	*Empidonax traillii*	7		6	1	
C	yellow-rumped warbler	*Dendroica coronata*	3	3			
		Total birds:	634				
		Species richness:	45				

Notes:

N = non-migrator

PM = partial migrator (seasonal migration, destination varies)

I = irruptive (unpredictable migration depending on the food supply)

C = complete (consistent migration, seasonal)

a: Peterson, 1990; Tekiela, 2001

APPENDIX C

Monitoring Results to Date and Comparison of Sites

LIST OF TABLES

Table C-1 Change in percent cover over time at Squally Beach transects C-5
Table C-2 Change in percent cover over time at Mowitch transects C-6
Table C-3 Change in percent cover over time at Middle Waterway (Simpson/Transects) transects.....C-7
Table C-4 Commencement Bay total catch for Year 7 (2008) monitoring by species C-8
Table C-5 Comparison of bird species and seasonal presence at the Hylebos Off-Channel (Jordan) site, Year 5 (2006) and Year 7 (2008) C-9
Table C-6 Comparison of bird species and seasonal presence at the Sha Dadx site, Year 5 (2006) and Year 7 (2008).....C-10

LIST OF FIGURES

Figure C-1 Percent cover of native plant species at Squally Beach Transect 1-1 from 2002 through 2008 .....C-11
Figure C-2 Percent cover of native plant species at Squally Beach Transect 1-2 from 2002 through 2008 .....C-11
Figure C-3 Percent cover of native plant species at Mowitch Site Transect 1-1 from 2002 through 2008 .....C-12
Figure C-4 Percent cover of native plant species at Mowitch Transect 1-2 from 2002 through 2008 .....C-12
Figure C-5 Percent cover of non-native plant species at Mowitch Transects 1-1 and 1-2 from 2002 through 2008 .....C-13
Figure C-6 Percent cover of native plant species at Middle Waterway Transect 1-1 from 2002 through 2008 .....C-14
Figure C-7 Percent cover of native plant species at Middle Waterway Transect 1-2 from 2002 through 2008 .....C-14
Figure C-8 Average length of Chinook salmon caught at all sites, Years 1-3 and 7 .....C-15
Figure C-9 Average length of coho salmon caught at all sites, Years 1-3 and 7 .....C-16
Figure C-10 Percent of Chinook that were wild, hatchery, or not checked, Years 1-3 and 7 .....C-17
Figure C-11 Percent of coho that were wild, hatchery, or not checked, Years 1-3 and 7.....C-18
Figure C-12 Average length of chum salmon caught at all sites, Years 1-3 and 7 .....C-19
Figure C-13 Average length of pink salmon caught at all sites, Years 1-3 and 7 .....C-20

C-1.0 BSC 2 Marsh Development/Species Composition

This section provides detailed results for BSC 2 for sites that were monitored in year 7 and provides temporal trends that were observed in the marsh zone at sites where this criterion was measured. This section accompanies the results presented in Section 4 of the main report. The information is described by site in the following sections.

Tables C-1, C-2, and C-3 summarize the results of the Spearman's rank tests, and Figures C-1 through C-7 compare the monitoring results over the time period. BSC 2 is being met at the Squally Beach site and only partially met at the Mowitch and Middle Waterway (Simpson/Trustees) sites.

C-1.1 Squally Beach

Table C-1 and Figures C-1 and C-2 display the results of the statistical comparison for the Squally Beach site.[9] Total percent cover for native species at Transect 1-1 did not change significantly between 2002 and 2008. Although not statistically significant, percent native plant cover at Transect 1-2 has shown some positive increase between 2002 and 2008. Percent cover of individual species, including seashore saltgrass, fleshy jaumea, and pickleweed, has increased by a statistically significant amount at both Transect 1-1 and Transect 1-2. At Transect 1-2, percent cover of Lyngby's sedge also increased by a statistically significant amount between 2002 and 2008. Percent canopy cover of fat-hen saltbush and American bulrush decreased at Transect 1-2 by a statistically significant amount between 2002 and 2008. Percent cover of NNI species did not change significantly at either transect over the time period.

[9] Only Squally Beach Transects 1-1 and 1-2 are discussed. Transect 1-3 was relocated between Year 5 and Year 7. The Year 7 results for Transect 1-3 will serve as baseline information for future comparisons.

C-1.2 Mowitch

Table C-2 and Figures C-3 through C-5 display the results of the statistical comparison for the Mowitch site. At Transect 1-1, percent cover of total native plant species and overall total species increased by a statistically significant amount between 2002 and 2008. Of the 10 native plant species documented at Transect 1-1, six species show a statistically significant increase in percent cover between 2002 and 2008. Fat-hen saltbush is the only native plant species at Transect 1-1 that decreased significantly in percent cover. Of the eight native plant species documented at Transect 1-2, only fleshy jaumea and pickleweed increased in percent cover by a significant amount between 2002 and 2008; these species also increased significantly at Transect 1-1. Percent cover of NNI species did not change significantly at either transect over the time period.

C-1.3 Middle Waterway (Simpson/Trustees)

Table C-3 and Figures C-6 and C-7 display the results of the statistical comparison for the Middle Waterway (Simpson/Trustees) site. Total native canopy cover increased significantly at Transect 1-1 but did not change significantly at Transect 1-2 between 2002 and 2008. Pickleweed is the only native plant species at either transect that increased in percent cover by a statistically significant amount between 2002 and 2008. Canadian sandspurry decreased by a statistically significant amount at both transects between 2002 and 2008. Percent cover of NNI species did not change significantly at either transect over the time period.

C-2.0 BSC 7 – Fish Access/Presence

This section provides detailed results for the fish monitoring conducted in Commencement Bay with an emphasis on comparing results between sites and summarizing information for the sites considered together. This section supplements the information provided in Section 4.3 of the main report.

Table C-4 summarizes the total catch over the seven sites that were monitored for fish presence. Figure C-8 shows the average length of Chinook salmon caught at all of the sites by month. There is a general upward trend on the graph for each year suggesting that this species may be

rearing in the estuary and using the area to forage. Figure C-9 shows the average length of coho salmon caught at all of the sites by month. In contrast with the Chinook results the pattern for the length of the coho is more complicated with a declining trend for several years and positive trend in the late/summer fall during year 7. Although Chinook had the broadest temporal distribution in Year 1, the data show fairly uniform temporal distribution of Chinook and coho during Years 2, 3, and 7 (Figures C-8 and C-9).

In all four years, the majority of Chinook observed at the sites were hatchery fish: 78 percent in Year 1, 65 percent in Year 2, 78 percent in Year 3, and 57 percent in Year 7 (Figure C-10).Coho identified as hatchery marked were 3 percent of the coho catch in Year 1, 41 percent in Year 2, 64 percent in Year 3, and 13 percent in Year 7 (Figure C-11). However, sampling procedures may account for the differences in percentage of hatchery-marked coho. During the Year 1 and Year 7 sampling, large numbers of coho (more than 1,000) were caught, most of them at the Yowkwala site, over a two- to three-day period in May. Approximately 40 of the fish were examined to determine species, length, and hatchery marks. The overall count was then estimated based on the representative sample. In making that estimate, no assumptions were made about hatchery marks. As a result, 96 percent of the coho catch in Year 1 and 80 percent of the coho catch in Year 7 were recorded as “not checked.” In Year 2, approximately 46 percent of the coho were recorded as “not checked” for marks. In Year 3, a concerted effort was made to check each Chinook and coho salmon for hatchery marks, with the result that only 9 percent of the Chinook and 5 percent of the coho catch were identified as “not checked.” Year 3 data may therefore provide a clearer picture of site use by hatchery and wild Chinook and coho salmon.

Of the coho and Chinook salmon checked for hatchery marks, the proportion of wild to hatchery fish varied over the four monitoring years, with the percentage of wild coho ranging from 1 percent (Year 1) to 31 percent (Year 3) and of wild Chinook ranging from 11 percent (Year 1) to 30 percent (Year 7) (Figures C-10 and C-11).

Chinook mean average fork lengths for all four monitoring years (Figure C-8) show evidence of multiple life history types migrating through, and possibly rearing within, the system. Coho mean average fork lengths for all four years were fairly similar over time (Figure C-9), indicating

a transitory and uniform population moving through the system. In Year 3, a number of adult or "jack" Chinook and coho salmon were caught at the Yowkwala site in late July through mid-October; as a result, increased lengths were seen for Chinook and coho in the latter part of the sampling season for Year 3. It is assumed that the adult salmon were accessing the site for foraging and/or staging purposes. During all four monitoring years, chum and pink salmon increased in size over time (Figures C-12 and C-13), indicating that both species may have been using the sites for rearing.

C-3.0 BSC 9 – Bird Use

This section provides a listing of the birds that were observed at the Hylebos Creek Off-Channel (Jordan) site and at the Sha Dadx site. Table C-5 shows the species richness at the Hylebos Creek Off-Channel (Jordan) site for Year 5 and Year 7, when 56 and 54 species were observed, respectively. Figure C-6 shows the species richness at the Sha Dax site in Year 7, when 56 and 45 species were observed, respectively.

Table C-1. Change in percent cover over time at Squally Beach transects

Common Name	Scientific Name	Mean Percent Cover				Spearman's Rank Correlation Coefficient Over Four Sampled Years	Statistical Result [a]
Squally Beach Transect 1-1		**2002**	**2004**	**2006**	**2008**		
Native Species							
orache, fat-hen saltbush	*Atriplex patula*	4.6	10.0	0.9	1.1	-0.60	
Lyngby's sedge	*Carex lyngbyei*	0.0	0.0	0.0	2.5	0.77	
seashore saltgrass	*Distichlis spicata*	2.9	7.5	18.3	11.0	0.80	+
entire-leaved gumweed	*Grindelia integrifolia*	0.0	2.1	8.4	9.1	1.00	+
fleshy jaumea	*Jaumea carnosa*	14	48	19	21	0.40	
seaside plantain	*Plantago maritima*	0.0	1.0	0.0	5.7	0.60	
pickleweed	*Salicornia virginica*	2.0	13.5	18.4	21.4	1.00	+
Total Canopy Cover, Native		19.1	78.3	71.5	75.2	0.40	
TOTAL (All Species)		19.0	78.3	71.5	75.2	0.40	
Squally Beach Transect 1-2		**2002**	**2004**	**2006**	**2008**		
Native Species							
orache, fat-hen saltbush	*Atriplex patula*	19.0	9.9	2.5	0.0	-1.00	-
Lyngby's sedge	*Carex lyngbyei*	0.0	20.5	32.8	33.2	1.00	+
seashore saltgrass	*Distichlis spicata*	0.0	4.4	13.0	12.8	0.80	+
fleshy jaumea	*Jaumea carnosa*	0.0	6.9	22.5	25.4	1.00	+
seaside plantain	*Plantago maritima*	0.0	0.0	0.0	2.7	0.77	
pickleweed	*Salicornia virginica*	0.0	2.7	6.8	7.5	1.00	+
Hooker's willow	*Salix hookeriana*	0.0	19.0	26.9	0.0	0.09	
American bulrush	*Scirpus americanus*	12.7	12.3	4.4	0.0	-1.00	-
Total Canopy Cover, Native		49.5	107.5	101.5	96.4	0.20	
Total Canopy Cover, Non-Native or Invasive		17.5	1.7	8.1	4.8	-0.40	
TOTAL (All Species)		68.8	99.1	109.8	101.6	0.80	+

a: "+" indicates a significantly increasing trend over four years, "-" indicates a significantly decreasing trend, blank cells have no significant trend (Spearman's rank test; two-tailed alpha = 0.05)

Table C-2. Change in percent cover over time at Mowitch transects

Common Name	Scientific Name	Mean Percent Cover				Spearman's Rank Correlation Coefficient Over Four Sampled Years	Statistical Result [a]
Mowitch Transect 1-1		**2002**	**2004**	**2006**	**2008**		
Native Species							
Canadian Sandspurry	*Spergularia canadensis*	0.0	5.3	2.9	2.4	0.20	
fleshy Jaumea	*Jaumea carnosa*	0.0	8.6	8.1	13.2	0.80	+
Lyngby's sedge	*Carex lyngbyei*	0.8	0.0	2.1	4.7	0.80	+
orache, fat-hen saltbush	*Atriplex patula*	4.9	1.7	0.6	0.0	-1.00	-
pickleweed	*Salicornia virginica*	0.0	3.0	13.7	14.6	1.00	+
seashore saltgrass	*Distichlis spicata*	0.0	5.6	11.7	11.6	0.80	+
seaside arrow-grass	*Triglochin maritimum*	6.1	6.3	6.8	3.5	-0.20	
seaside plantain	*Plantago maritima*	1.5	7.8	10.4	13.3	1.00	+
spike-rush	*Eleocharis sp.*	0.0	10.8	6.8	8.9	0.40	
tufted hairgrass	*Deschampsia cespitosa*	0.0	2.1	1.1	3.3	0.80	+
Total Canopy Cover, Native		10.5	69.1	79.8	81.2	1.00	+
Non-Native of Invasives (NNI)							
brass buttons	*Cotula coronopifolia*	1.9	11.0	2.1	5.0	0.40	
Total Canopy Cover, NNI		2.7	11.3	6.5	5.8	0.20	
TOTAL (All Species)		13.7	72.3	79.5	77.5	0.80	+
Mowitch Transect 1-2		**2003**	**2004**	**2006**	**2008**		
Native Species							
canadian sandspurry	*Spergularia canadensis*	6.7	6.0	6.0	7.1	0.20	
fleshy jaumea	*Jaumea carnosa*	0.0	0.0	1.3	2.2	0.95	+
orache, fat-hen saltbush	*Atriplex patula*	1.9	0.0	0.6	0.0	-0.60	
pickleweed	*Salicornia virginica*	0.0	0.0	7.4	9.9	0.95	+
seashore saltgrass	*Distichlis spicata*	0.0	0.0	0.0	1.1	0.77	
seaside arrow-grass	*Triglochin maritimum*	0.8	5.4	2.3	2.7	0.40	
seaside plantain	*Plantago maritima*	0.3	0.0	0.0	5.5	0.26	
spike-rush	*Eleocharis sp.*	16.0	34.8	17.3	23.3	0.40	
Total Canopy Cover, Native		33.3	57.8	44.6	52.9	0.40	
NNI Species							
brass buttons	*Cotula coronopifolia*	5.5	19.4	11.0	9.7	0.20	
Total Canopy Cover, NNI		7.4	19.4	11.0	10.2	0.20	
TOTAL (All Species)		67.3	87.9	57.3	63.0	-0.60	

a: "+" indicates a significantly increasing trend over four years, "-" indicates a significantly decreasing trend, blank cells have no significant trend (Spearman's rank test; two-tailed alpha = 0.05)

Table C-3. Change in percent cover over time at Middle Waterway (Simpson/Transects) transects

Common Name	Scientific Name	Mean Percent Cover				Spearman's Rank Correlation Coefficient Over Four Sampled Years	Statistical Result [a]
Middle Waterway Transect 1-1		**2002**	**2004**	**2006**	**2008**		
Native Species							
orache, fat-hen saltbush	*Atriplex patula*	3.5	3.6	0.0	1.6	-0.60	
seashore saltgrass	*Distichlis spicata*	9.4	46.5	20.1	23.5	0.40	
pickleweed	*Salicornia virginica*	0.0	11.6	35.0	38.3	1.00	+
Canadian sandspurry	*Spergularia canadensis*	11.6	2.8	2.9	1.9	-0.80	-
Total Canopy Cover, Native		24.2	49.1	59.3	68.7	1.00	+
TOTAL (All Species)		24.2	49.1	59.3	68.7	1.00	+
Middle Waterway Transect 1-2			**2004**	**2006**	**2008**		
Native Species							
pickleweed	*Salicornia virginica*		1.7	14.6	18.7	1.00	+
Canadian sandspurry	*Spergularia canadensis*		30.7	27.2	5.4	-1.00	-
Total Canopy Cover, Native			26.1	45.9	23.8	-0.50	
TOTAL (All Species)			26.1	45.9	23.8	-0.50	

a: "+" indicates a significantly increasing trend over four years, "-" indicates a significantly decreasing trend, blank cells have no significant trend (Spearman's rank test; two-tailed alpha = 0.05)

Table C-4. Commencement Bay total catch for Year 7 (2008) monitoring by species

Common Name	Scientific Name	Total Catch
barred perch	*Amphistichus argenteus*	1
bay pipefish	*Syngnathus leptorhynchus*	12
buffalo sculpin	*Enophrys bison*	6
cabezon sculpin	*Scorpaenichthys marmoratus*	2
Chinook salmon	*Oncorhynchus tshawytscha*	1,061
chum salmon	*Oncorhynchus keta*	10,672
coho salmon	*Oncorhynchus kisutch*	7,389
crescent gunnel	*Pholis laeta*	1
cutthroat	*Oncorhynchus clarki*	6
bull trout/Dolly Varden	*Salvelinus malma malma*	1
English sole	*Pleuronectes vetulus*	4
lingcod	*Ophiodon elongatus*	3
northern sculpin	*Icelinus borealis*	2
Pacific herring	*Clupea pallasii*	320
Pacific sand lance	*Ammodytes hexapterus*	318
Pacific staghorn sculpin	*Leptocottus armatus*	845
penpoint gunnel	*Apodichthys flavidus*	26
pile perch	*Rhacochilus vacca*	103
pink salmon	*Oncorhynchus gorbuscha*	20,645
rosylip sculpin	*Ascelichthys rhodorus*	12
saddleback gunnel	*Pholis ornata*	100
sailfin sculpin	*Nautichthys oculofasciatus*	1
shiner perch	*Cymatogaster aggregata*	5,783
snake prickleback	*Lumpenus sagitta*	438
speckled sanddab	*Citharicthys stigmaeus*	42
starry flounder	*Platichthys stellatus*	97
steelhead	*Onchorynchus mykiss*	47
striped perch	*Embiotoca lateralis*	134
surf smelt	*Hypomesus pretiosus*	1,247
threespine stickleback	*Gasterosteus aculeatus*	153
tidepool sculpin	*Oligocottus maculosus*	14

Table C-5. Comparison of bird species and seasonal presence at the Hylebos Off-Channel (Jordan) site, Year 5 (2006) and

Migratory Pattern [a]	Common Name	Scientific Name	Total	2006	2008
N (PM)	American crow	*Corvus brachyrhynchos*	24	10	14
PM	American goldfinch	*Carduelis tristis*	54	31	23
N (PM)	American robin	*Turdus migratorius*	239	175	64
PM	Anna's hummingbird	*Calypte anna*	2	1	1
PM (N)	bald eagle	*Haliaeetus leucocephalus*	1	0	1
N	band-tailed pigeon	*Patagioenas fasciata*	2	0	2
C	barn swallow	*Hirundo rustica*	6	2	4
N	belted kingfisher	*Ceryle alcyon*	9	3	6
N (PM)	Bewick's wren	*Thryomanes bewickii*	4	2	2
N	black-capped chickadee	*Poecile atricapilla*	43	24	19
C	black-headed grosbeak	*Pheucticus melanocephalus*	9	5	4
C	brown-headed cowbird	*Molothrus ater*	3	1	2
C	bufflehead	*Bucephala albeola*	1	1	0
N	bushtit	*Psaltriparus minimus*	44	23	21
N (PM)	Canada goose	*Branta canadensis*	23	21	2
PM	cedar waxwing	*Bombycilla cedrorum*	39	14	25
N	chestnut-backed chickadee	*Poecile rufescens*	10	8	2
C	common goldeneye	*Bucephala clangula*	4	1	3
C	common yellowthroat	*Geothylpis trichas*	8	4	4
N (PM)	Cooper's hawk	*Accipiter coopreii*	3	0	3
N	downy woodpecker	*Picoides pubescens*	11	5	6
N (PM)	European starling	*Sturnus vulgaris*	67	63	4
N (I)	evening grosbeak	*Coccothraustes vespertinus*	2	0	2
C	gadwall	*Anas strepera*	2	0	2
C (PM)	glaucous-winged gull	*Larus glaucescens*	4	0	4
NM	golden-crowned kinglet	*Regulus satrapa*	1	1	0
C	golden-crowned sparrow	*Zonotrichia atricapilla*	1	1	0
N	graylag goose	*Anser anser*	1	1	0
PM	great blue heron	*Ardea herodias*	5	2	3
N	green-winged teal	*Anas crecca*	16	16	0
C (PM)	gull	*Larus sp.*	1	1	0
C	hermit thrush	*Catharus guttatus*	3	1	2
C	hooded merganser	*Lophodytes cucullatus*	1	1	0
N (PM)	house finch	*Carpodacus mexicanus*	54	51	3
PM (N)	mallard	*Anas platyrhynchos*	90	66	24
N	marsh wren	*Cistothorus palustris*	3	2	1
PM	mourning dove	*Zenaida macroura*	15	5	10
N	northern flicker	*Colaptes auratus*	15	0	15
C	northern rough-winged swallow	*Stelgidopteryx serripennis*	8	3	5
PM	olive-sided flycatcher	*Contopus cooperi*	6	2	4
PM (C)	Oregon junco	*Junco hyemalis*	12	12	0
?	peregrine falcon	*Falco peregrinus*	1	0	1
N	pied-bill grebe	*Podilymbus podiceps*	1	1	0
I	pine siskin	*Carduelis pinus*	55	0	55
C	purple martin	*Progne subis*	2	0	2
N (I)	red-breasted nuthatch	*Sitta canadensis*	2	2	0
N	red-breasted sapsucker	*Sphyrapicus ruber*	3	1	2
N	red-shafted flicker	*Colaptes auratus cafer*	16	11	5
N (PM)	red-tailed hawk	*Buteo jamaicensis*	16	11	5
N (PM)	red-winged blackbird	*Agelaius phoeniceus*	8	5	3
PM	ruby-crowned kinglet	*Regulus calendula*	3	2	1
C	rufous hummingbird	*Selasphorus rufus*	3	0	3
PM (C)	savannah sparrow	*Passerculus sandwichensis*	1	0	1
C	semipalmated sandpiper	*Calidris pusilla*	1	1	0
C (N)	sharp-shinned hawk	*Accipiter striatus*	2	0	2
N	song sparrow	*Melospiza melodia*	70	28	42
C (PM)	spotted sandpiper	*Actitis macularia*	7	7	0
PM (N)	spotted towhee	*Pipilo maculatus*	15	3	12
N	Steller's jay	*Cyanocitta stelleri*	21	14	7
C	Swainson's thrush	*Catharus ustulatus*	2	2	0
N	teal	*Anas sp.*	3	3	0
C	tree swallow	*Tachycineta bicolor*	6	1	5
C	violet-green swallow	*Tachycineta thalassina*	32	0	32
C	warbling vireo	*Vireo gilvus*	5	4	1
C	western tanager	*Piranga ludoviciana*	4	2	2
C	western wood-pewee	*Contopus sordidulus*	5	5	0
C	white-crowned sparrow	*Zonotrichia leucophrys*	5	5	0
PM	willow flycatcher	*Empidonax traillii*	3	2	1
C	Wilson's warbler	*Wilsonia pusilla*	1	0	1
C	yellow warbler	*Dendroica petechia*	1	1	0
C	yellow-rumped warbler	*Dendroica coronata*	31	24	7
		Total Birds	1171	694	477
		Species Richness	70	56	54

Notes:

N = non-migrator

PM = partial migrator (seasonal migration, destination varies)

I = irruptive (unpredictable migration depending on the food supply)

C = complete (consistent migration, seasonal)

a: Peterson, 1990; Tekiela, 2001

Table C-6. Comparison of bird species and seasonal presence at the Sha Dadx site, Year 5 (2006) and Year 7 (2008)

Migratory Pattern [a]	Common Name	Scientific Name	Total	2006	2008
N (PM)	American crow	*Corvus brachyrhynchos*	90	62	28
PM	American goldfinch	*Carduelis tristis*	153	124	29
N (PM)	American robin	*Turdus migratorius*	72	30	42
N	barn owl	*Tyto alba*	5	4	1
C	barn swallow	*Hirundo rustica*	10	3	7
N (PM)	Bewick's wren	*Thryomanes bewickii*	15	8	7
N	black-capped chickadee	*Poecile atricapilla*	76	45	31
C	black-headed grosbeak	*Pheucticus melanocephalus*	11	6	5
N (PM)	Brewer's blackbird	*Euphagus cyanocephalus*	40	40	0
C	brown-headed cowbird	*Molothrus ater*	1	0	1
C	bufflehead	*Bucephala albeola*	1	0	1
N	bushtit	*Psaltriparus minimus*	49	36	13
N (PM)	Canada goose	*Branta canadensis*	91	50	41
C	Caspian tern	*Sterna caspia*	2	2	0
PM	cedar waxwing	*Bombycilla cedrorum*	33	11	22
C	cliff swallow	*Petrochelidon pyrrhonota*	8	8	0
C	common yellowthroat	*Geothylpis trichas*	23	11	12
N (PM)	Cooper's hawk	*Accipiter coopreii*	1	0	1
PM (N)	double-crested cormorant	*Phalacrocorax auritus*	1	1	0
N	downy woodpecker	*Picoides pubescens*	15	13	2
N (PM)	European starling	*Sturnus vulgaris*	99	25	74
C	fox sparrow	*Passerella iliaca*	1	1	0
C (PM)	glaucous-winged gull	*Larus glaucescens*	23	16	7
N	golden-crowned kinglet	*Regulus satrapa*	1	1	0
C	golden-crowned sparrow	*Zonotrichia atricapilla*	7	0	7
PM	great blue heron	*Ardea herodias*	8	3	5
N	green-winged teal	*Anas crecca*	20	20	0
C	hooded merganser	*Lophodytes cucullatus*	2	0	2
N (PM)	house finch	*Carpodacus mexicanus*	35	33	2
N	house sparrow	*Passer domesticus*	2	0	2
PM (C)	killdeer	*Charadrius vociferus*	2	2	0
PM	Lincoln's sparrow	*Melospiza lincolnii*	1	1	0
PM (N)	mallard	*Anas platyrhynchos*	71	51	20
PM	mourning dove	*Zenaida macroura*	41	1	40
N	northern flicker	*Colaptes auratus*	3	0	3
PM (N)	northern harrier	*Circus cyaneus*	1	1	0
C	northern shoveler	*Anas clypeata*	3	0	3
PM	olive-sided flycatcher	*Contopus cooperi*	2	0	2
PM (C)	Oregon junco	*Junco hyemalis*	15	9	6
C	osprey	*Pandion haliaetus*	2	1	1
?	peregrine falcon	*Falco peregrinus*	1	1	0
I	pine siskin	*Carduelis pinus*	56	0	56
N	red-shafted flicker	*Colaptes auratus cafer*	5	5	0
N (PM)	red-tailed hawk	*Buteo jamaicensis*	18	7	11
N (PM)	red-winged blackbird	*Agelaius phoeniceus*	3	1	2
N	rock dove	*Columba livia*	29	17	12
PM	ruby-crowned kinglet	*Regulus calendula*	3	3	0
C	rufous hummingbird	*Selasphorus rufus*	2	2	0
PM (C)	savannah sparrow	*Passerculus sandwichensis*	10	8	2
N	song sparrow	*Melospiza melodia*	96	45	51
C (PM)	spotted sandpiper	*Actitis macularia*	1	1	0
PM (N)	spotted towhee	*Pipilo maculatus*	9	3	6
N	Steller's jay	*Cyanocitta stelleri*	15	8	7
C	Swainson's thrush	*Catharus ustulatus*	5	5	0
C	swallow	*Tachycineta sp.*	8	8	0
C	tree swallow	*Tachycineta bicolor*	28	21	7
PM (NM)	varied thrush	*Ixoreus naevius*	2	2	0
C	violet-green swallow	*Tachycineta thalassina*	34	19	15
C	warbling vireo	*Vireo gilvus*	8	8	0
N	western scrub jay	*Aphelocoma californica*	16	4	12
C	western tanager	*Piranga ludoviciana*	4	2	2
C	western wood-pewee	*Contopus sordidulus*	2	2	0
C	white-crowned sparrow	*Zonotrichia leucophrys*	1	0	1
PM	willow flycatcher	*Empidonax traillii*	9	2	7
C	yellow-rumped warbler	*Dendroica coronata*	4	1	3
C	yellow-throated warbler	*Dendroica dominica*	3	3	0
C	yellow warbler	*Dendroica petechia*	6	6	0
		Total birds	1414	803	611
		Species richness	67	56	45

Notes:

N = non-migrator

PM = partial migrator (seasonal migration, destination varies)

I = irruptive (unpredictable migration depending on the food supply)

C = complete (consistent migration, seasonal)

a: Peterson, 1990; Tekiela, 2001

Figure C-1. Percent cover of native plant species at Squally Beach Transect 1-1 from 2002 through 2008

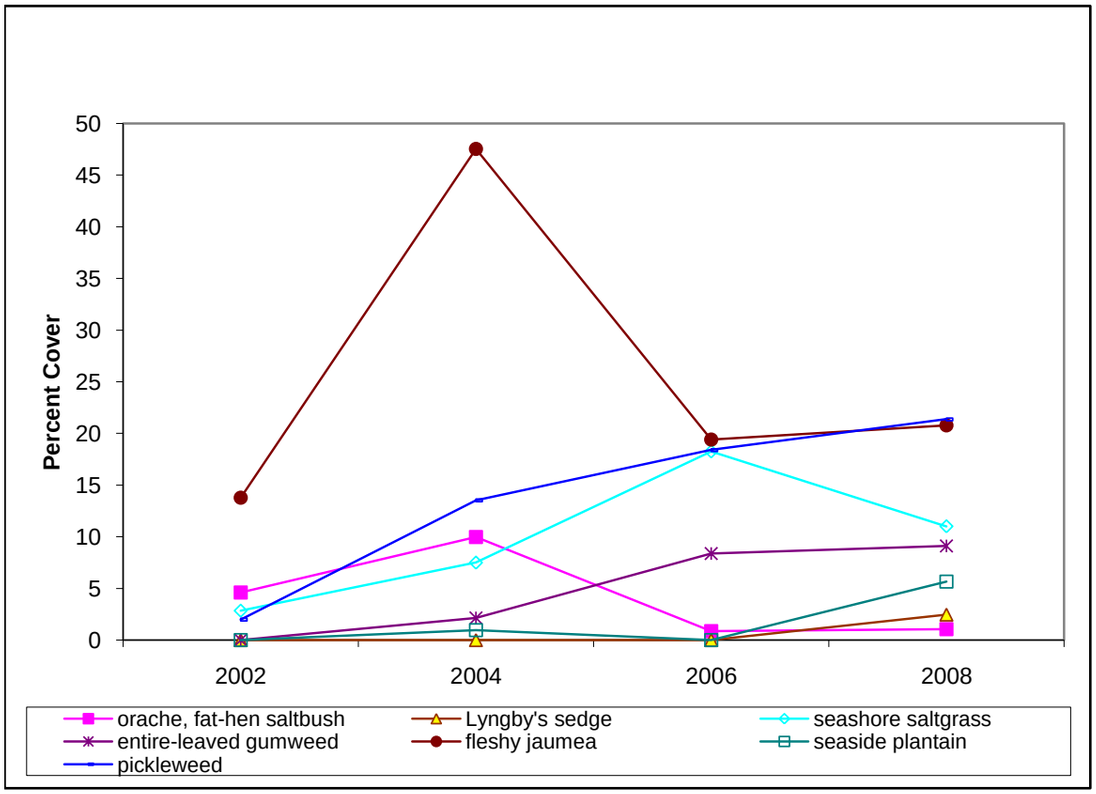


Figure C-2. Percent cover of native plant species at Squally Beach Transect 1-2 from 2002 Through 2008

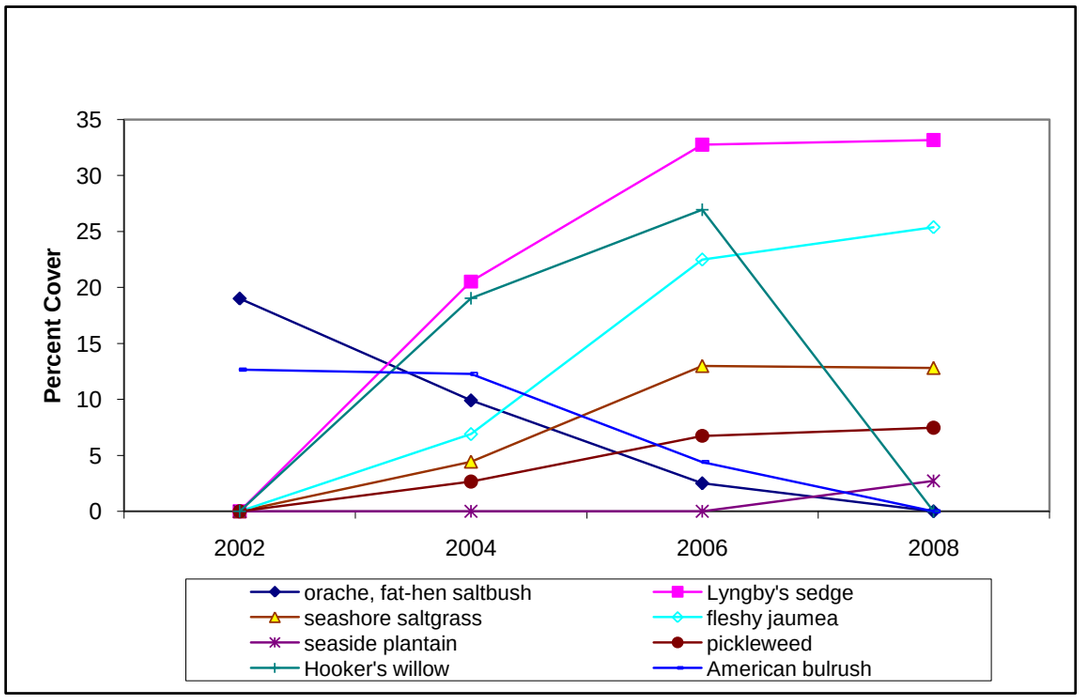


Figure C-3. Percent cover of native plant species at Mowitch Site Transect 1-1 from 2002 Through 2008

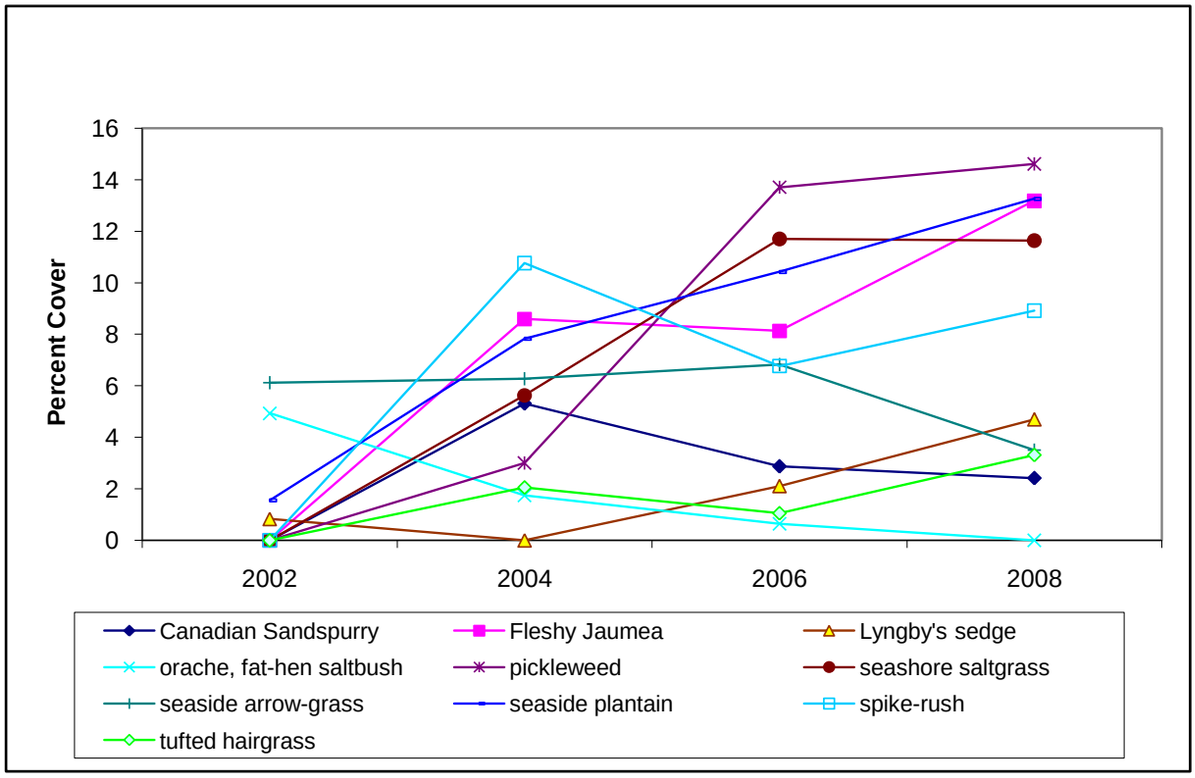


Figure C-4. Percent cover of native plant species at Mowitch Transect 1-2 from 2002 through 2008

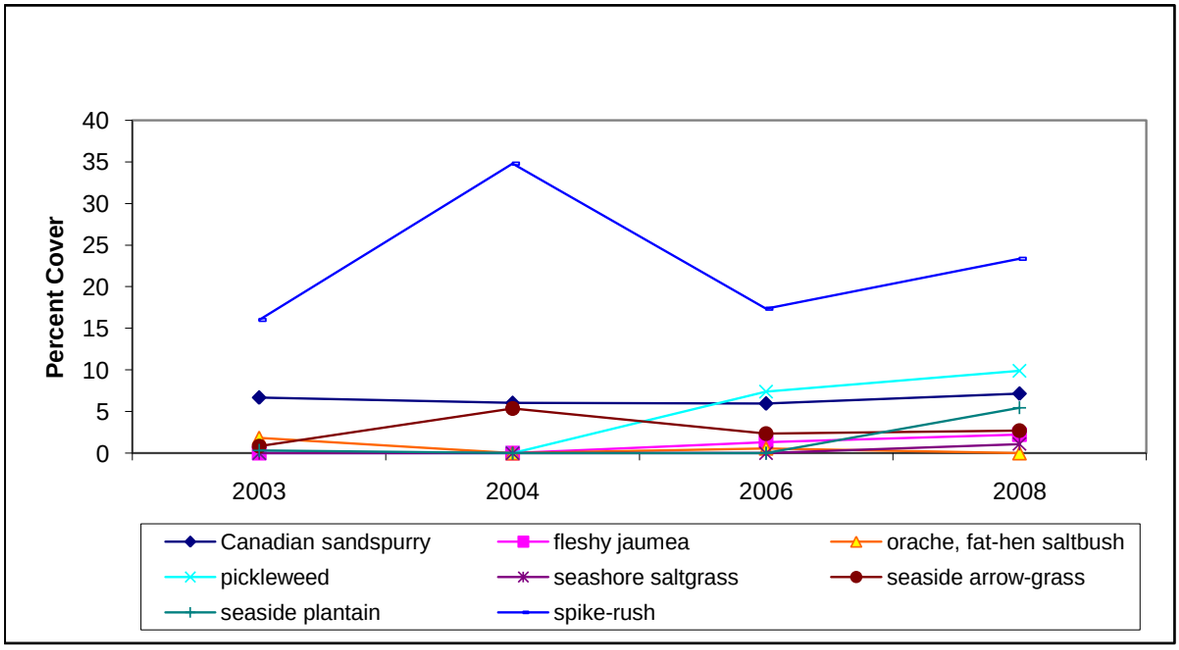


Figure C-5. Percent cover of non-native plant species at Mowitch Transects 1-1 and 1-2 from 2002 Through 2008

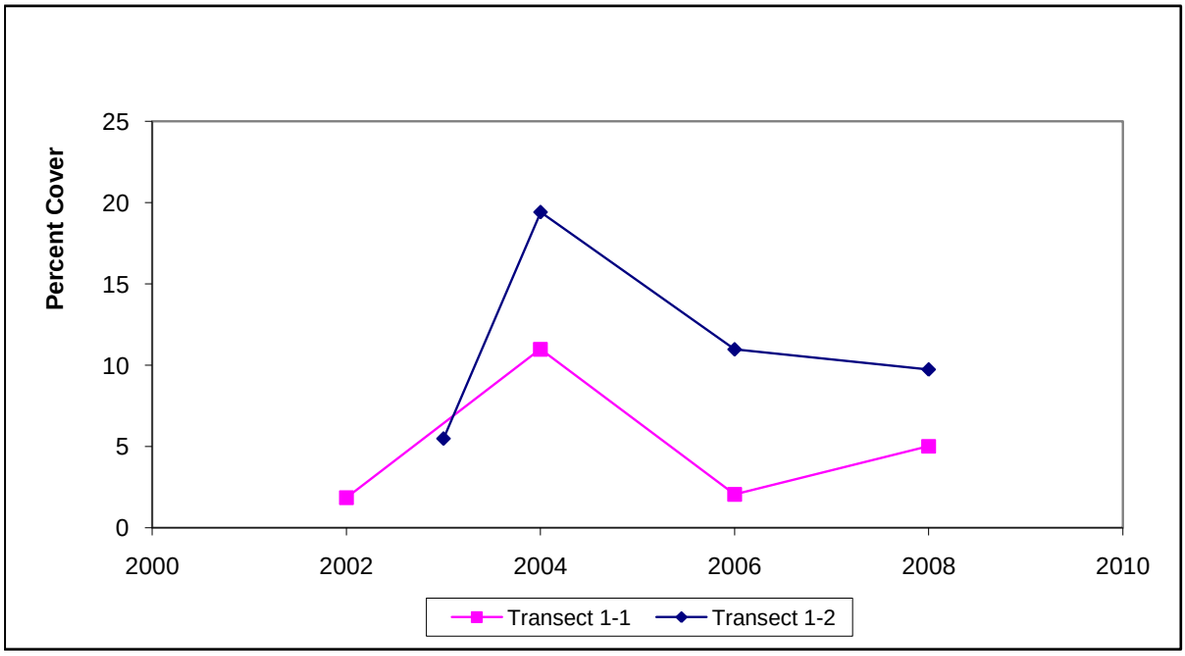


Figure C-6. Percent cover of native plant species at Middle Waterway Transect 1-1 from 2002 Through 2008

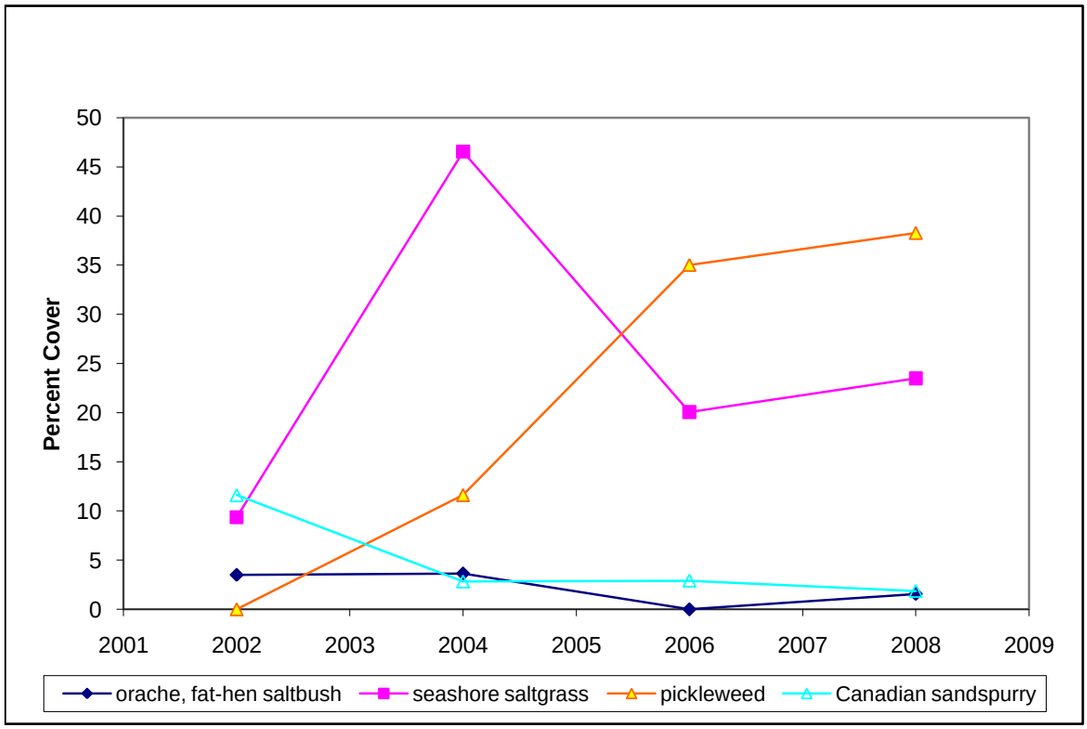


Figure C-7. Percent cover of native plant species at Middle Waterway Transect 1-2 from 2002 Through 2008

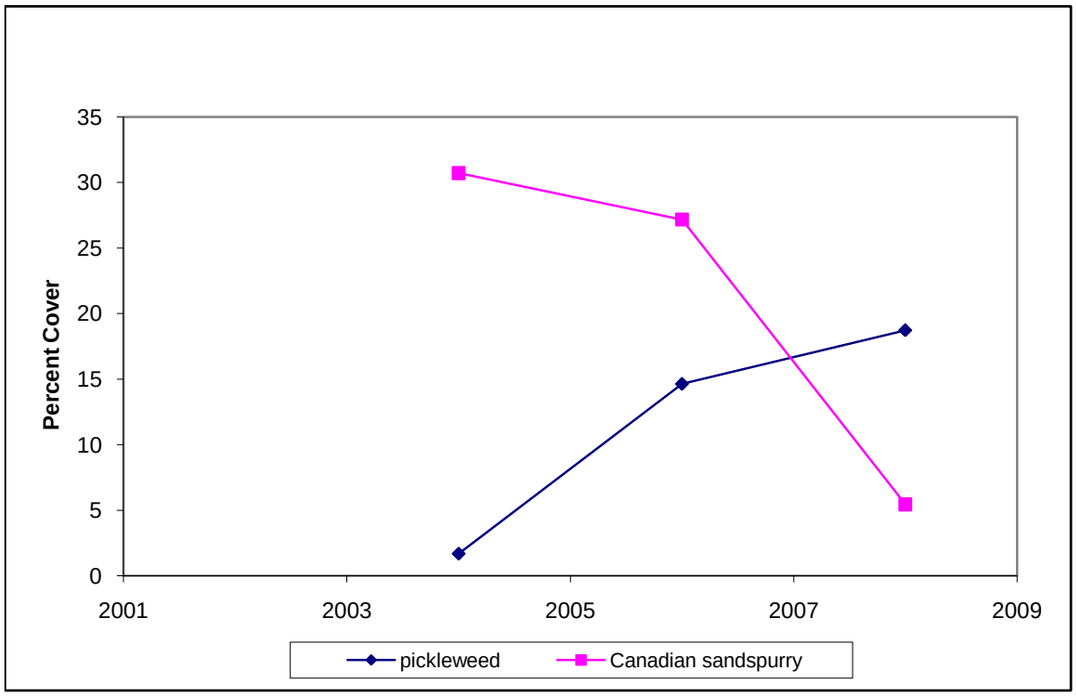
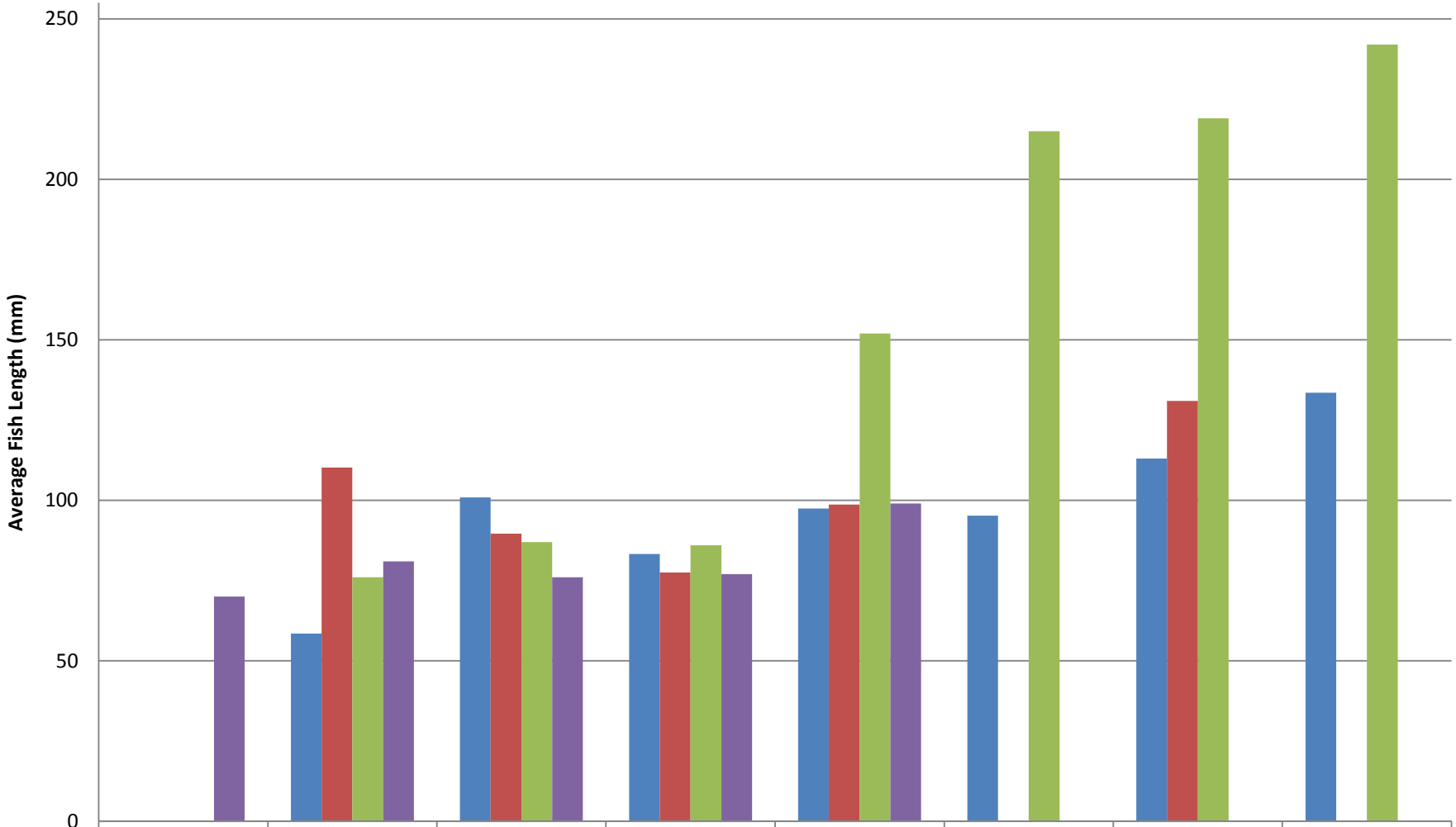
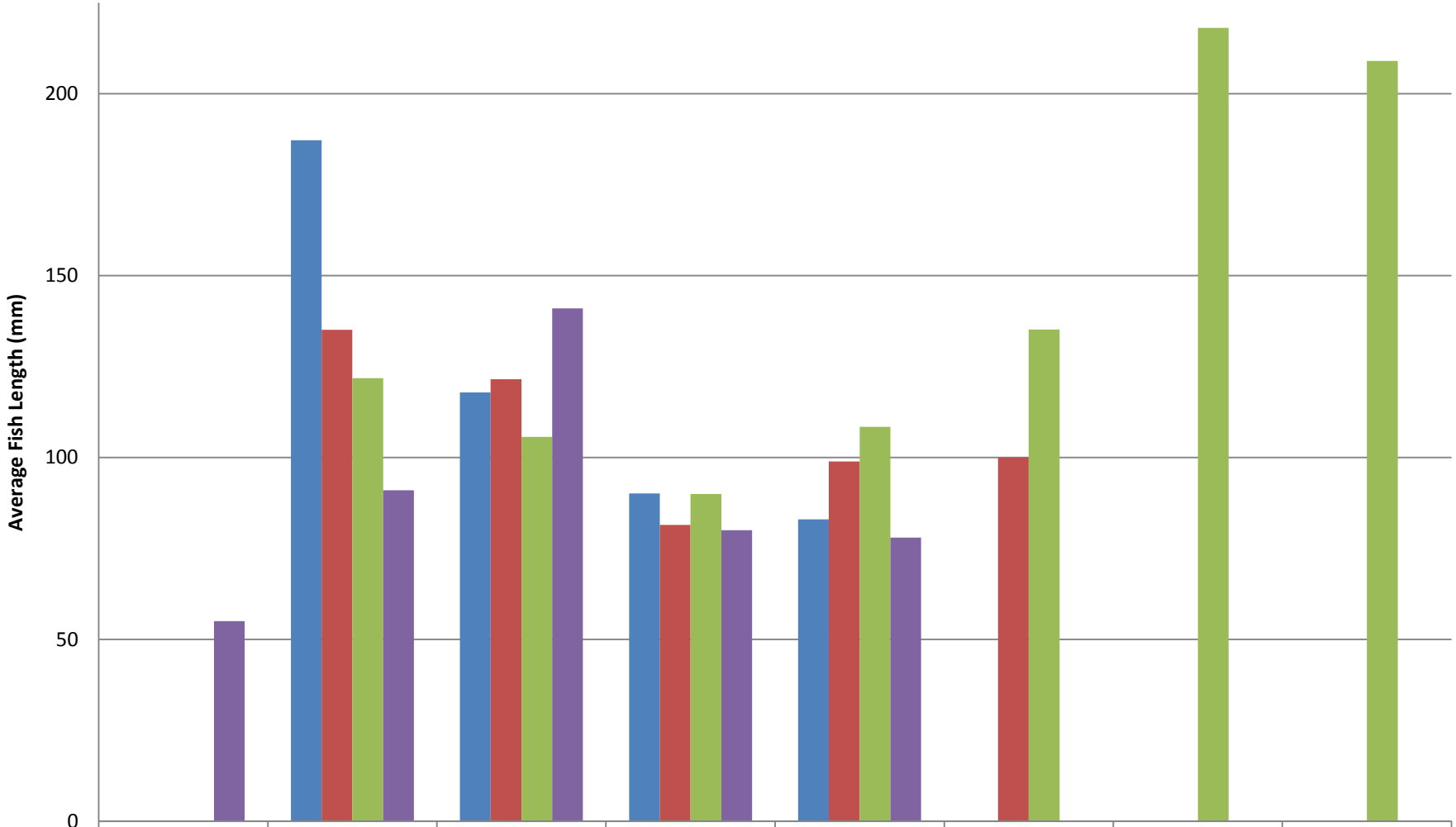


Figure C-8. Average length of Chinook salmon caught at all sites, Years 1-3 and 7



	March	April	May	June	July	August	September	October
2002		58.5	100.9	83.3	97.4	95.2	113	133.5
2003		110.2	89.6	77.5	98.7		131	
2004		76	87	86	152	215	219	242
2008	70	81	76	77	99			

Figure C-9. Average length of coho salmon caught at all sites, Years 1-3 and 7



	March	April	May	June	July	August	September	October
2002		187.2	117.9	90.1	83			
2003		135.1	121.5	81.5	98.9	100		
2004		121.8	105.7	90	108.4	135.2	218.1	209
2008	55	91	141	80	78			

Figure C-10. Percent of Chinook that were wild, hatchery, or not checked, Years 1-3 and 7

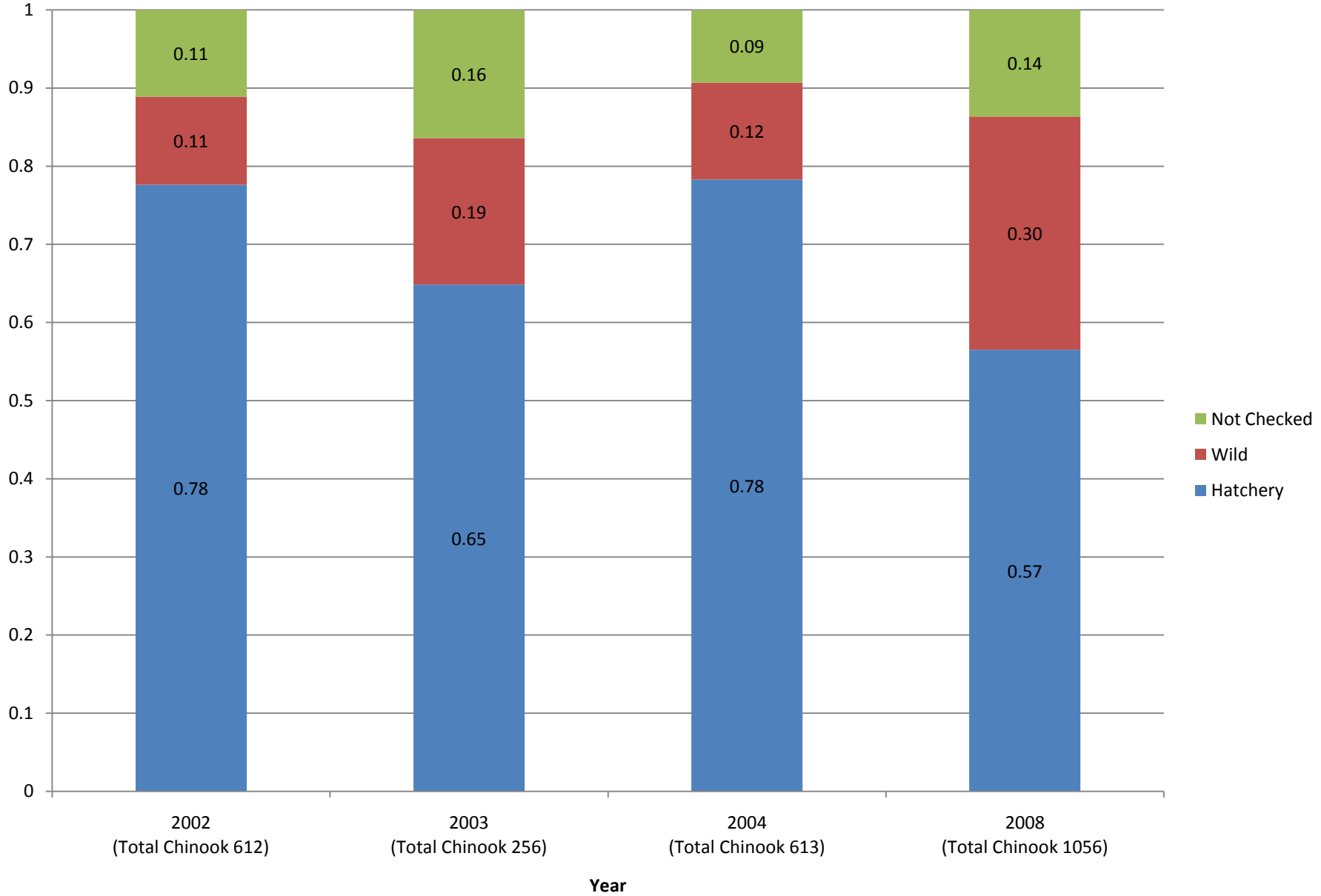


Figure C-11. Percent of coho that were wild, hatchery, or not checked, Years 1-3 and 7

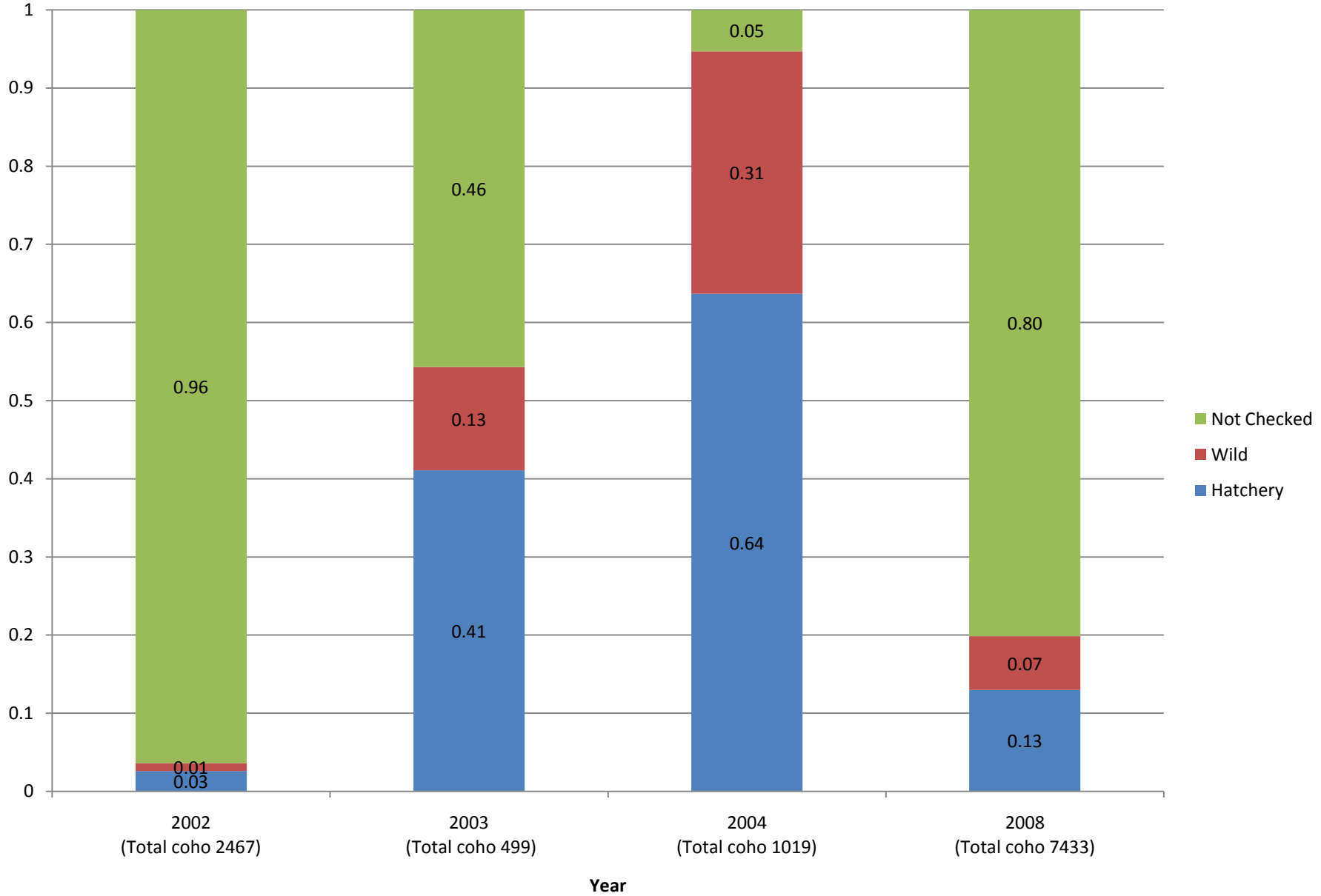
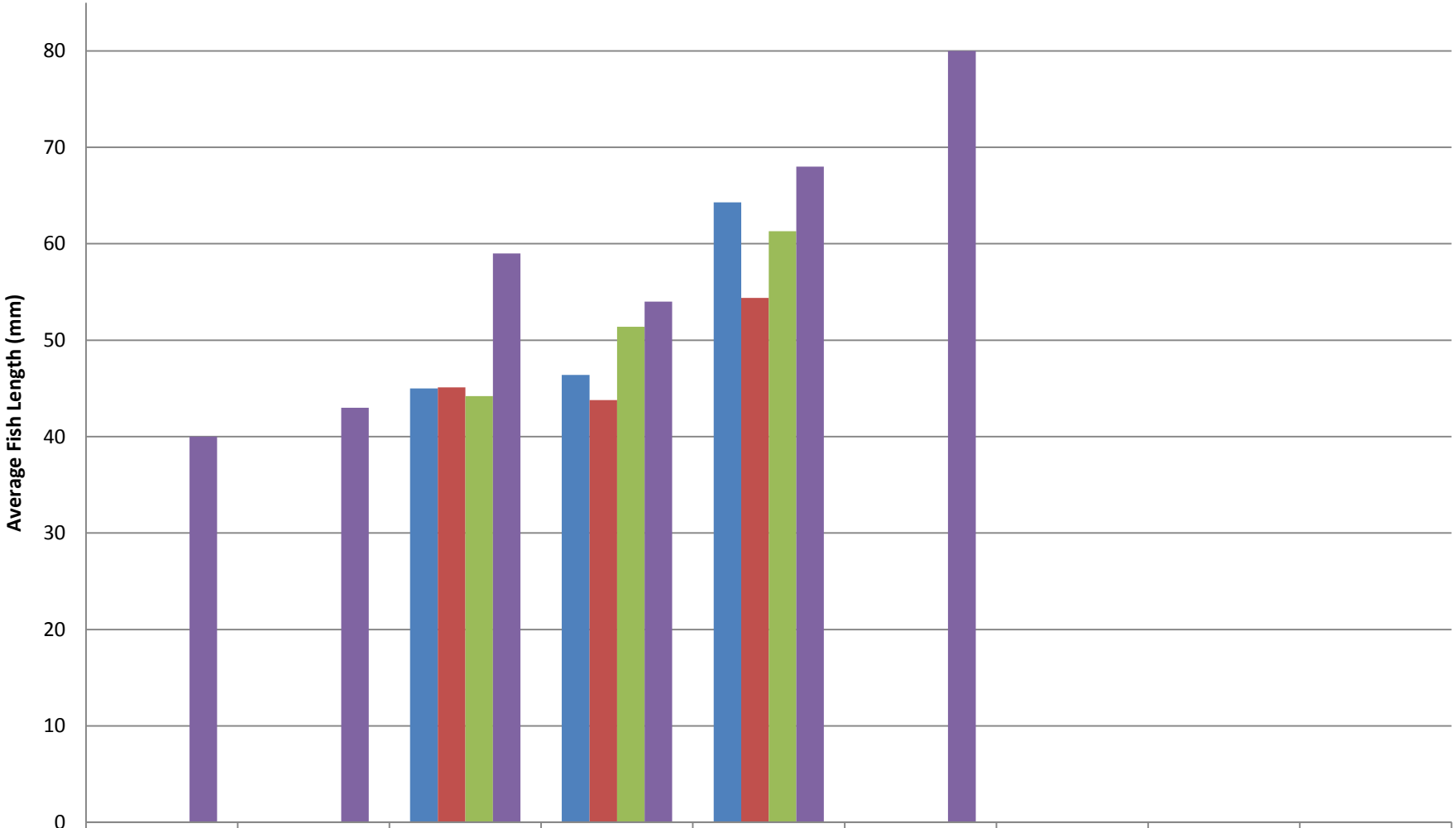
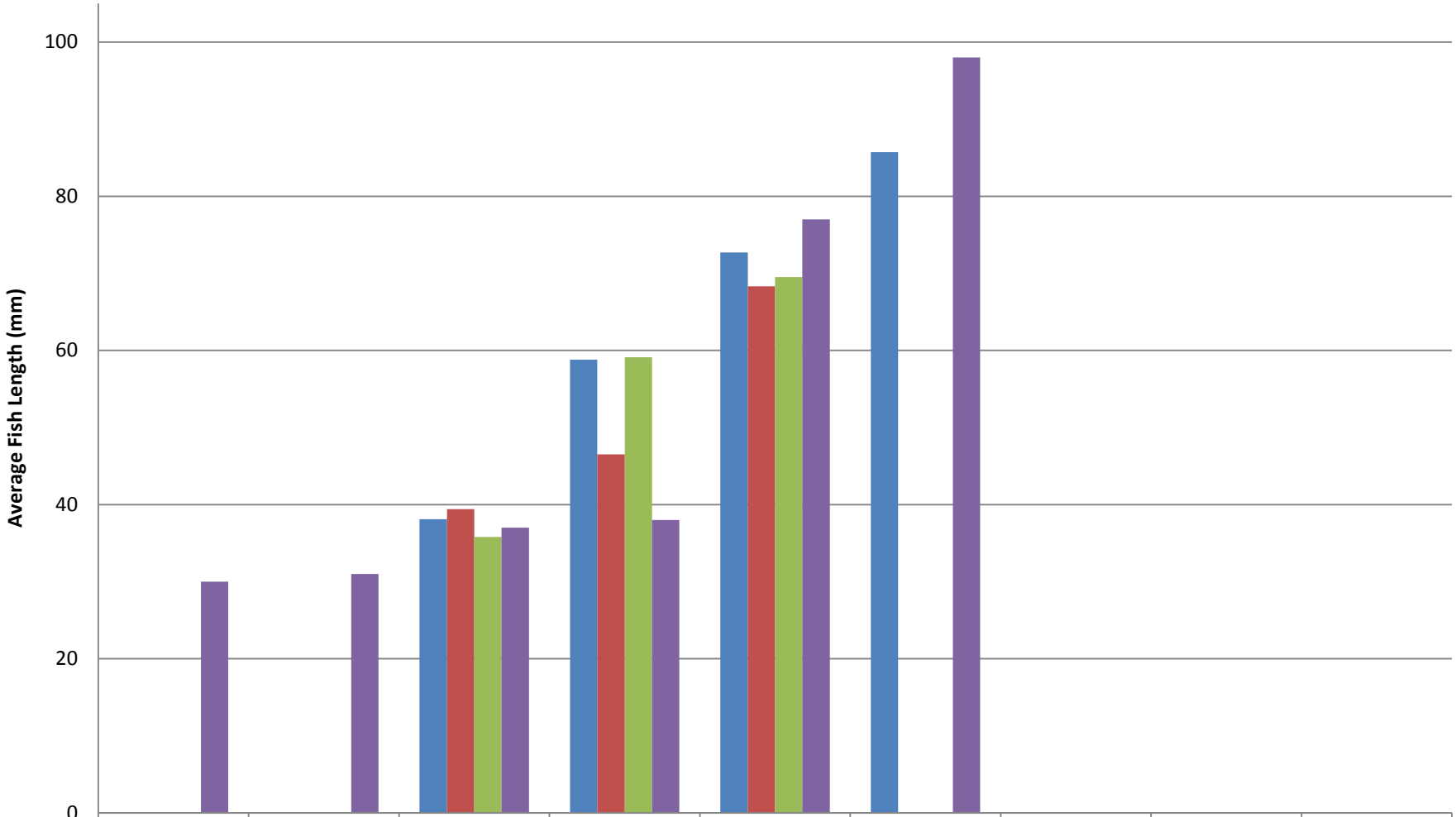


Figure C-12. Average length of chum salmon caught at all sites, Years 1-3 and 7



	February	March	April	May	June	July	August	September	October
2002			45	46.4	64.3				
2003			45.1	43.8	54.4				
2004			44.2	51.4	61.3				
2008	40	43	59	54	68	80			

Figure C-13. Average length of pink salmon caught at all sites, Years 1-3 and 7



	February	March	April	May	June	July	August	September	October
2002			38.1	58.8	72.7	85.7			
2003			39.4	46.5	68.3				
2004			35.8	59.1	69.5				
2008	30	31	37	38	77	98			

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