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Annual Adaptive Management Report for Compensatory Mitigation at Keyport Lagoon

Mitigation of Pier B Development at the Bremerton Naval Facilities
Compensatory Mitigation at Keyport Lagoon
Naval Underwater Warfare Center Division
Keyport, Washington

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June 2012

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Richland, Washington 99352

Executive Summary

Unites States Navy capital improvement projects are designed to modernize and improve mission capacity. Such capital improvement projects often result in unavoidable environmental impacts by increasing over-water structures, which results in a loss of subtidal habitat within industrial areas of Navy bases. In the Pacific Northwest, compensatory mitigation often targets alleviating impacts to Endangered Species Act-listed salmon species. The complexity of restoring large systems requires limited resources to target successful and more coordinated mitigation efforts to address habitat loss and improvements in water quality that will clearly contribute to an improvement at the site scale and can then be linked to a cumulative net ecosystem improvement.

The MILCON P356 Maintenance Wharf is replacing Pier B resulting in an increase in overwater structure area and subsequent loss of subtidal habitat within the industrial area of Puget Sound Naval Shipyard and Intermediate Maintenance Facility (PSNS&IMF). Under a Memorandum of Agreement between the U.S. Navy and the intergovernmental consultation panel, compensatory mitigation for MILCON P356 Maintenance Wharf must be conducted by removing Pier 8 within the PSNS&IMF and restoring tidal connectivity of an enclosed coastal lagoon located at Naval Undersea Warfare Center-Keyport.

The demolition of Pier 8 removed approximately 0.6 acres of overhead structure in the same location of the construction impacts associated with building Pier B and partially offset the increased shading of the new Pier B design. A three-dimensional (3D) finite element shade model was developed to model the increase in photosythetically active radiation (PAR) reaching the seabed from Pier 8 removal and also the reduction from the new Pier B footprint. This model suggested that the removal of Pier 8 increased the PAR values above the minimum requirement for benthic primary productivity in the shallow water region and indicates an increase in the potential growth of marine resources over approximately 1.2 acres (i.e., almost twice the area the dock actually covered). In addition, the model estimated that even if the new Pier B structure was removed, there would not be sufficient PAR reaching the seabed to sustain benthic macrophytes such as eelgrass and kelp due to the bathymetry at the Pier B location.

The second mitigation action was to create the Keyport Lagoon Restoration project and implement the key elements required to effectively develop regional ecosystem-based mitigation strategies including:

1. Creating a stakeholder team to develop a Restoration and Adaptive Management Plan (RAMP) to provide the framework for implementing adaptive management that leverages existing regional-scale efforts (Thom et al. 2010);

2. Incorporating lessons learned from decades of local, regional, and ecosystem-scale coastal restoration activities (e.g. Army Corp of Engineers projects to assess the cumulative ecosystem improvements on the Columbia River following multiple restoration projects (Thom et al. 2010; Diefenderfer et al. 2011)); and

3. Instituting an organizing framework or “currency” that is a systematic and quantitative measure of Net Ecosystem Improvement (NEI) and incorporates the framework for adaptively managing restoration projects at multiple scales.

The RAMP provides a framework for conducting the restoration of the Keyport Lagoon and evaluating the effectiveness of the mitigation measures and details an adaptive management process for addressing uncertainties and adapting to unforeseen conditions. This document details the pre-restoration activities performed since 2009 to measure the baseline metrics that will be used to quantify the ecosystem changes after restoration and evaluate the critical uncertainties (e.g. sediment quality) identified in the RAMP. Performance metrics based on ecological structure and processes (e.g., salmon use, plant community, nutrient flux) were monitored before restoration to create the baseline index for the NEI. A NEI model, described in the RAMP, will be used to evaluate the ecological changes that result from the removal of the weir and new hydrology at Keyport Lagoon.

The ecosystem monitoring for this baseline study used standard monitoring protocols developed originally in the Columbia River estuary and are applicable to reference and restored wetlands in Puget Sound. Our existing conditions study showed that there were more fish species, including species of salmonids, immediately outside the lagoon than inside. Water properties, specifically temperature, were notably elevated in the lagoon and exceeded salmonid thresholds of concern for temperatures during some summer periods. In fact, the 7-day average daily maximum (7-DADmax) exceeded a threshold of 17.5ºC 46% of the time inside the lagoon and only 3.6% of the time outside the lagoon. The tidal marsh presently in the lagoon contained a lower plant species richness and fewer salt-tolerant species compared to the reference site and accretion rates were low in the Keyport Lagoon wetland.

This baseline data set is unprecedented in scope and applicability to the restoration of a pocket estuary in the Pacific Northwest. The data set also provided new information that allowed us to better predict the outcomes from the restoration actions. This both refines expectations and verifies that the restoration of the lagoon would have significant positive effects for fish as well as water properties in the region of the system. We now believe that the tidal marsh will expand in area and will become more diverse. Water properties, especially temperature, should improve substantially in favor of juvenile salmon. On the negative side, some increased, but infrequent, inundation may cause erosion on some shorelines surrounding the lagoon. This data set, which when combined with the post-restoration monitoring, provides a unique quantification of the effect of specific actions to restore what now are believed to be highly important ecological elements (pocket estuaries) in the Puget Sound landscape. Applying similarity analysis to compare conditions between the present lagoon and the reference systems was effective in simplifying our analysis of a complex data set. Once the weir is removed, the organizing Net Ecosystem Improvement index (applied using similarity analysis) would allow us to systematically quantify the changes through time, and present the net change in a simple, scientifically sound method.

As part of the adaptive management process, critical uncertainties identified in the RAMP, such as sediment quality and potential changes in the inundation frequency and extent were further clarified and identified suggested actions provided by the stakeholder team. Briefly these include:

- Dioxins and PCBs are extremely persistent in the environment and can affect human health at low concentrations. The lack of clear sediment benchmarks (e.g. dioxins) tied to ecological risk endpoints under the scenario of hydrologic reconnection of Keyport Lagoon must be addressed. Future studies require a coupled measurement and modeling approach. This includes a focus on porewater concentrations to identify the freely dissolved phase and better predict ecotoxicological endpoints.

- Conduct risk modeling for dioxins and furans by coupling sorption models based on sediment concentrations of PCDD/F and TOC and then with PCBs and TOC (Cornelissen et al. 2008) and passive sampling within the lagoon. This would provide values of freely dissolved concentrations, which are then characterized based on the potential risk to biota (e.g. low, medium, high).

- Collaborate with project ENVVEST Regional Mussel Watch sampling to optimize regional sampling that targets biological thresholds of concern and could be incorporated into risk modeling for dioxins/PCBs.

- Water level modeling identified the potential periodic inundation of additional areas including wooded areas to the west of the lagoon, the fields by the pavilion on the north shore of the lagoon, and potentially by the building closest to the lagoon on the west side. This inundation and subsequent errosion during higher tides may be beneficial for ecological function as more of the terrestrial-aquatic interface can be used as a resource, but could also potentially impact infrastructure at the base. These estimates and their implications should be investigated more thoroughly to make sure the potential threat to infrastructure is identified and understood.

Acknowledgments

This research would not have been possible without the valuable assistance from the various team members and stakeholders that volunteered their time and resources. We received valuable comments from all the stakeholders, and we would like to particularly thank Tom Ostrom and Paul Dorn from the Suquamish Tribe, Dr. Robert Johnston from the U.S. Navy, and Doris Small and Chris Waldbillig from the Washington Department of Fish and Wildlife. In addition, Washington Department of Fish and Wildlife provided essential field assistance from Doris Small and Chris Waldbillig for their help with the fish collection and providing the collection permits. In addition, Paul Dorn (Suquamish Tribe), David Kunz, Cindi Kunz, Tiffany Nabbors, and Stephanie Sparks (U.S. Navy) helped with the fish sampling and Erik Kunz (Western Washington State University student) helped with water property sampling and a vegetation survey. We would also like to thank Brenda Padgham of the Bainbridge Island Land Trust for coordinating access to the reference site at Battle Point and Dallas Young, who owns the property and allowed us access. The authors would also like to thank Dr. Patrick Louchouarn (Texas A&M University), Dr. Li-Jung Kuo (PNNL), and Dr. Gerard Cornelissen (Norwegian Geotechnical Institute) for their technical review and valuable contributions to the recommended actions for dioxins and PCBs.

Acronyms and Abbreviations

3D	three-dimensional
7-DADmax	Seven Day Average Daily Maximum Temperature
AM	Adaptive Management
CCME	Canadian Sediment Quality Guidelines
CMP	Compensatory Mitigation Plan
CSL	Cleanup Screening Level
CVN	Carrier Vessel Nuclear (Aircraft Carrier)
DOC	dissolved organic carbon
GPS	Global Positioning System
ISQG	Interim Marine Sediment Quality Guidelines
MILCON	Military Construction
MLLW	Mean Lower Low Water
NAVD88	North American Vertical Datum 1988
NBK-Bremerton	Naval Base Kitsap-Bremerton
NEI	Net Ecosystem Improvement
PAR	Photosynthetically Active Radiation
PCB	Polychlorinated biphenyl ethers
PCDD/F	Polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran
PNNL	Pacific Northwest National Laboratory
PSNS&IMF	Puget Sound Naval Shipyard and Intermediate Maintenance Facility
RAMP	Restoration and Adaptive Management Plan
RTK	Real-time Kinematic
SEV	Sum exceedance value
SQS	Sediment Quality Standard
TEF	Toxic Equivalence Factor
TEQ	Toxic Equivalent
TGO	Trimble Geomatics Office
TOC	Total Organic Carbon
TSS	Total Suspended Sediment
WAC	Washington Administrative Code
WSE	Water Surface Elevation

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1.0 Introduction

1.1 Purpose

Unites States Navy capital improvement projects are designed to modernize and improve mission capacity. Such capital improvement projects often result in unavoidable environmental impacts by increasing over-water structures, which results in a loss of subtidal habitat within industrial areas of Navy bases. The requirement for mitigation is triggered by Section 7 of the Endangered Species Act, which requires federal agencies to ensure actions do not jeopardize threatened or endangered species. In the Pacific Northwest, compensatory mitigation often targets alleviating impacts to Endangered Species Act-listed salmon species. The reasons for the demise of salmon in the Puget Sound have been identified as 1) loss of habitat, 2) overfishing, 3) disease and predation, 4) inadequate regulations, and 5) "other natural and man-made factors affecting species survival" including pollutants and degraded water quality (*Federal Register* 2007). With this in mind, successful and more acceptable mitigation efforts should address habitat loss and improvements in water quality that will clearly contribute to an improvement at the site scale and can then be linked to a cumulative net ecosystem improvement.

The continuous need to modernize, improve mission capacity, and target total ownership cost reduction strategies requires a more cost-effective and comprehensive approach to compensatory mitigation. To this end, the Keyport Lagoon Restoration project implemented the key elements required to effectively develop regional ecosystem-based mitigation strategies including:

1. Creating a stakeholder team to develop a Restoration and Adaptive Management Plan (RAMP) to provide the framework for implementing adaptive management that leverages existing regional-scale efforts;
2. Incorporating lessons learned from decades of coastal restoration experience including the Army Corp of Engineers projects to assess the cumulative ecosystem improvements on the Columbia River following multiple restoration projects; and
3. Instituting an organizing framework or "currency" that is a systematic and quantitative measure of Net Ecosystem Improvement (NEI).

The collaborative and cooperative stakeholder working group process is imperative to develop a reputable compensatory mitigation program that meets the regulatory agencies requirements, provides the tribes with treaty rights a tool to support ecosystem-based improvements in their normal and accustomed fishing grounds, and provides an effective adaptive management strategy for mitigation (Johnston et al. 2004; ENVVEST 2007). Evaluating the effectiveness of restoration requires applying the lessons learned from multiple site-scale restoration projects conducted on the Columbia River, which provided sufficient scientific underpinnings to apply knowledge gained from measuring cumulative impacts of anthropogenic stressors on ecosystems, "in reverse," to assess ecological restoration successes and calculate the NEI index (Thom et al. 2010; Diefenderfer et al. 2011).

Due to uncertainties inherent in any restoration activity, an adaptive management (AM) program is required to enhance the evaluation and decision-making process and maximize the efficacy of the restoration. Adaptive management provides a framework for decision-making by evaluating the performance of the restoration through monitoring, assembling and analyzing the available information, and making corrective actions as needed to achieve the desired ecosystem state. Adaptive management therefore allows managers, researchers, and stakeholders to learn from experience in a collaborative setting in order to make educated decisions.

This document details the pre-restoration or baseline metrics that will be used to quantify the ecosystem changes after restoration. Performance metrics based on ecological structure and processes (e.g., water level, temperature, salmon use, plant community, nutrient flux) were monitored before restoration to create the baseline index. A NEI model, described in the RAMP (Thom et al. 2010), will be used to evaluate the ecological changes that result from the removal of the weir and new hydrology at Keyport Lagoon.

The purpose of the document is two-fold: 1) provide a summary of the baseline environmental data collected at the Keyport Lagoon from 2009-2012, and 2) provide a template for the annual monitoring reports that guides the adaptive management process for the lagoon restoration or other restoration activities.

The report is structured in a standardized adaptive management format designed to accommodate future evaluations. It contains sections that act primarily as placeholders for future adaptive management decision support. Ultimately, it will provide the calculations for the NEI score and evaluation of performance metrics used to monitor the effectiveness of mitigation efforts undertaken for the Military Construction (MILCON) P365 Maintenance Wharf and potentially other mitigation efforts.

1.2 Background and Need

The Puget Sound Naval Shipyard & Intermediate Maintenance Facility (PSNS&IMF) and Naval Base Kitsap-Bremerton (NBK-Bremerton) located on Sinclair Inlet, Bremerton, Washington (Figure 1.1) are committed to a culture of continuous process improvement. This culture includes all aspects of NBK-Bremerton operations and targets protected species and improves environmental health. However, unavoidable environmental impacts result from capital improvement projects that are required to modernize and improve mission capacity for servicing aircraft carriers and other ships at PSNS&IMF (Friedrich 2008). The MILCON P356 Maintenance Wharf is replacing Pier B resulting in an increase in overwater structure area and subsequent loss of subtidal habitat within the industrial area of PSNS&IMF. Under a Memorandum of Agreement between the U.S. Navy and the intergovernmental consultation panel (U.S. Navy 2008a), compensatory mitigation for MILCON P356 Maintenance Wharf must be conducted by removing Pier 8 within the PSNS&IMF and restoring tidal connectivity of an enclosed coastal lagoon located at NUWC-Keyport (Figure 1.1). The documentation for the development of the compensatory mitigation plan (CMP) and the agency responses are provided in the following documents:

1. *CVN Maintenance Wharf Mitigation Plan, Compiled Final Mitigation Plan of 6 June 2008, Responses to Comments of 25 July 2008* (U.S. Navy 2008a),
2. *Biological Assessment Naval Base Kitsap Keyport Shallow Lagoon Restoration Addendum Responses to Agency Comments* (U.S. Navy 2008b),

3. *P356 CVN Maintenance Wharf Water Quality Protection and Monitoring Plan*, Revised 25 July 2008 (U.S. Navy 2008c).

The MILCON P356 project includes demolition of the existing Pier B and the associated pile-supported substation (85,694 ft^2) located within the NBK-Bremerton. The new Pier B will comprise a 151,125 ft^2 wharf and seismic wall connected to Dry Dock 6 to the east. Construction of the new wharf will require the removal of 824 existing piles (including 570 creosote-treated piles and 10 steel piles) and replacement with approximately 328 24-in. solid concrete octagonal piles and 78 36-in. hollow cylindrical concrete piles. The construction of the new wharf will create 48,431 ft^2 of new overwater shading and require 17,000 ft^2 of subtidal fill along the Dry Dock 6 mole wall for seismic stability. The project will also replace Quaywall 729 and integrate the existing quaywall foundation with the new pier. This entire project will impact 0.4 ac of subtidal habitat with placement of fill and 1.1 ac with new overwater coverage. These impacts require mitigation efforts to offset the environmental impacts the MILCON P356 project is likely to have on local ecosystem services, and the CMP determined a multi-faceted approach including work in Sinclair Inlet and the Keyport Lagoon would be appropriate compensation.

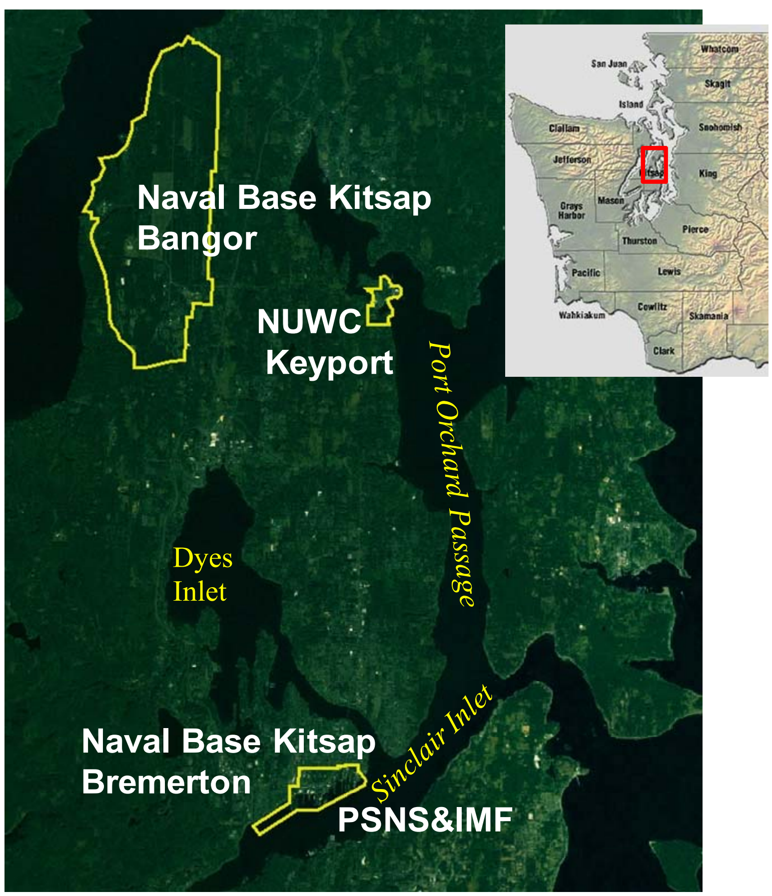

Figure 1.1. Relative Locations of Major Navy Bases on the Kitsap Peninsula, Puget Sound, Washington

1.3 Compensatory Mitigation

As mentioned above, the compensatory mitigation for the MILCON P356 project is being approached as a multi-faceted process, incorporating activities in three different locations to offset the anticipated impacts of the Pier B construction. The locations are hydrologically connected and include Sinclair Inlet, Dyes Inlet, and Keyport Lagoon.

1.3.1 Sinclair Inlet

In addition to the construction of the new Pier B at PSNS&IMF, the MILCON P356 project also detailed the removal of the Pier 8 at PSNS&IMF. This was done to remove existing overhead structure and offset the increased shading at Pier B. This demolition removed approximately 0.6 acres of overhead structure in the same location of the construction impacts associated with building Pier B. To assess the implications of the pier removal and new Pier B footprint, a three-dimensional (3D) finite element shade model was developed for the MILCON P356 construction project to compute the reduction (or increase) in photosynthetically active radiation on the seabed due to shadows created by the old Pier B, new Pier B, and removal of Pier 8 (see Thom et al. 2010, Appendix B). The completed shade model was computed as a function of 3D geometry of the structure, bathymetry, incident solar radiation, and water surface elevation change. This model suggested that the removal of Pier 8 increased the photosynthetically active radiation (PAR) values above the minimum requirement for benthic primary productivity in the shallow water region and indicates an increase in the potential growth of marine resources over approximately 1.2 acres (i.e., almost twice the area the dock actually covered). In contrast, even if the new Pier B structure was removed, there would not be sufficient PAR reaching the seabed to sustain benthic macrophytes such as eelgrass and kelp. This results primarily from the bathymetry at the Pier B location.

1.3.2 Dyes Inlet

Hydrodynamic modeling studies were conducted and concluded there was significant exchange of water and transport of sediment between Sinclair and Dyes Inlets; therefore, the two inlets should be treated as a single water body with respect to the watershed planning (Wang and Richter 1999). Therefore, the Navy also facilitated the purchased of land around Chico Creek, located in Dyes Inlet, and has committed support to restoration for salmonid habitat on the newly purchased land.

1.3.3 Keyport Lagoon

The third component of the compensatory mitigation for MILCON P356 is the intent to restore natural tidal hydrodynamics to the coastal lagoon identified as Keyport Lagoon (Figure 1.2), located 8 miles north of Bremerton on Port Orchard Passage. This would change the artificially impounded lagoon back into a pocket estuary, theoretically providing habitat for salmonids and their prey (Beamer et al. 2003 and 2006). Specifically, the CMP provides for the demolition and removal of the existing Keyport Lagoon bridge, concrete sill, and foundation (existing sill elevation +10.5 ft Mean Lower Low Water [MLLW]) and subsequent construction of two 42-ft span arch culverts including footings (proposed channel elevation +5 ft MLLW) (U.S. Navy 2008a). In addition, the CMP details the development of an agency/stakeholder group (i.e., the Stakeholder Working Group) led by the Navy to provide input to the Navy on the design of the RAMP for Keyport Lagoon.

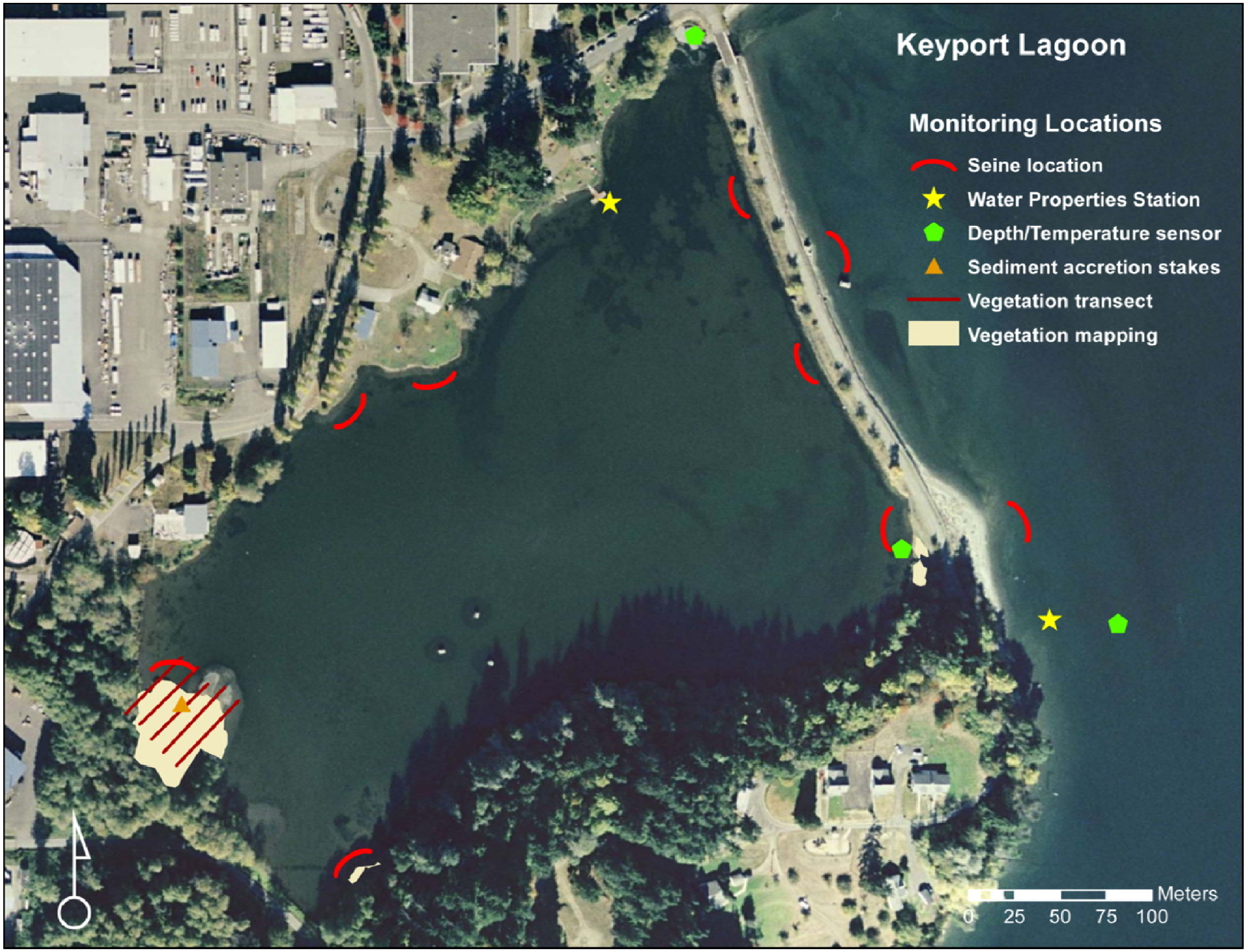

Figure 1.2. Map Showing Monitoring Locations within Keyport Lagoon

While this activity and the Chico Creek restoration are not located at the PSNS&IMF, the CMP determined that these actions, along with the removal of Pier 8, would effectively compensate for marine impacts of the MILCON P356 project by enhancing feeding, refuge/physiology, and reproduction functions within the eastern Kitsap County watershed planning shorelines of Puget Sound (U.S. Navy 2008a). These mitigation actions are designed to result in a net improvement of ecosystem function in the region relative to the impacts the may occur from construction of Pier B.

The RAMP (Thom et al. 2010) provides a framework for conducting the restoration of the Keyport Lagoon and evaluating the effectiveness of the mitigation measures and details an adaptive management process for addressing uncertainties and adapting to unforeseen conditions. The actions detailed in the CMP benefit the regional ecosystem by addressing habitat loss and achieving improvements in water quality that may contribute to recovery and eventual delisting of threatened or endangered species (i.e., salmon). Therefore, the RAMP incorporates the long-term plan for salmon recovery in Puget Sound collaboratively developed by watershed groups across the Sound (Shared Strategy 2007) and the work conducted by the Puget Sound Nearshore Ecosystem Restoration Project (Gelfenbaum et al. 2006). Developing a salmon-friendly restoration plan for Keyport Lagoon is not an exact science; it is open to interpretation by resource agencies, tribes with treaty rights, environmental groups, and other stakeholders. Therefore, this innovative approach is being done in collaboration with the Stakeholder Working Group in order to 1) provide scientifically credible evaluation criteria, 2) obtain stakeholder concurrence, and 3) achieve acceptance by the scientific community.

The RAMP outlined the following null hypothesis: (H_0) *Actions to restore natural tidal hydrodynamics will not improve the opportunity and capacity of the lagoon for juvenile estuarine-dependent salmon and other pelagic species, or the water quality*. We are evaluating this null hypothesis for a set of parameters that characterizes fish species abundances, vegetation assemblages, and water properties. Taken together, these parameters provide strong indicators of the expected changes once the hydrodynamics of the system are restored. We will test the null hypothesis through evaluating the similarity in parameter values before and after restoration as well as the conditions outside the lagoon (as well as with reference sites conditions as appropriate) compared with inside the lagoon. We expect that restoration will result in an increase in similarity between inside and outside conditions for water properties and vegetation, as well as improvement in fish access to the lagoon. We expect that restoring processes such as hydrodynamic reworking of the basin bathymetry and re-introduction of suspended sediments will facilitate the development of improved ecosystem conditions as well as long-term self-maintenance of the system. The RAMP also identified uncertainties that could affect full realization of expected changes, and potential actions to rectify these problems.

The primary tool for evaluating changes at the Keyport Lagoon in order to validate the CMP goal of a net improvement in ecological function is being carried out using the NEI approach to restoration for nearshore Puget Sound estuaries (Thom et al. 2005). The NEI approach will be applied directly to the Keyport Lagoon mitigation, examining the net change through quantitative metrics from primarily a before-breach/removal basis compared to a post-breach/removal basis. When appropriate and possible, these metrics inside the Keyport Lagoon will also be compared to a reference site thought to be representative of the projected end stage of restoration within a regional system (i.e., a local pocket estuary).

Lastly, the RAMP provides an adaptive framework for monitoring the progress of the restoration effects dealing with unforeseen complications. An adaptive management approach to planning and management can help minimize the uncertainties inherent in this type of mitigation and restoration (Thom 2000). Adaptive management, in the most general definition, is a process for testing hypotheses through management experiments in natural systems, collecting and interpreting new information, and making changes based on the monitoring information to improve the management of ecosystems (Busch and Trexler 2003). In short, adaptive management is a process that allows managers, researchers, and stakeholders to learn from experience and react to conditions as they emerge. This report is intended to be used as a tool in this adaptive management process, providing the necessary information so the Navy, Stakeholder Working Group, and researchers can make informed decisions based on the most current scientific data from the monitoring program.

1.4 Actions During this Phase of the Project

Actions performed during the first part of the project primarily include the collection of pre-restoration environmental data at one or all of the following locations (see Section 2.0 for details): inside the Keyport Lagoon, immediately outside the lagoon split, and at a reference pocket estuary at Battle Point on Bainbridge Island. Specific tasks conducted by the Pacific Northwest National Laboratory (PNNL) included data collection in the following areas:

1. Local hydrology
2. Water property sampling
3. Habitat/substrate elevation
4. Sediment accretion
5. Channel morphology (at reference site only)
6. Vegetation surveys
7. Fish surveys
8. Sediment chemistry memorandum evaluating benchmarks for dioxin and furans (Brandenberger et al. 2011).

Tasks completed by other organizations working within the stakeholder group included:

1. Pier 8 at PSNS&IMF was removed;
2. A comprehensive survey of the Lagoon (elevation and bathymetry) and hydrologic and wave modeling was completed (Anchor QEA, LLC et al. 2011a);
3. Chemical analyses of surface and subsurface sediment sampling collected from Keyport Lagoon was completed for a suite of organic and inorganic contaminants (Anchor QEA, LLC et al. 2011b;c);
4. Regional mussel watch sampling was conducted in 2010 (see Johnston et al. 2009). Indigenous bivalves were collected from Sinclair Inlet, Dyes Inlet, Port Orchard Passage, Rich Passage, Agate Passage, Liberty Bay, and Keyport Lagoon. Composite samples were analyzed for a suite of trace metals and organic contaminants plus stable isotopes of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) (Brandenberger et al. 2010); and
5. Construction activities conducted by the Navy included the bulk of the construction of the new Pier B at the PSNS&IMF.

1.5 Summary of Changes from the RAMP

If, through the adaptive management process, changes are made to the RAMP to increase the chances for successful restoration at the Keyport Lagoon, they will be noted in this section so the readers may place the results that follow in the proper context. There have been no substantive changes in either the methodology or the adaptive management approach detailed in the RAMP. The pre-restoration or baseline data reported herein will provide the foundation for decision-making later in the adaptive management process and for future NEI calculations.

2.0 Methods

The methods for the ongoing monitoring at the Keyport Lagoon and reference site at Battle Point are highlighted here to aid in understanding the process and results. For more of the rationale and details of sampling methods, see the Field Sampling Plan in the RAMP (Thom et al. 2005, Appendix A). The pre-restoration monitoring focused on four primary focus areas that included: hydrology, water properties, habitat structure, and fish populations. Collectively, these metrics provide indicators of ecosystem condition and can be monitored over time to assess change and restoration success.

2.1 Hydrology

Pressure transducers (HOBO U-20 water level logger, Onset Computer Corp) were deployed to measure water depth inside and outside Keyport Lagoon in April 2009 and at the Battle Point reference site in July 2011. The sensor located inside Keyport Lagoon by the weir was damaged by a log during the first deployment year and was subsequently moved to a safer location along the eastern shore in 2011 (Figure 1.2). The data from the loggers were used to evaluate annual hydrologic patterns including inundation patterns. The data loggers are continuously deployed and will remain until the completion of the project.

Sensor	Deployment Date	Retrieval date
Keyport Outside	4/23/09	in place
Keyport Inside (near weir)	4/23/09	4/21/11
Keyport Inside (SW corner)	4/21/10	in place
Battle Point	7/13/11	in place

Inundation frequency and the sum exceedance value (SEV) were calculated at the elevations recorded at the site during the following time periods, which were standardized to include the exact same days in each year:

Growing season:	April 2 to November 18 (229 days)
Annual deployment period:	April 24 to April 20 (of the next year; 361 days)
Fish migration period:	March 1 to July 31 (153 days)

The SEV is a single measurement that incorporates magnitude and duration of surface water flooding (Simon et al. 1997, Gowing et al. 2002, Araya et al. 2010). The growing season used in the calculations was based on the number of frost-free days for the region as determined by the Natural Resource Conservation Service in the wetland determination table for Kitsap County, WA (NRCS 2002). The SEV is the cumulative amount of water (based on hourly measurements in meters) over the average elevation during the growing season and a full year using the following equation:

$$\text{SEV} = \sum_{i=1}^{n} (d_{\text{elev}})$$

where n is the number of hours present in the time period evaluated, and d_{elev} is the hourly water surface elevation above the average marsh elevation.

2.2 Water Properties

2.2.1 Long-term Temperature Measurements

Continuous measurements of water temperature were collected at two locations as part of the deployment of pressure transducers (HOBO U-20 water level/temperature logger, Onset Corporation) described in Section 2.1. The sensors were located in the most northerly portion inside the lagoon (referenced as “Inside depth/temperature sensor” in Figure 1.2, but moved to the eastern shore as described in Section 2.1) and outside the lagoon (referenced as “outside depth/temperature sensor” in Figure 1.2). The temperature data presented in this record were collected at 1-hour intervals between April 23, 2009 and April 21, 2011.

2.2.2 Synoptic Measurements of Water Property Data

In addition to the continuous measurements of temperature, water property parameters were measured on an intermittent seasonal basis between April 2009 and October 2011 (Table 2.1).

Table 2.1. Collection Dates of Water Property Parameters Inside and Outside Keyport Lagoon between 2009 and 2011

Year	Spring			Summer			Fall			Winter		
	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb
Year 1		4/9/09				8/6/09				12/8/09		
Year 2				6/2/10								2/09/11
Year 3		4/21/09			7/19/11			10/6/11				

Bulk surface water was sampled from a dock inside the lagoon near the weir and from a second station outside the lagoon, just shoreward of the HOBO depth/temperature sensor (Figure 1.2). The stations were approached by land and/or wading and sampled throughout an approximate 12-hour period of a full tidal cycle ranging between high and low water on an outgoing and incoming tide. Samples were collected approximately every 1.5 hours to characterize the range of conditions found inside and outside the lagoon during a tidal exchange. The collection method, parameters sampled, and analytical methods are summarized in Table 2.2. Specific details of sample collection and analysis methodology are provided in the RAMP (Thom et al. 2010, Appendix A).

In addition to the surface water collections at the two sites, vertical profiles of temperature, salinity and dissolved oxygen were collected on some sampling dates from various locations around the inside of the lagoon to provide an indication of seasonal depth stratification. These were collected from a boat using a handheld sonde (YSI, Yellow Springs, Ohio) at 0.5-m increments.

2.2.3 Data Analysis

Water property data were analyzed by date, station (inside and outside the lagoon), and season. The daily mean and variance (including field duplicates) was calculated, and exploratory analysis of the data was examined through correlation and principal component and similarity analyses for the parameters listed in Table 2.2. Data were also grouped by season for certain analyses: Winter (December – February), Spring (March – May), Summer (June – August), and Fall (September – November) (Table 2.1).

A cluster analysis was calculated for a subset of water property parameters using standardized variables defined as the observation minus the mean, divided by the standard deviation. The similarity between site-season combinations were calculated by Euclidean distance and a complete linkage rule. The overall approach of using similarity indices as an initial step in the NEI calculation is discussed in greater detail in Section 2.5.

Table 2.2. Keyport Lagoon Water Property Parameters Measured, Field and Laboratory Methods, and Sampling Frequency

Parameter	Field Method	Laboratory Method	Sampling frequency	Schedule
Long term continuous data loggers (inside and outside lagoon)				
Water level elevation	HOBO water level/temperature loggers	NA	1 hour	Ongoing since April 2009
Temperature				
Synoptic surface water collections (inside and outside lagoon)				
Temperature	Handheld sonde	NA	~ every 1.5 hours for 12 hour tidal cycle	Eight sample dates representing seasonal conditions
Salinity				
D.O.				
Chlorophyll_*a*	Surface Grab Sample	EPA method 445.0		
POC		Sugimura and Suzuki (1988)		
TSS (inorganic and organic fraction)		APHA Standard Methods 2540 C & E		
PO_4-P	Surface Grab Sample	Bernhardt and Wilhelms (1967)		
SiO_4-Si	Surface Grab Sample	Armstrong et al. (1967)		
NO_3-N				
NO_2-N				
NH_4-N	Surface Grab Sample	Slawyk and MacIsaac (1972)		
TP	Surface Grab Sample	Valderamma (1981)		
TN				
Vertical water column profiles (inside lagoon)				
Temperature	Handheld sonde	NA	Representative locations at 0.5-m vertical increments	Selected sampling dates (see text)
Salinity				
D.O.				
Water Depth				

D.O. = dissolved oxygen; TOC = total organic carbon; POC = particulate organic carbon; DOC = dissolved organic carbon; PO_4-P = phosphate; SiO_4-Si = silicate; NO_3-N = nitrate; NO_2-N = nitrite; NH_4-N = ammonia

2.3 Habitat Structure

The habitat metrics monitored in this baseline study represent important structural components that can be inferred to provide critical habitat functions. Elevation, hydrology (discussed above), and substrate are the primary factors that control wetland vegetation and are critical to designing and evaluating the effectiveness of restoration projects (Kentula et al. 1992). Specifically, sediment accretion is important for maintaining wetland elevation. These rates can vary substantially between natural and restored systems (Diefenderfer 2008), and baseline information on rates is important for understanding potential evolution of a restoration site. Assessment of channel cross sections and channel networks provides information on the potential for many important estuarine functions including fish access

(Simenstad and Cordell 2000) and export of prey, organic matter, and nutrients. This information is also necessary to develop the relationship between cross-section dimensions and marsh size, which aids in understanding the channel dimensions necessary for a self-maintaining restored area (Diefenderfer et al. 2009). Evaluating vegetation composition and species cover provides an indication of the many functions provided by wetland vegetation. These functions include the production of organic matter (macrodetritus), food web support, habitat for many fish and wildlife species including salmon, and contributing to overall biodiversity of the Puget Sound nearshore ecosystem. The habitat monitoring for this baseline study used standard monitoring protocols developed originally in the Columbia River estuary (Roegner et al. 2009) and are applicable to reference and restored wetlands in Puget Sound.

2.3.1 Elevation

Elevation surveys conducted by the PNNL were completed using a survey-grade Trimble real-time kinematic (RTK) Global Positioning System (GPS) and an auto-level. At Keyport Lagoon and the Battle Point reference site, the RTK base station was positioned over a Washington State Department of Transportation benchmark (GP18308-31) located nearby. The RTK rover was used to measure elevation at the approximate center of each vegetation sample location and along the elevation gradient from at the upper and lower boundaries of vegetation communities. At Keyport, a temporary reference point was also established then an auto-level was used for surveying points relative to the reference point. Elevations were also collected for channel cross sections of the tidal channel at the reference site. All depth sensors were also surveyed so water depths could be converted to water surface elevation.

All RTK elevation data were processed using Trimble Geomatics Office (TGO) and Geographical Information System software. The data from the Washington State Department of Transportation benchmark were used to correct the rest of the elevation data in TGO. The TGO is also used to verify data and make any necessary corrections based on field notes. Geographical Information System software is used to verify spatial data exported from TGO. Data collected using the auto-level method are entered into a spreadsheet and corrected using the RTK reference point elevations exported from TGO. All elevation surveys are referenced to the North American Vertical Datum 1988 (NAVD88). Average marsh elevations were calculated by averaging all the elevations from the vegetation survey plots that were vegetated.

2.3.2 Sediment Accretion

We deployed a set of sedimentation stakes at the Keyport Lagoon site in September 2009 and at the Battle Point reference site in July 2011. These stakes are polyvinyl chloride posts separated by 1 m where the distance from the plane at the top of the stakes to the sediment surface is measured as accurately as possible every 10 cm along the 1-m distance. The stakes are deployed during the summer and measured one year later to evaluate the change in surface elevation over the year. The 11 measurements are averaged, and the annual measurements are compared to each other to determine annual accretion or erosion rates in cm/year for the time period sampled.

2.3.3 Channels

Channel cross-section elevations were measured at the Battle Point reference site to characterize the primary tidal channel at the Battle Point reference site using the RTK GPS. Five channel cross sections from the mouth of the primary marsh channel to the headwaters were surveyed; intermediate cross-section surveys were conducted at the confluence of major secondary channels or equidistant along the channel, as appropriate (Adamus 2005, Roegner et al. 2009). Channel cross-section surveys were not conducted at the Keyport Lagoon site because most of the area is currently underwater. In future years, post-restoration, this metric will be added at the site.

2.3.4 Vegetation

Emergent marsh vegetation was sampled at the reference and restoration sites to quantify species assemblage and cover using a stratified random sampling design (Roegner et al. 2009). With this design, transects were established at set intervals along an established "baseline" with sample plots spaced equally on each transect with a randomly selected starting point. At each sample plot, cover by species is estimated in a 1-m^2 quadrat using 5% increments. The number of sample plots was determined based on the size and homogeneity of the area (Tiner 1999). In addition, vegetation mapping of broad plant communities was collected using a handheld GPS unit (GeoXT, Trimble, Sunnyvale, California).

Average percent cover was calculated for all the sample areas. The Bray-Curtis similarity was calculated on the square root transformed average cover using all 28 species found at both sites. Cluster analysis with complete linkage was conducted on the dissimilarity matrix resulting from the Bray-Curtis calculations.

2.4 Fish Surveys

Fish community compositions were sampled inside and outside the Keyport Lagoon numerous times throughout the year during this baseline study (Table 2.3). The sampling timing was largely dictated by the contract dates, but when possible, fish surveys were conducted monthly and twice a month when salmonids were more likely to be in the area (i.e., March through June). Samples were collected at six sites inside the lagoon (Figure 1.2) that represented the major shoreline types, with the exception of the bluff on the southern edge where beach seining was too difficult. Two additional sites were sampled immediately outside the lagoon in Port Orchard Passage (Figure 1.2). While this area is not a true reference site due to its very different habitat characteristics (i.e., exposed sandy shoreline), it provides an idea of the potential fish populations in the area that may take advantage of the Keyport Lagoon and place the community distribution inside the lagoon into context.

Table 2.3. Dates of Fish Sampling at the Keyport Lagoon for the Baseline Survey

Year	Sample Dates
2009	April 23; July 30
2010	March 30; April 23; May 7 and 21; June 4 and18; July 2; December 17
2011	January 21; February 18; March 3 and 18; April 1, 15, and 29; May 13 and 31; June 10 and 24; July 8; August 5; September 9; October 14

Fish surveys were conducted using a round-haul beach seine technique (e.g., Sather et al. 2009). The beach seine measures 24 m long and 1.8 m high, is composed of 0.3cm-mesh knotless nylon net, and is similar to those used locally by the Washington Department of Fish and Wildlife and in other estuary studies (e.g., Beamer et al. 2006). A 15.24 m (50 ft) line was attached to each end of the seine for deployment. The net was usually deployed using a small boat, but in very shallow water and outside the lagoon the seine was set by foot. The seine was set parallel to the shore and as close to 15.24 m offshore as possible. Scientists then hauled in on the end lines, pulling the ends of the seine net toward shore and creating a semi-circular pattern (Figure 2.1) that swept an area approximately 366 m^2. Once both ends of the net reached the shore, the field crew worked to evenly haul the net taking care to have the lead line remain in contact with the substrate. As the seine was hauled to shore, the catch was concentrated toward the center of the net. Fish were then removed from the net and placed into holding buckets filled with new water (i.e., from the immediate location). Battery-powered bubblers were usually used to aerate the buckets, especially in warm water or in the event of large catches. The fish were then identified to the lowest taxonomic group possible (usually species) and counted. For each species, overall lengths (except in species with obviously forked caudal fins when fork length was used) were recorded for up to 20 fish per haul. Fish were released back into the immediate area when processing was completed. This approach is based on the methods of Dorn and Best (2005) to allow comparability between the regional monitoring and Keyport Lagoon fish surveys. Other data were usually collected in conjunction with the seine set and included the time, temperature, salinity, and dissolved oxygen.

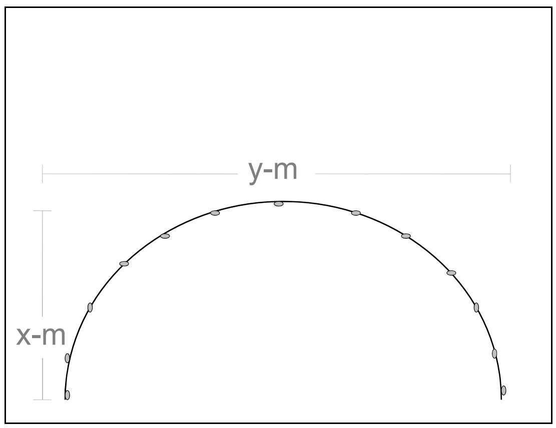

Figure 2.1. Round Haul Net Deployment Technique (Sather et al. 2009). The offshore distance (x) and the total length of the set (y) are evaluated with each set to determine the area swept.

2.5 NEI Calculations

The calculation of the NEI index is fundamentally simple and based on a conceptual model of the environmental components important for pocket estuaries to provide valuable ecosystem services. The NEI will consist of a number of metrics taken inside the Keyport Lagoon before and after the construction of the new bridge, and potentially outside the lagoon and at the reference site at Battle Point on Bainbridge Island (see Table 2.4 for examples). Similarity indices will be run on each metric to determine the relative comparability between the different data sets. These similarity values will then be used to calculate change (plus or minus) in relation to what would be expected from the restoration process. For example, one would expect that the tidal hydrology between the impounded lagoon and Port Orchard Passage to be relatively dissimilar before restoration but to have a much higher similarity value after the retaining sill is breached and the new bridge is constructed. Similarly, one would anticipate that the vegetation-elevation associations at the lagoon and the reference site would converge (i.e., become more similar) over time after tidal connectivity is restored at the lagoon. Once an individual similarity comparison is made for each metric and a relative value of improvement or degradation is assigned (i.e., a + or -), the individual values will be summed to provide a relative change from the last point. This relative change will be stronger with the greater number of similar values (e.g., pluses) there are for each metric and should provide an easily understood value for comparing changes in overall ecosystem function over time.

The NEI will provide one value for comparison but the underlying theory and similarity calculations should provide insight into the causal factors driving the change trend. Expressing the performance of individual metrics provides managers and stakeholders a tool to down-select processes and functions that are underperforming and may require review within the adaptive management process. For example, the NEI in five years indicates that restoration is having a positive impact, but the change was hypothesized to be more significant and faster. Looking at the list of individual similarity comparisons (and trends) may point out that all metrics are generally improving except for channel formation, which is consistently diverging relative to the reference site. The stakeholder group would then evaluate potential factors that may result in the divergence and create new goals or actions required within the adaptive management process to enhance recovery or accept the divergent condition. Actions would be identified by the adaptive management report and may include mechanically creating some channels to initiate the essential processes that maintain channels in pocket estuaries. Such targeted information can help save time and money, support the adaptive management process with scientifically defensible data, and increase the chances for a successful outcome to the restoration.

Table 2.4. Example of Metrics that Can be Considered in Calculating the NEI and the Different Dataset to be Potentially Used for Comparison[a]

Metric	Areas for comparison			
	Before	After	Outside	Reference
Tidal hydrology	✓	✓	✓	✓
Sediment accretion	✓	✓		✓
Channel formation	✓	✓		✓
Vegetation/elevation comparisons	✓	✓		✓
Water properties (salinity, temperature)	✓	✓	✓	✓
Salmon populations	✓	✓	✓	?
Other fish populations	✓	✓	✓	✓

[a]Before and After refer to data collected inside the Keyport Lagoon in relation to pre- and post- weir removal, Outside refers to data collected outside the lagoon in Port Orchard Passage, and Reference refers to the reference site at Battle Point.

3.0 Results

3.1 Hydrology

Water level loggers were placed inside and outside the lagoon (see Figure 1.2 for locations) then converted from water depth to water surface elevation (WSE) to allow comparison between WSEs at both locations. Conversion to WSE also allows for comparison to other relevant elevations, such as marsh elevations and the elevation of the weir. The hydrograph showing the WSE over the 2-year time period is shown in Figure 3.1 with the average marsh elevation and the weir elevation for reference. The most obvious difference between the Inside and Outside WSEs is the daily range of tides measured at the Outside sensor (~3 – 5 m) and the muted range measured at the Inside sensor (~0.1 – 0.7 m) (see Table 3.1). Differences between years are also observable, with 2009 having a greater number of winter high-water events than 2010 both inside and outside the lagoon.

Table 3.1. Weir Elevation (datum conversions from NOAA Vertical Datum Transformation Tool)

	Weir Elevation	
Datum	Feet	meters
NAVD88	7.6	2.32
MLLW	10.2	3.10

Some inter-annual variability is apparent between years in both the Inside and Outside WSE. Inundation of the average marsh elevation at Keyport Lagoon was greatest during the period from April 2009 to April 2010 (Table 3.2.) as measured by the percent of time inundated and the SEV (incorporating duration and magnitude). Comparison of data from the Inside and Outside sensors shows that the percent of time inundated would not necessarily increase if the hydrologic regime was closer to that outside the lagoon; however, the magnitude of the inundation (SEV) would be greater. During the growing season, the existing hydrology at the lagoon site resulted in 0.5 m-hours of inundation, while the estimated inundation using the Outside data resulted in 41 m-hours. Inundation was lowest during the growing season, indicating that most of the inundation occurs during the winter, which is likely due to a combination of high tides and high precipitation events.

Inundation at the Battle Point reference site was calculated using the WSE's from the Outside sensor at Keyport Lagoon, since the reference site sensor was not installed until 2011. These calculations are estimates of the inundation of the site but provide an indication of patterns that could be expected. Similar to Keyport Lagoon, the average marsh elevation (10.9 ft, MLLW) was inundated the greatest percentage of time during the 2009 to 2010 period. However, the slightly lower average elevation resulted in a greater SEV at this site in both years than at the Keyport Lagoon site. Likewise, during the growing season inundation was 71 m-hours at the average marsh elevation at the Battle Point site.

Table 3.2. Inundation Calculations for the Average Marsh Elevation inside Keyport Lagoon (11.2 ft, MLLW) using the WSE for Inside and Outside the Lagoon

	Frequency of Inundation		SEV	
Period	Inside WSE	Outside WSE	Inside WSE	Outside WSE
2010 Growing Season	0.3%	5.1%	0.5	41.0
April 2009 – April 2010	14.5%	8.2%	134.7	155.7
April 2010 – April 2011	3.7%	7.0%	37.8	115.3

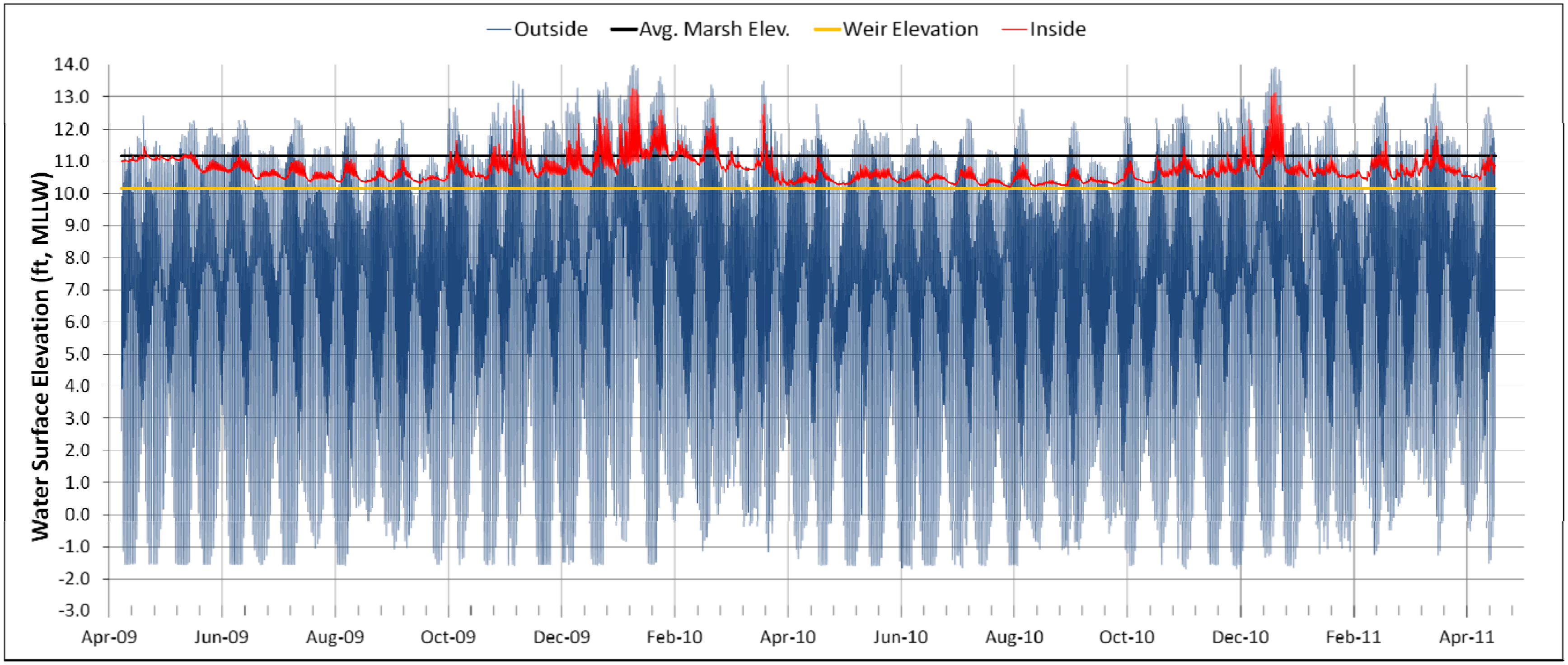

Figure 3.1. WSE Relative to MLLW from Data Collected by Water Level Loggers Located Inside and Outside Keyport Lagoon between April 2009 and April 2011

Another way of looking at the differences in inundation patterns is to look at the frequency of inundation over the entire elevation range for the site (Figure 3.2). The patterns are quite different between the inside and outside of Keyport Lagoon. Most notable is the sharp increase in frequency below 11-ft elevation (relative to MLLW) inside the lagoon caused by the weir retaining water (weir elevation = 10.2 ft, MLLW). This inundation pattern at Keyport Lagoon has resulted in a difference between the lower marsh elevations at Keyport Lagoon (10 ft, MLLW) and Battle Point (9 ft, MLLW) (see Section 3.2.5; Figure 3.8), with most of the marsh at Keyport Lagoon above 11 ft, MLLW. The inundation frequency observed outside is a good indication of the frequencies of inundation that would be expected inside the lagoon post-restoration.

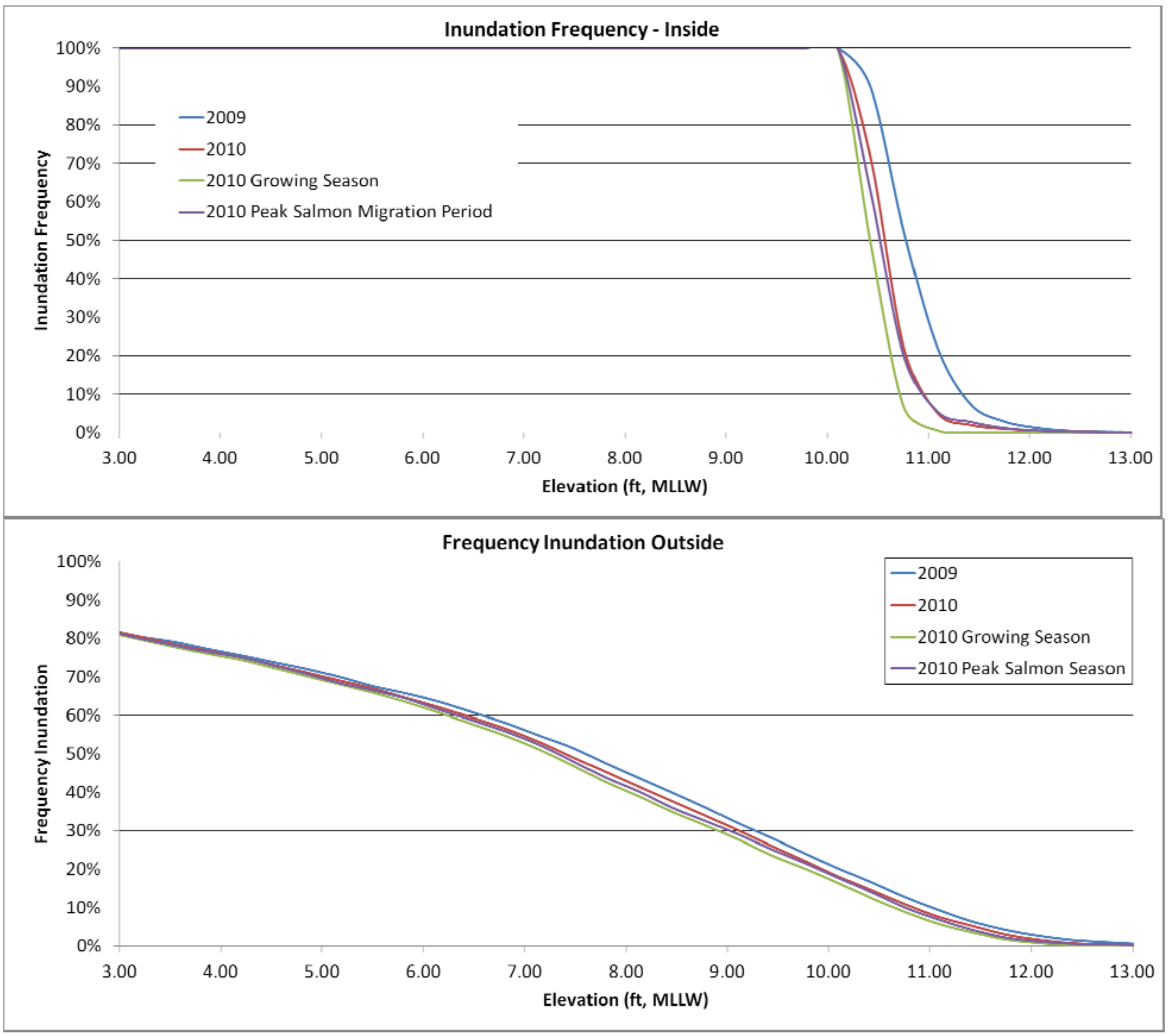

Figure 3.2. Frequency of Inundation Over the Elevation Range of the Marsh Vegetation at Keyport Lagoon and Battle Point Sites Using Data from the Inside and Outside Sensors

3.2 Water Properties

3.2.1 Long-term Temperature Measurements

Data from the long-term temperature sensors, collected between 2009 and 2011, showed a notable daily, monthly, and seasonal fluctuation of water temperature inside and outside the lagoon (Table 3.3, Figure 3.3). The monthly mean high temperature occurred during the summer months (June through August) and ranged between 22 and 24°C inside the lagoon and between 14 and 15.5°C outside the lagoon (Figure 3.3, Table 3.3), with an average temperature differential of approximately 9°C between the inside and outside. The monthly mean low temperatures occurred during the winter months (December through February) and ranged between 7.8 and 10.2°C. The temperature difference between inside and outside the lagoon was closely coupled during the winter (~1°C difference) with higher temperatures occurring inside the lagoon. The magnitude of the daily temperature fluctuation was generally greater on the inside of the lagoon. During the winter months, the sensor was infrequently exposed to the atmosphere, accounting for the negative minimum temperature values (Table 3.3, November and December 2010, and January 2011).

As a point of reference, the Washington State Department of Ecology's Aquatic Life Temperature Criteria in Marine Waters (WAC 2011) would consider marine waters at 16°C to be designated Excellent in the quality category. Temperatures of concern for salmon vary depending on the lifestage and activity (e.g., spawning, rearing, migration), location, and season. An example threshold of 17.5ºC (WAC 2011) was plotted on Figure 3.3, using the 7-day average daily maximum (7-DADmax), which shows that 46% of the time this temperature was exceeded inside the lagoon, and 3.6% of the time it was exceeded outside the lagoon.

Table 3.3. Monthly Mean (± 1 S.D.) Water Temperature from Water Elevation/Temperature Sensors Inside and Outside Keyport Lagoon

Date	Inside Water Temp. (°C)			Outside Water Temp. (°C)		
2009	**Mean (S.D.)**	**Max.**	**Min.**	**Mean (S.D.)**	**Max.**	**Min.**
April, 09	18.51 (1.13)	20.71	14.71	10.63 (0.82)	15.47	9.47
May, 09	21.81 (3.17)	28.36	13.27	11.97 (1.44)	20.42	9.47
June, 09	23.43 (2.19)	28.36	17.67	14.91 (1.14)	18.43	12.21
July, 09	23.76 (2.12)	28.75	19.47	15.42 (0.96)	19.95	13.27
August, 09	22.57 (1.92)	28.36	18.05	15.49 (0.84)	19.85	13.85
September, 09	20.29 (1.43)	23.10	16.05	14.75 (0.57)	16.90	13.27
October, 09	13.92 (1.36)	18.05	10.85	12.66 (0.62)	14.04	10.85
November, 09	10.77 (0.97)	13.75	7.78	10.31 (0.74)	12.01	8.58
December, 09	8.36 (1.04)	11.14	6.06	7.84 (0.89)	9.97	3.89
2010						
January, 10	8.76 (0.35)	9.47	7.68	8.52 (0.25)	8.88	7.38
February, 10	10.75 (1.24)	13.65	8.68	8.78 (0.16)	9.57	8.38
March, 10	12.82 (1.82)	17.86	7.98	9.36 (0.54)	12.30	8.38
April, 10	14.47 (2.42)	19.09	8.88	10.25 (0.82)	13.46	8.88
May, 10	19.11 (2.49)	24.55	13.65	12.27 (0.82)	17.57	10.46
June, 10	22.26 (2.01)	25.71	16.33	13.93 (0.86)	18.52	11.92
July, 10	23.89 (1.52)	28.66	18.81	15.44 (1.02)	20.23	13.56
August, 10	22.81 (1.62)	27.76	17.76	15.30 (0.78)	18.33	13.56
September, 10	20.20 (1.15)	23.39	16.24	14.55 (0.40)	15.95	13.56
October, 10	17.64 (2.65)	23.97	11.82	13.04 (0.87)	14.80	10.85
November, 10	10.77 (2.74)	14.61	3.05	10.05 (1.68)	11.92	0.01
December, 10	8.38 (0.50)	9.47	6.17	8.30 (0.55)	9.28	2.62
2011						
January, 11	8.46 (0.84)	10.46	5.86	7.52 (0.65)	8.38	-1.34
February, 11	10.24 (1.59)	13.08	5.04	7.41 (0.53)	8.58	5.04
March, 11	10.08 (1.46)	12.59	5.86	7.76 (0.76)	11.92	5.86
April, 11	13.48 (1.77)	17.38	8.88	8.95 (0.48)	13.65	8.28

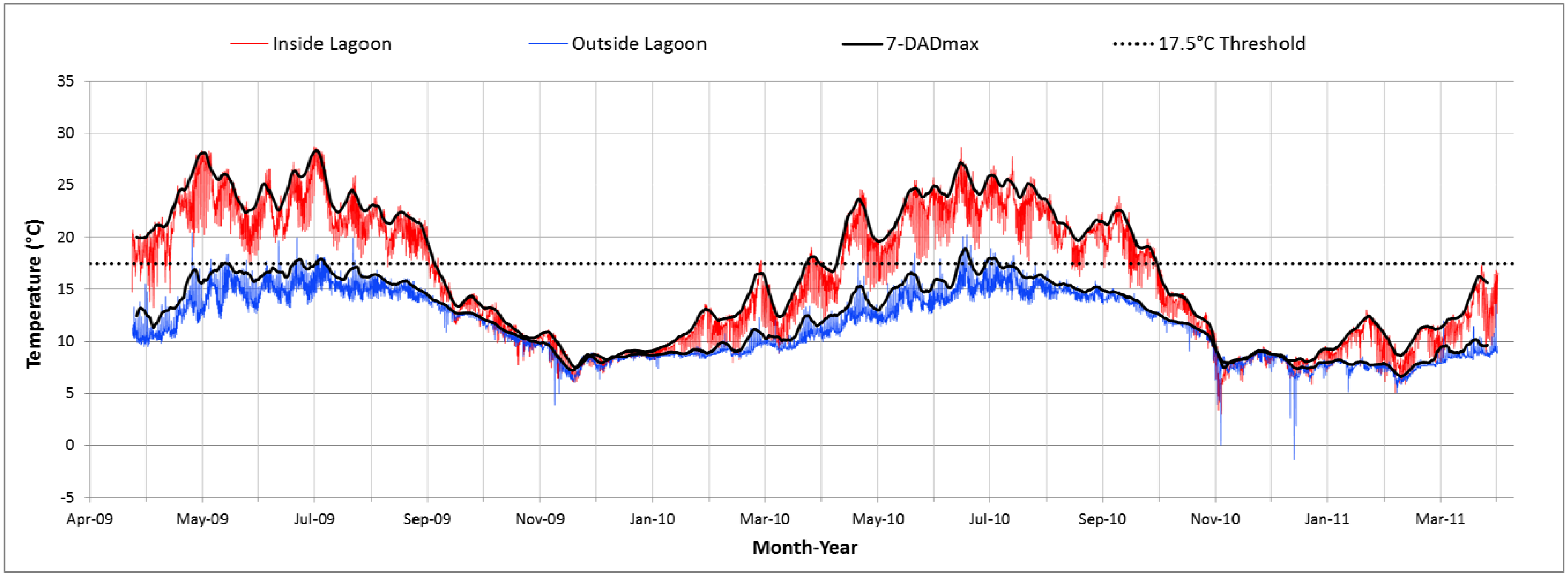

Figure 3.3. Hourly Temperature Observations from the Long-term Depth/Temperature Sensors Inside (red) and Outside (blue) the lagoon. The 7-day average daily maximum (7-DADmax) is shown along with the Washington State Department of Ecology's Aquatic Life Temperature threshold of concern for salmon.

3.2.2 Synoptic Water Property Measurements

Water property samples were collected during a range of tidal phases and amplitudes throughout the study. Figure 3.4 shows the predicted tidal elevation (Nobeltec Tides and Currents, were. 3.5.107) and measured water level from the HOBO sensors for each day of sampling. The predicted tidal amplitude ranged from a high of 14.8 ft (MLLW) on April 28, 2009 to a low of 9.5 ft (MLLW) on February 9, 2011 (Figure 3.4). The timing of sampling was uniformly distributed throughout the day based on the predicted tidal exchange of incoming and outgoing water for that day (Figure 3.4, samples inside and outside lagoon). However, because of the lack of tidal exchange within the lagoon, data were averaged throughout the day for most analyses rather than partitioned by tidal stage. The weir height, at approximately 10.5 ft (MLLW), restricted the flow of water into the lagoon during an incoming tide until the water level had reached the height of the weir. This is illustrated in Figure 3.4(f) where the predicted and measured water level outside the lagoon reached 13.0 ft (MLLW), thus allowing the water to spill over the weir into the lagoon, raising the water level for a short time to approximately 11 ft (MLLW) on a higher incoming tide. Hence, the effective water elevation inside the lagoon ranged between 10.5 and 11 ft (MLLW), an elevation change of 0.6 ft that occurred during high spring tides. Water is, effectively, flowing over the weir leaving the lagoon most of the time due to a small stream entering the west end of the lagoon effect. These data confirm the conditions assessed by the Navy and summarized in the CMP (U.S. Navy 2008a).

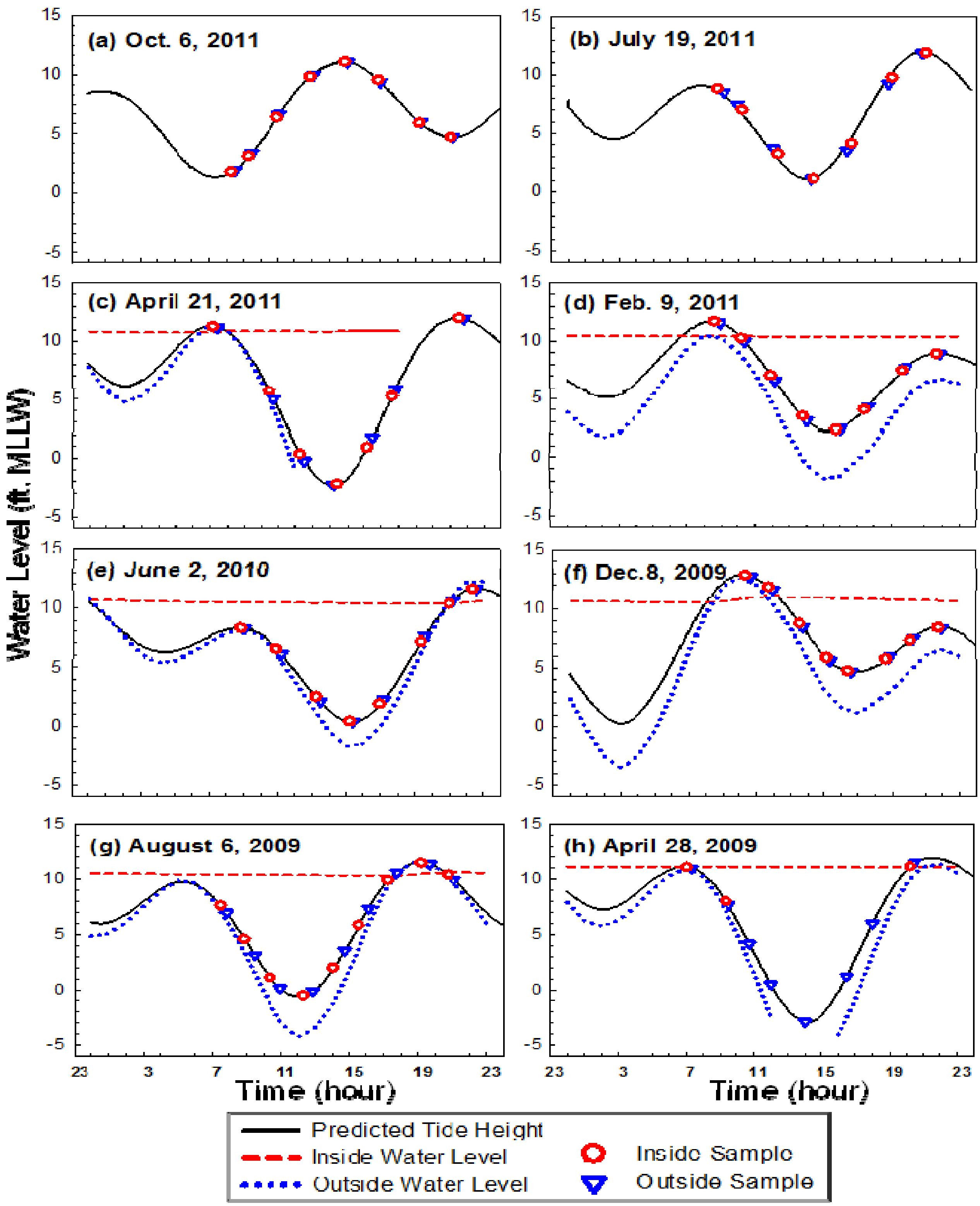

Figure 3.4. Predicted and Measured Water Elevation (ft, MLLW) Inside the Lagoon for each Water Property Sampling Date, Between (a) October 6, 2011 and (h) April 28, 2009. The time of sample collection is shown on predicted tides. Measured water elevation was not available for all sample dates.

Selected water property parameters are summarized in Table 3.4 and Figure 3.5. Several of these physical and biogeochemical constituents (e.g., temperature, salinity, DOC) will be used as water property performance metrics for future NEI calculations, and as such, are providing a baseline characterization prior to the weir removal. The data are summarized by date and by stations inside and outside the lagoon, shown in Figure 1.2. A summary of all of the water property data is provided in Appendix B.

The temperature data collected during the sampling events (Table 3.4, Figure 3.5) corresponded to the temperature data collected from the long-term sensors (Figure 3.3), although the site location and sample depth varied somewhat between measurement types. The mean temperature inside the lagoon was greater during all months except the winter months when they very closely corresponded (December 2009, February 2011) (Figure 3.5). Salinity was always lower inside the lagoon compared to the outside (Figure 3.5b) due to the freshwater stream inflow from the western portion of the lagoon. A surface salinity low of 11.6 psu was measured from the dock inside the lagoon during April 2011, with a high of 33 psu measured outside the lagoon during July 2011. Near-surface dissolved oxygen levels were generally higher outside the lagoon compared to inside during spring and summer and similar or slightly lower during the winter months (Figure 3.5). Generally, dissolved oxygen levels were higher than 4.0 mg/L, a threshold for designation as "fair" quality for fish health in Washington State waters (WAC 2011).

However, dissolved oxygen levels decreased with depth inside the lagoon as shown in an example profile from June 2010 (Figure 3.6). Chlorophyll*a* levels (Figure 3.5d) were similar inside and outside the lagoon, with the exception of the summer months (August 2009 and June 2010) when the mean levels outside the lagoon were approximately four times greater than the inside. Samples were collected close to shore just outside the lagoon and occasionally captured localized algal blooms that were ephemeral in nature. Note the variability in concentration throughout the day outside the lagoon was very high as well: August 2009 (12.4 ±10.0 µg/L) and June 2010 (12.3±7.4 µg/L). The DOC concentrations (Figure 3.5e) were consistently slightly elevated inside the lagoon compared to outside, and as such, represented a source of carbon export to the nearshore environment. The DOC during October 2011 was elevated above all other seasonal measurements by a factor 2 to 4-fold both inside and outside the lagoon.

Total suspended sediment (TSS) concentrations (Figure 3.5f) varied between location and by date depending on factors such as wind resuspension in the nearshore, tidal stage, and algal biomass. Additional water quality data are summarized in Appendix B.

Table 3.4. Mean (± 1 S.D.) of Selected Water Property Parameters for Each Date Sampled Inside and Outside Keyport Lagoon. KO = Outside Lagoon, KI = Inside Lagoon Site.

Date	Site		Surface water temp. (°C)	Salinity (psu)	D.O. (mg/L)	chl a (ug/L)	DOC (mg C/L)	Total Suspended solids (mg/L)	TN (ug/L)	PO4 (ug/L)
4/28/2009	KI	n=8	15.53	11.58	12.36	1.66	-	4.64	-	11.14
			(0.95)	(0.12)	(1.03)	(1.10)	-	(0.61)	-	(4.97)
	KO	n=3	11.50	29.03	13.29	0.65	-	20.62	-	46.66
			(1.49)	(0.46)	(2.29)	(0.11)	-	(14.65)	-	(9.29)
8/6/2009	KI	n=9	23.36	27.01	6.46	2.85	2.94	16.00	582.41	107.12
			(0.31)	(0.31)	(0.75)	(0.40)	(0.61)	(5.09)	(47.93)	(9.53)
	KO	n=9	17.36	29.69	10.68	12.41	1.16	16.63	443.49	64.76
			(0.59)	(0.08)	(1.24)	(10.03)	(0.46)	(3.59)	(77.10)	(3.42)
12/8/2009	KI	n=8	5.19	23.21	6.55	1.24	2.15	6.35	1305.40	63.51
			(1.39)	(2.38)	(1.23)	(0.44)	(0.28)	(2.62)	(88.67)	(5.35)
	KO	n=8	7.61	29.48	7.18	0.87	0.97	4.65	775.28	86.68
			(0.38)	(0.24)	(0.77)	(0.38)	(0.09)	(1.05)	(57.37)	(1.80)
6/2/2010	KI	n=8	19.97	22.34	7.78	3.12	2.90	2.97	328.55	24.69
			(0.87)	(0.91)	(0.68)	(1.42)	(0.20)	(0.62)	(28.22)	(8.45)
	KO	n=8	13.68	28.75	10.49	12.28	1.66	24.69	360.92	70.27
			(0.71)	(0.11)	(0.42)	(7.38)	(0.09)	(19.05)	(84.86)	(7.14)
2/9/2011	KI	n=8	5.98	15.82	11.48	0.67	2.89	4.64	1167.62	45.01
			(1.82)	(2.02)	(0.96)	(0.14)	(0.23)	(1.43)	(69.80)	(2.18)
	KO	n=8	7.79	27.20	11.09	0.70	1.26	10.76	605.32	77.29
			(0.44)	(0.29)	(0.64)	(0.16)	(0.14)	(7.63)	(72.63)	(1.28)
4/21/2011	KI	n=8	16.49	22.87	12.89	5.21	2.86	4.70	406.90	13.41
			(2.44)	(2.15)	(1.54)	(1.68)	(0.40)	(1.42)	(60.97)	(7.37)
	KO	n=8	11.89	26.83	12.22	2.10	1.70	15.39	446.25	60.61
			(2.60)	(1.66)	(1.18)	(0.55)	(0.48)	(17.49)	(40.44)	(5.42)
7/19/2011	KI	n=6	23.36	25.57	7.52	5.57	3.73	8.32	405.36	55.29
			(1.24)	(1.14)	(1.16)	(3.03)	(0.19)	(4.21)	(44.80)	(15.66)
	KO	n=7	15.75	33.27	8.12	2.79	1.84	13.82	783.68	66.37
			(2.46)	(0.70)	(0.94)	(1.94)	(0.73)	(10.44)	(198.53)	(11.69)
10/6/2011	KI	n=8	17.88	23.13	-	5.11	7.80	10.98	571.94	81.08
			(0.33)	(1.81)	-	(2.03)	(0.87)	(5.01)	(101.58)	(9.78)
	KO	n=8	13.51	30.19	-	4.66	7.91	13.36	482.30	61.09
			(0.35)	(0.65)	-	(3.90)	(1.93)	(8.58)	(42.37)	(8.08)

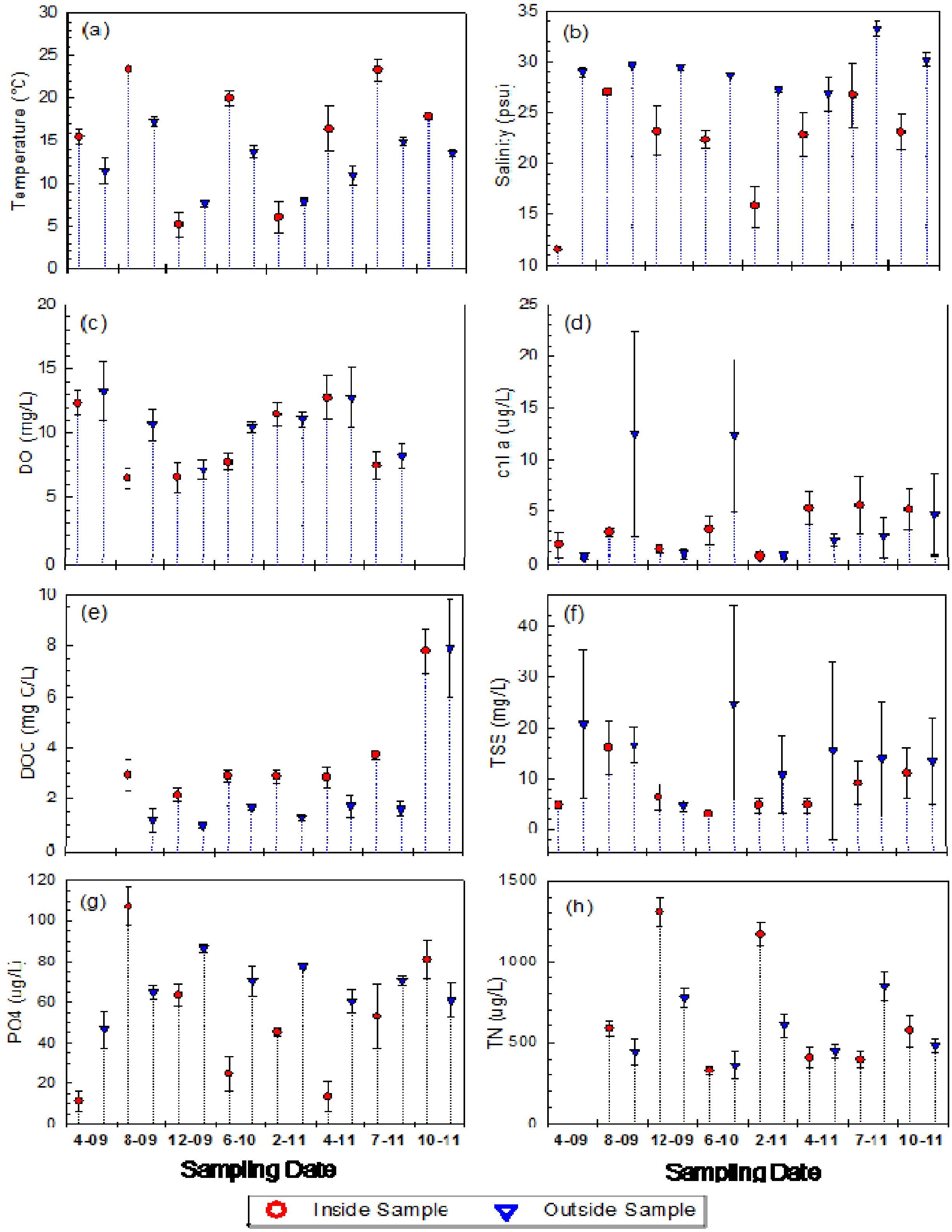

Figure 3.5. The mean (±1 S.D.) for Selected Water Quality Metrics from Each Date Sampled (Table 2.1) for a) Surface Water Temperature, b) Salinity, c) D.O., d), chl_a, e) DOC, and f) TSS

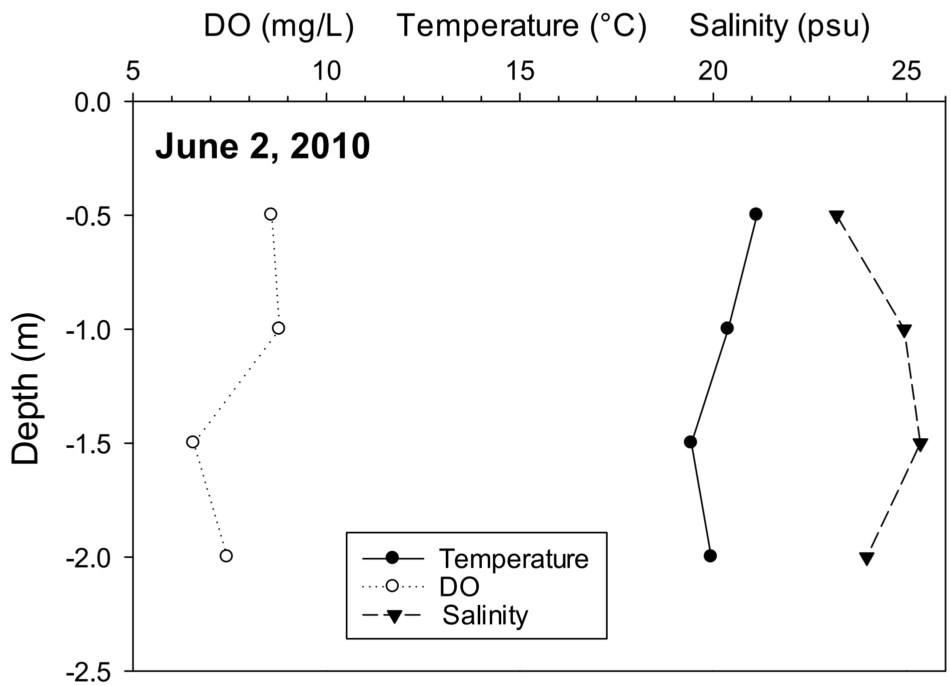

Figure 3.6. An Example Depth Profile of Water Temperature from Representative Locations Inside Keyport Lagoon

3.2.3 Similarity Index for Baseline NEI Characterization

As a means of summarizing the relative differences and similarities inside and outside the lagoon, a similarity index was calculated for the full suite of water property variables listed in Table 3.5 and shown in Appendix B). The analysis indicated a median value of 50% similarity (C.I. 48% - 62%) between water properties inside the lagoon and outside of the lagoon. Table 3.5 shows the similarity analysis by month for each site pair (inside and outside), which ranged from a low of 28% in February 2011 to a high of 56% in October 2011.

Table 3.5. Similarity Index for Each Site Pair by Month and Year for All Variables. KI = Keyport Inside station, KO = Keyport Outside station.

Inside	Outside	Similarity
KI 8-09	KO 8-09	48%
KI 12-09	KO 12-09	50%
KI 6-10	KO 6-10	40%
KI 2-11	KO 2-11	28%
KI 4-11	KO 4-11	50%
KI 7-11	KO 7-11	41%
KI 10-11	KO 10-11	56%

A similarity index was also calculated for a reduced suite of variables (temperature, salinity, DOC, TN and PO_4). This suite of variables provided a similar result with a median of 48% similarity (C.I. 40%

- 50%). A non-metric multi-dimensional scaling test was used to evaluate differences among the dates and the two sites sampled using the reduced suite of variables mentioned above. The plot in Figure 3.7 does not show a distinct pattern between site location and/or date, although the outside station dates are clustered more closely together than the inside station dates.

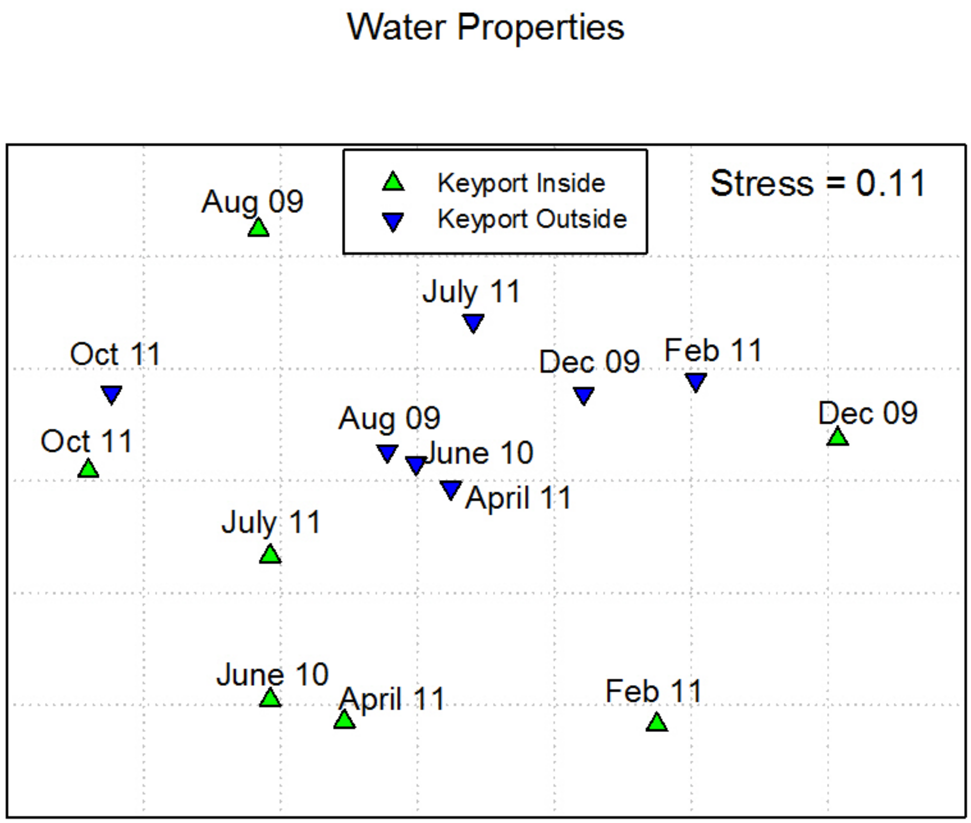

Figure 3.7. Multidimensional Scaling Plots for Collective Water Property Metrics Based on Seasonal Sampling Inside and Outside the Lagoon. Axes are dimensionless and proximity is based on Euclidean distance, with points closer together indicating greater similarity.

3.3 Habitat Structure

3.3.1 Elevation

Elevations at the Keyport Lagoon site and the Battle Point reference site were collected relative to the NAVD88 and are reported here as such unless noted otherwise. The surveyed elevation range of the vegetated marsh plain in the lagoon was 2.2 m to 2.8 m and at the Battle Point site was 2.0 m to 3.3 m. The average marsh elevation at the Keyport Lagoon site was 2.63 m and at the Battle Point reference site was 2.54 m. The overall slope and profile of the sites are shown in Figure 3.8. The weir elevation is approximately 2.320 m (NAVD88) as measured with the RTK GPS on 9/4/09. Conversions of this elevation to other datums are provided in Table 3.1.

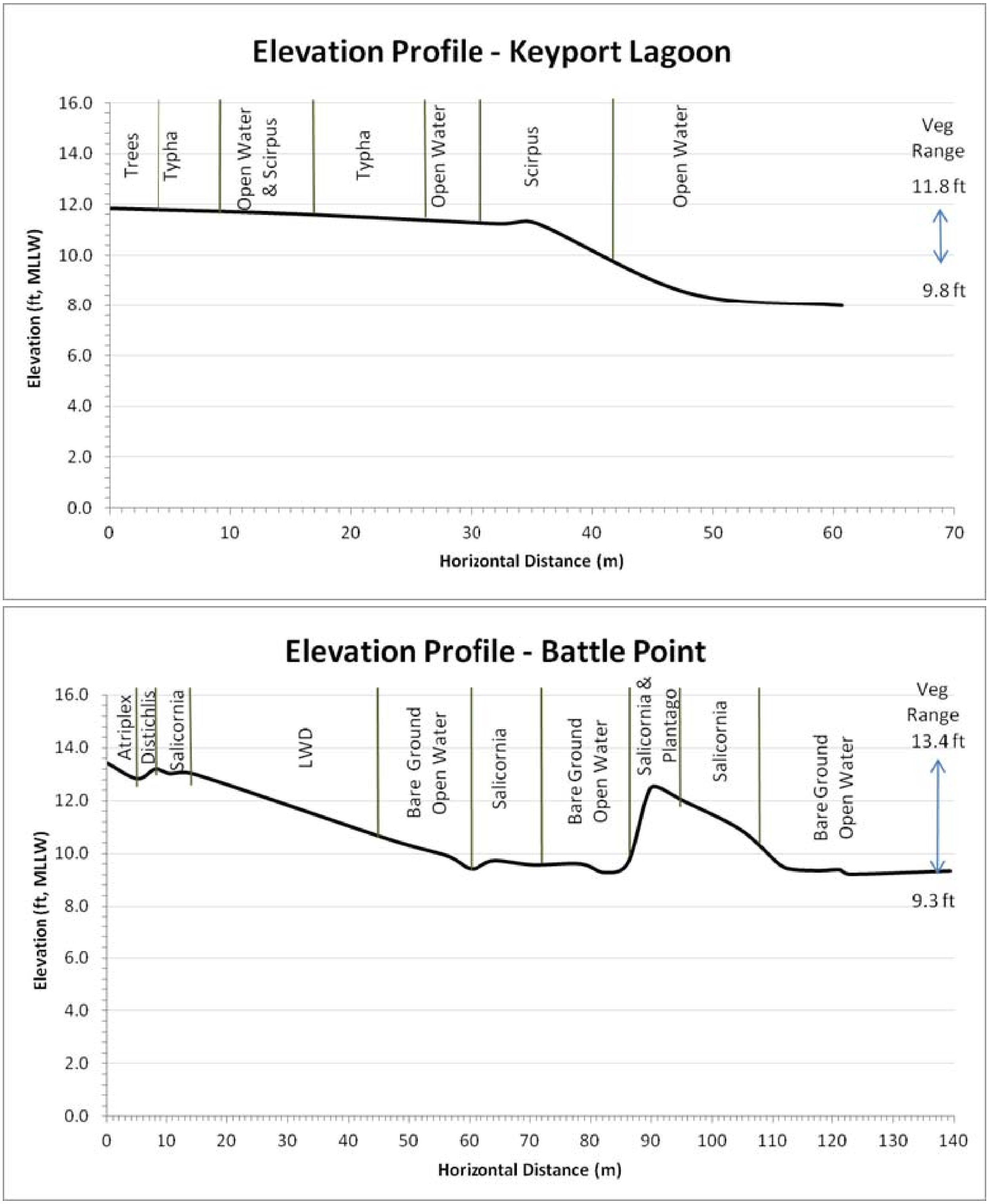

Figure 3.8. Representative Elevation Profiles and Cover Type from Keyport Lagoon and the Battle Point Reference Site (see and Figures 3-9 and 3-10 for locations of profile transects).

3.3.2 Sediment Accretion

The annual sediment accretion rate at Keyport Lagoon was calculated to be 0.85 cm/year for the sampling period between April 2009 and July 2011. Sediment accretion stakes were installed at the Battle Point reference site in 2011 and will be measured in future years to determine annual rates.

3.3.3 Channels

Channel cross sections were measured at the Battle Point site. Total channel length from the mouth to the upper lagoon was 281 m, with 199 m of the channel surveyed between the mouth and the constriction mid-lagoon (see Figures 3.9 and 3.10 for locations of cross sections). The thalweg elevations between cross-sections varied little but the bank elevations decreased from the mouth to the constriction mid-lagoon at cross section 5. The channel was elevated near the mouth (at the second cross section) and was approximately 0.29 m higher than the thalweg at the deepest point surveyed (Table 3.6).

The Battle Point reference site cross sections and WSE's from the Outside sensor at Keyport Lagoon were used to calculate channel (different than marsh) inundation frequencies during three periods: the annual deployment periods, April 24 through April 20 of 2009-2010 and 2010-2011, and the 2010 peak salmon migration period. The percent of time in which water levels were greater than 50 cm in the channel and greater than 10 cm above the banks was determined for the three periods (Table 3.6) as indicators of connectivity and salmonid access to the Battle Point reference site channel and bank. In general, the percent of time the water level was either above 50 cm in the channel or above 10 cm on the banks was slightly lower during the peak salmon migration period than during the two annual deployment periods; similarly, inundation was generally more prevalent during the 2009-2010 deployment than the 2010-2011 deployment. Access near the channel mouth (cross section 2) was limited to inundation approximately 13% of the time for all three periods. There is of particular importance in channel mouth access as this is the initial entryway; if inundation is low near the channel mouth, there are further limitations on access up channel despite higher frequencies of inundation. Channel and bank access varied in a similar pattern for the three periods, first decreasing, increasing, and then decreasing again. For example, the percent time that the water level in the channel was greater than 50 cm during the peak migration period first decreased from the channel mouth up the channel to cross section 2, increased from cross section 2 to 3 and 4, and then decreased from cross section 4 to 5. The percent time the banks were inundated was lowest at the mouth for the three periods, lowest during peak salmon migration at 0.19%, and highest up channel at cross section 5.

Table 3.6. Channel Cross Section Elevations and Inundation Frequencies

Elevation (ft, MLLW)				Annual Deployment Period, 2009-2010		Annual Deployment Period, 2010-2011		Peak Salmon Migration Period, 2010	
Cross Section Location	Bank	Thalweg	Channel Depth (m)	% Time WL >50 cm in channel	% Time WL >10 cm at top of channel bank	% Time WL >50 cm in channel	% Time WL >10 cm at top of channel bank	% Time WL >50 cm in channel	% Time WL >top channel bank +10 cm
1 (mouth)	10.1	5.7	1.32	22.16	0.58	20.11	0.29	19.72	0.19
2	8.8	6.3	0.76	15.47	4.37	13.46	3.31	12.95	2.35
3	7.3	5.8	0.45	21.53	19.56	19.31	17.59	19.07	17.10
4	7.4	5.4	0.63	26.58	17.74	24.82	15.88	23.74	15.21
5	7.0	6.0	0.33	19.62	22.36	17.64	20.30	17.15	19.86

3.3.4 Vegetation and Elevation

Vegetation community maps for the Battle Point reference site and the Keyport Lagoon site are provided in Figure 3.9 and Figure 3.10. The sites are very different in their vegetation species assemblages even through their elevations are not dramatically different (Figure 3.8). This is likely due to the differences in inundation and salinity between the two sites (see Section 3.1 and 3.2.2 above).

Results for quantitative vegetation sampling are presented here for the northern and southern sample plots at Keyport Lagoon for years 2009 and 2011 (Key-N; 25 quadrats and Key-S; 5 quadrats) and Battle Point sampling in 2011 (BP; 32 quadrats). Twenty-eight species including grasses, herbs, sedges, and rushes were observed on average at least once in the study area. There were seven species having an average cover greater than 10% (Table 3.7).

Table 3.7. Species with Greater than 10% Average Cover by Site and Year (vegetation species names are provided in Appendix A: Vegetation Species Cover).

		Site				
Species Code	Species Type	Key-N 2009	Key-S 2009	Key-N 2011	Key-S 2011	BP 2011
CACA	Grass	8	32	30	60	0
SYSU	Herb	1	31	4	6	0
SAVI	Herb	1	0	0	0	24
POAN	Herb	7	3	5	16	0
SCMA	Sedge	12	0	16	0	0
TYLA	Herb	8	0	11	0	0

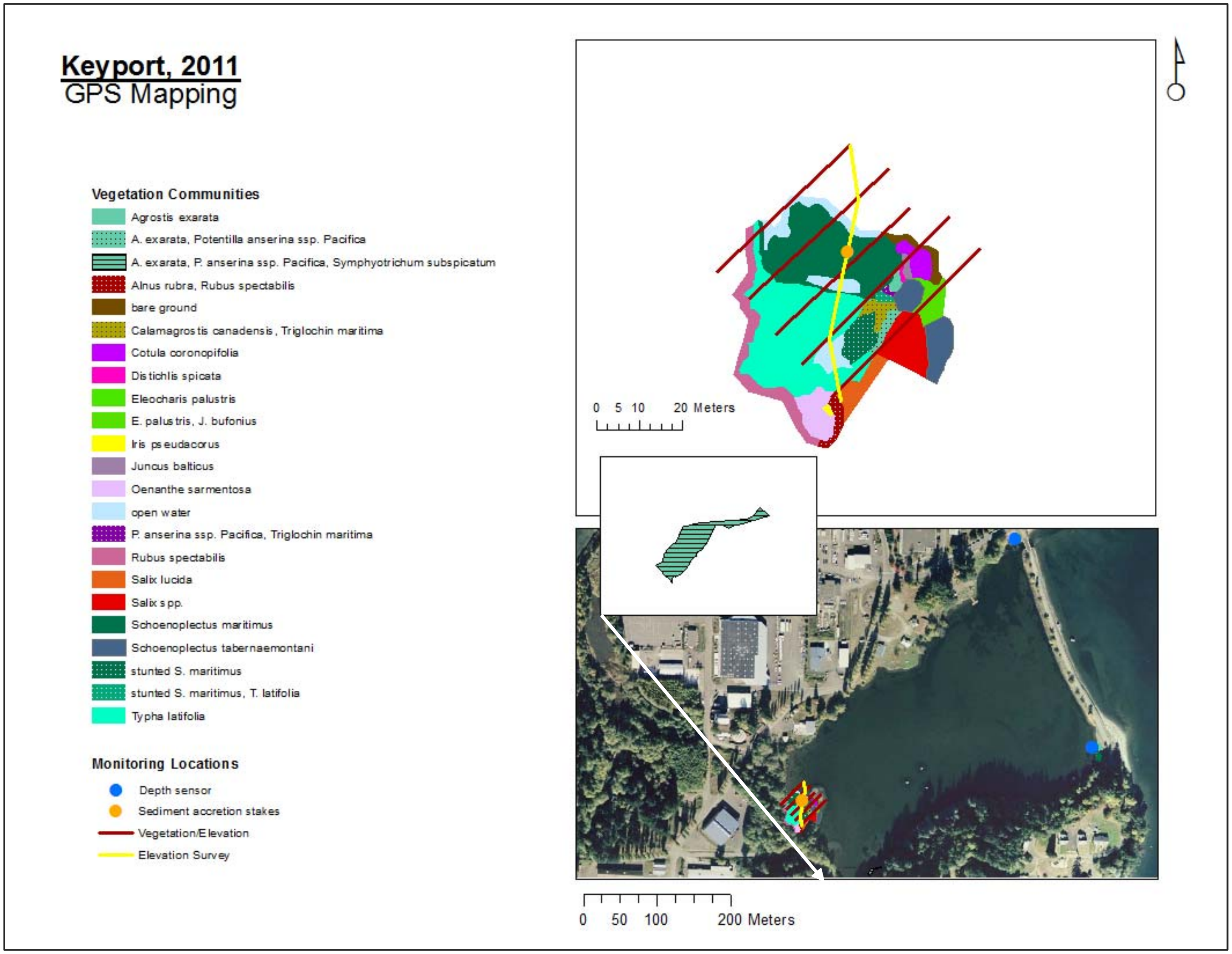

Figure 3.9. Keyport Lagoon Vegetation Community Map from On-site GPS Mapping with the Southwest Area of the Lagoon Shown in the Two Boxes (the small box represents the locations just south of the aerial photo extent).

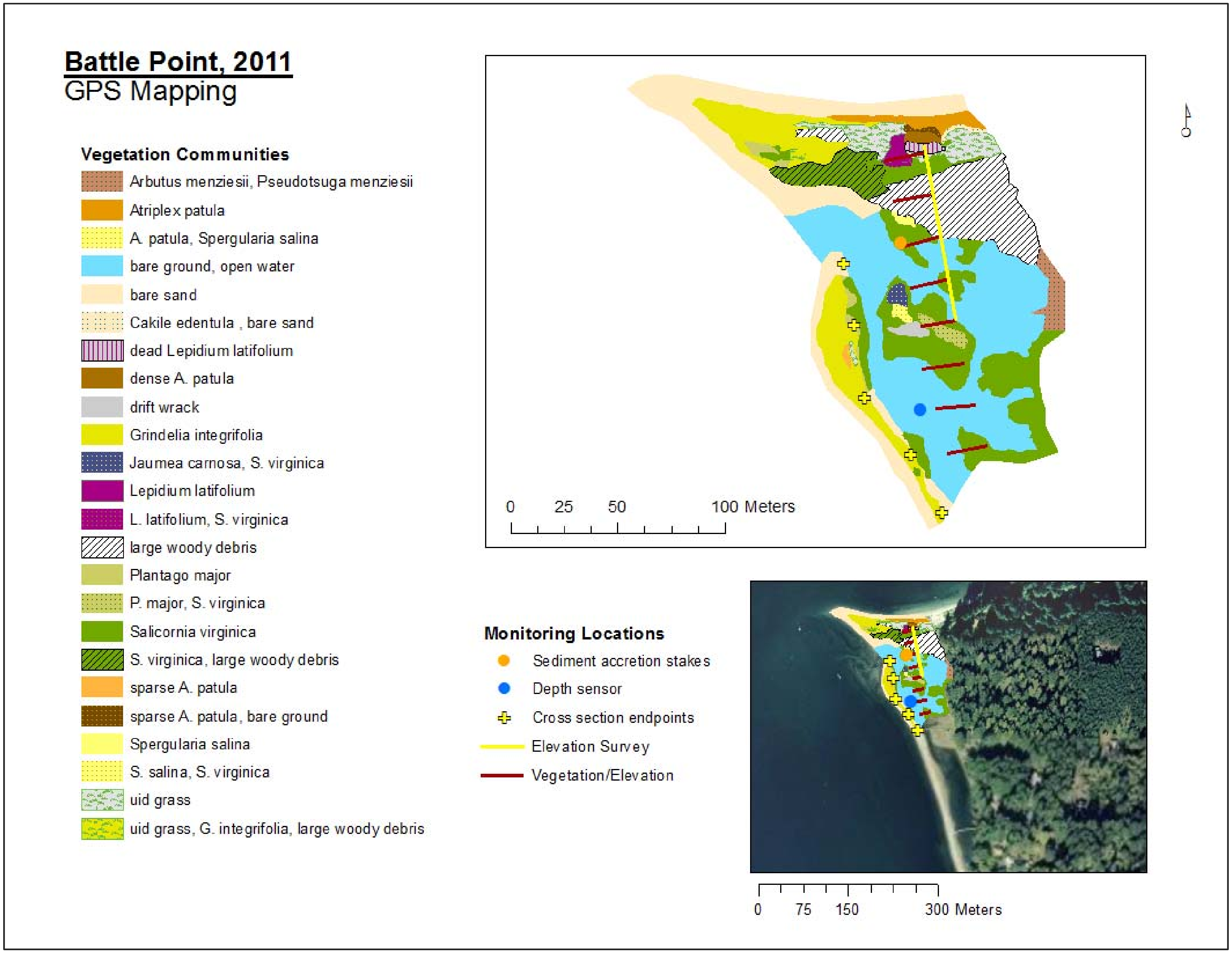

Figure 3.10. Battle Point Vegetation Community Map from On-site GPS Mapping Locations of other monitoring metrics are also shown.

Each site has a different mix of major plants. To show this, the number of times a plant is the dominant species or has the maximum absolute cover in a quadrat (greater than 10%) was calculated (Table 3.8). The Key-N sample area was more diverse than the other areas. The Battle Point site had different dominant species even though the sites generally covered the same elevation range (Table 3.).

Table 3.8. Major Species Occurrence by Site

Maximum Plant	BP 2011		Maximum Plant	Key-N 2009	Key-N 2011	Key-N		Maximum Plant	Key-S 2009	Key-S 2011	Key-S
SAVI	13		SCMA	5	8	13		CACA	1	4	4
DISP2	2		TYLA	3	5	8		SYSU	1		1
LELA	1		POAN	1	2	3					
SPSA	1		COCO		2	2					
			SODU	2		2					
			CACA	1		1					
			ELPA	1		1					
			HEHE		1	1					
			OESA	1		1					
			SYSU		1	1					

Table 3.9. Elevation Associated with Plants Occurring with Maximum Cover More than Once with Greater than 10% Cover

Site	Maximum Plant	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	3.0	3.1	Total
BP_2011	SAVI (herb)	1	1	3	2	3	1			1	1		13
	DISP2 (grass)										1	1	2
Key-N_2009	SCMA (sedge)						1	2	2				5
	TYLA (herb)								3				3
	SODU (herb)									2			2
Key-N_2011	SCMA (sedge)			1	1		1	3	2				8
	TYLA (herb)								3	2			5
	POAN (herb)								2				2
	COCO (herb)							2					2
Key-S_2011	CACA (grass)							1	3				4

The average percent cover and the overall elevation range (not just where it was the maximum) of each species are shown in Figure 3.11. Overall cover was low at the lagoon site because some of the sample quadrats were located in the non-vegetated (open water) portion. These sample locations were included in the survey area to try to cover the potential elevation range that the marsh may cover after restoration. Most of the cover at the Keyport Lagoon site was composed of native, brackish species. The species found at the Battle Point site were primarily native, halophytic species found in salt marshes.

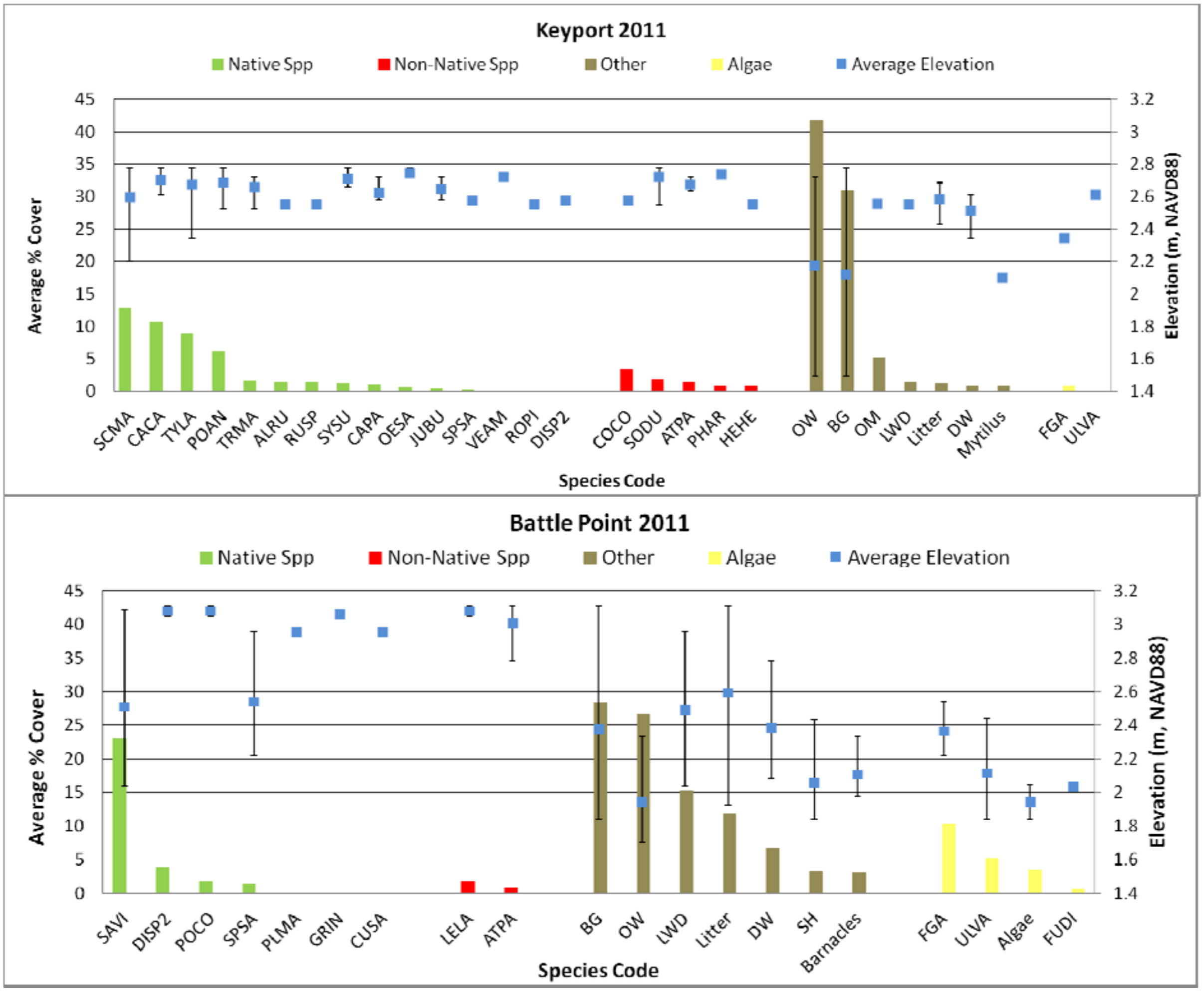

Figure 3.11. Vegetation Species Cover and Elevations for Keyport and Battle Point Sites. Bars represent the minimum and maximum elevations at which the vegetative species occurred within the sample area (see Appendix A for species names associated with codes along the x-axis).

3.3.5 Permanent Plots

Permanent vegetation plots, marked in 2009, were surveyed again in 2011 at Keyport Lagoon. The results from these plots provide an indication of trends occurring at a site over time. The plots showed some changes that were likely due to the sampling in July 2009 versus September 2011. Another difference was that one plot showed some erosion; the 1-m plot was located on the edge of the marsh in 2011, whereas it was a short distance from the edge in 2009.

3.3.6 Similarity Analysis

The Keyport Lagoon and Battle Point sites were not similar to each other when compared using the average percent vegetation cover by species (Figure 3.12). A nonparametric confidence interval about the background similarity between the inside and outside sampling regions is 5% – 15% with a median value of 10% (Table 3.10). Following the planned changes to the hydrologic regime inside the lagoon, the similarity is expected to increase over time.

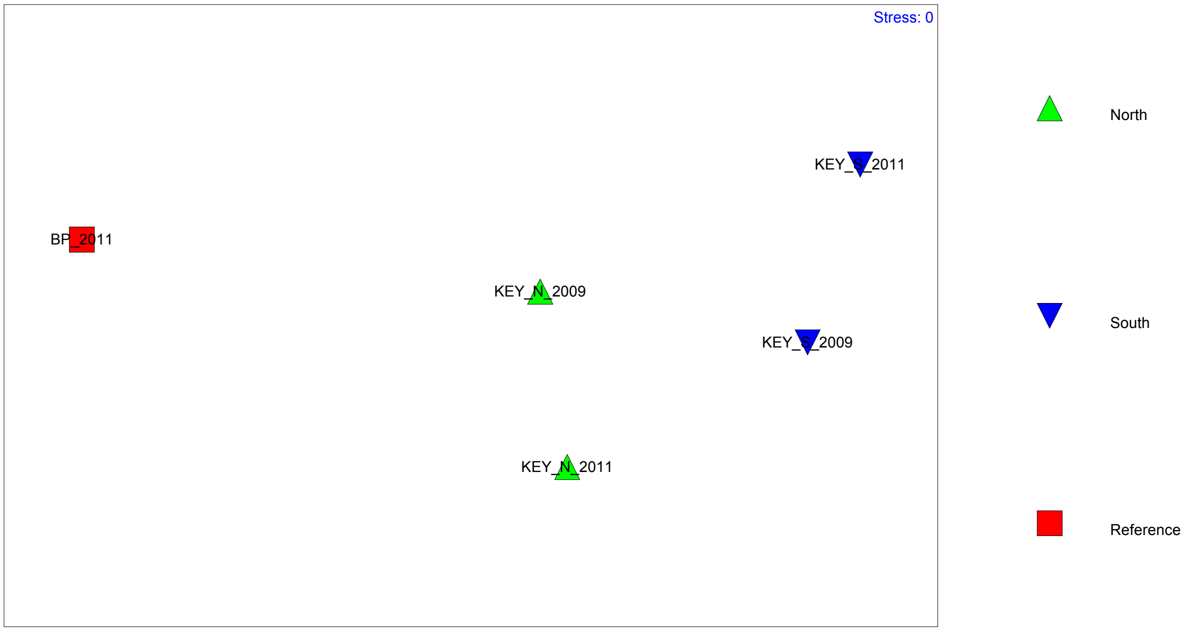

Figure 3.12. Multidimensional Scaling Plot (MDS) for Average Vegetative Cover at Site-Year Combinations. The sites are Keyport Lagoon North, Keyport Lagoon South, and Battle Point reference. Axes are dimensionless and proximity is based on Euclidean distance, with closer proximity indicating similarity.

Table 3.10. Bray-Curtis Similarity

	KEY_N_2009	KEY_S_2009	KEY_N_2011	KEY_S_2011	BP_2011
KEY_N_2009	100	35.26	59.65	21.60	16.97
KEY_S_2009	35.26	100	28.96	28.29	6.55
KEY_N_2011	59.65	28.96	100	28.92	14.21
KEY_S_2011	21.60	28.29	28.92	100	0.00
BP_2011	16.97	6.55	14.21	0.00	100

3.4 Fish Sampling

3.4.1 Overall Fish Trends

Beach seining for fish inside and outside the Keyport Lagoon was conducted twice in 2009, from March through July in 2010, and December 2010 through October 2011 for a total of 25 sampling dates. In total, almost 59,000 fish were caught over this time. While 23 taxa were represented in these catches (Table 3.11), most of the fish caught were three-spine stickleback (see Table 3.11for scientific names), gobies (most likely Bay gobies), surf smelt, staghorn sculpin, and shiner perch (Figure 3.13). In fact, nearly half of the fish caught inside the lagoon were stickleback (Table 3.12). When gobies are added to the stickleback numbers, the two species comprise 85% of the catch inside the lagoon. Outside the lagoon, surf smelt comprised 60% of the catch, and 90% with staghorn sculpins (Table 3.12). Size information for the top five most abundant fish species/groups is summarized in Table 3.13. These size data are pooled for all size classes, and all the top species had very small new recruits at some point during the year to compliment the larger individuals.

Table 3.11. Fish Caught During the Course of the Baseline Study Listed are the common name, scientific name (or lowest taxa) and whether they were caught inside the Keyport Lagoon or outside the lagoon in Port Orchard Passage.

Common Name	Scientific Name	Lagoon	Outside
Salmonids			
Chinook	*Oncorhynchus tshawytscha*		✓
Chum	*Oncorhynchus keta*	✓	✓
Cutthoat	*Oncorhynchus clarkii*		✓
Pink salmon	*Oncorhynchus gorbuscha*	✓	✓
Non-salmonids			
Bay pipefish	*Syngnathus leptorhynchus*	✓	✓
English sole	*Parophrys vetulus*		✓
Flatfish spp.	Pleuronectiformes	✓	✓
Goby spp	Gobiidae	✓	✓
Greenling	*Hexagrammos* spp.		✓
Gunnel spp.	Pholidae		✓
Herring	*Clupea pallasii*	✓	✓
Pacific snake prickleback	*Lumpenus sagitta*		✓
Padded sculpin	*Artedius fenestralis*	✓	✓
Prickly sculpin	*Cottus asper*	✓	
Rock sole	*Lepidopsetta bilineata*		✓
Sandlance	*Ammodytes hexapterus*	✓	
Sculpin spp.	Cottoidea	✓	✓
Sharpnose sculpin	*Clinocottus acuticeps*	✓	
Shiner perch	*Cymatogaster aggregata*	✓	✓
Staghorn sculpin	*Leptocottus armatus*	✓	✓
Starry flounder	*Platichthys stellatus*	✓	✓
Stickleback	*Gasterosteus aculeatus*	✓	✓
Surf smelt	*Hypomesus pretiosus*	✓	✓

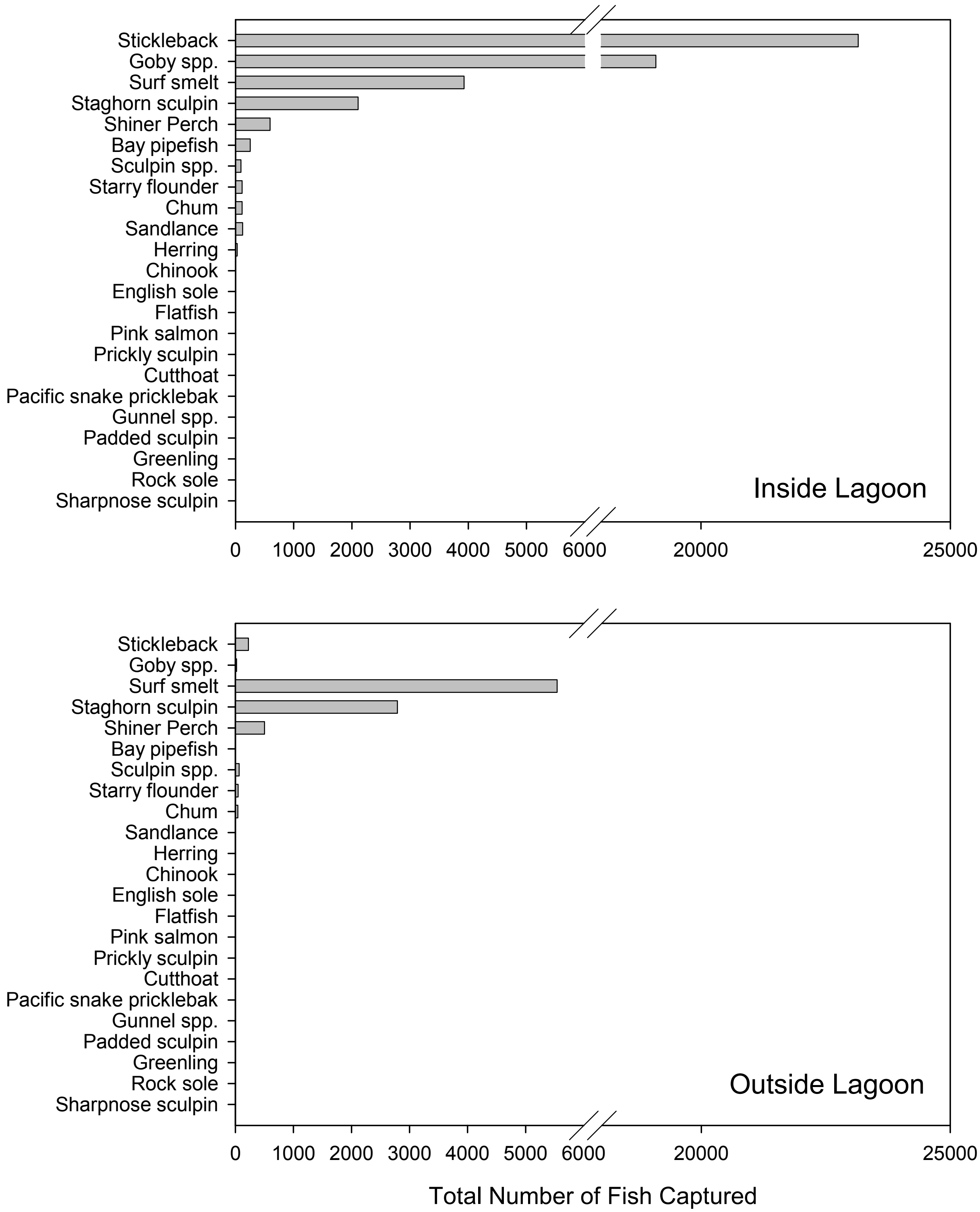

Figure 3.13. Total Number of Fish, by Lowest Taxonomic Group, Captured Inside and Outside the Keyport Lagoon from 2009 – 2011

Table 3.12. Species of Fish Captured in Beach Seines Inside the Keyport Lagoon and Outside the Lagoon in Port Orchard Passage. Table also shows the total number of each species caught over the sampling period and the cumulative proportion of the catch.

Inside the lagoon			Outside the lagoon		
Taxa	Total #	Cumulative Proportion	Taxa	Total #	Cumulative Proportion
Stickleback	23152	0.467	Surf smelt	5542	0.597
Goby spp.	19100	0.851	Staghorn sculpin	2790	0.897
Surf smelt	3926	0.931	Shiner perch	504	0.952
Staghorn sculpin	2106	0.973	Stickleback	225	0.976
Shiner perch	595	0.985	Sculpin spp	66	0.983
Bay pipefish	254	0.990	Starry flounder	47	0.988
Sandlance	123	0.993	Chum	44	0.993
Starry flounder	114	0.995	Goby spp.	20	0.995
Chum	113	0.997	Chinook	13	0.996
Sculpin spp.	95	0.999	English sole	13	0.998
Herring	31	1.000	Cutthoat	4	0.998
Flatfish spp.	7	1.000	Pacific snake prickleback	4	0.998
Prickly sculpin	5	1.000	Bay pipefish	3	0.999
Pink salmon	2	1.000	Pink salmon	3	0.999
Padded sculpin	1	1.000	Herring	2	0.999
Sharpnose sculpin	1	1.000	Gunnel spp.	2	1.000
			Flatfish spp.	1	1.000
			Padded sculpin	1	1.000
			Greenling	1	1.000
			Rock sole	1	1.000

Table 3.13. Size Summary for the Top Five Most Numerous Fish Caught Inside and Outside the Keyport Lagoon

INSIDE			Length (mm)				
Species	Total Caught	Total Measured	MEDIAN	MEAN	MIN	MAX	SE
Stickleback	23152	2416	35	42.2	7	86	0.381
Goby spp.	19097	1396	37	37.8	12	70	0.208
Surf smelt	3926	679	63	62.3	22	129	0.542
Staghorn sculpin	2085	1111	57	58.9	12	157	0.827
Shiner perch	541	253	42	49	30	136	1.152

OUTSIDE			Length (mm)				
Species	Total Caught	Total Measured	MEDIAN	MEAN	MIN	MAX	SE
Surf smelt	3926	679	42	46	34	171	0.775
Staghorn sculpin	2811	769	49	60.7	14	172	1.244
Shiner perch	545	235	86	78.9	35	196	1.680
Stickleback	225	81	40	47.6	21	79	1.932
Sculpin spp.	66	12	15.5	16.9	13	24	0.965

When pooling all the fish caught except for the salmonids, there appears to be a seasonal pattern inside the Keyport Lagoon with the highest abundances in the summer (Figure 3.14). Indeed, catch abundance inside the lagoon during the summer was significantly greater than the winter and spring ($p < 0.001$). However, there was no seasonal effect on catch abundance outside the lagoon ($p = 0.439$), although this may be largely driven by the lack of a peak in fish abundance in 2009 and 2010 (Figure 3.14). The observed increase in fish caught in May 2011 was primarily driven by an anomalous catch of surf smelt during a very low tide and may be swamping a normally small increase in the fish abundance in the other years. Whether the numbers outside do fluctuate seasonally or not, catch was significantly greater inside the lagoon than outside ($p = 0.001$).

Similarity analyses suggest there is limited agreement between the inside and outside of the lagoon (Figure 3.15). A nonparametric confidence interval about the Bray-Curtis similarity between the inside and outside sampling regions is 20% – 47% with a median value of 34%. The average of the winter-spring similarity was significantly greater than the average of the summer-fall similarity ($p = 0.014$). The similarity decreased significantly as the catch abundance inside the lagoon increased ($p = 0.011$).

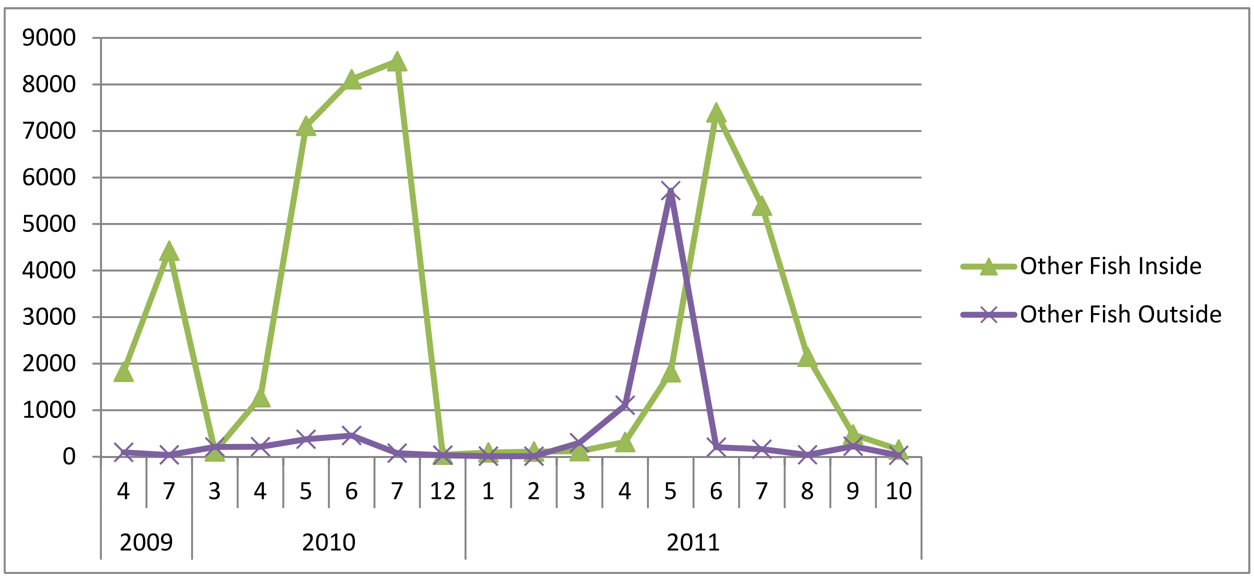

Figure 3.14. Seasonal Abundance of All Non-Salmonid Fish (Other Fish) Caught Inside and Outside the Keyport Lagoon from 2009 – 2011. Note the x axis is scale is not uniform.

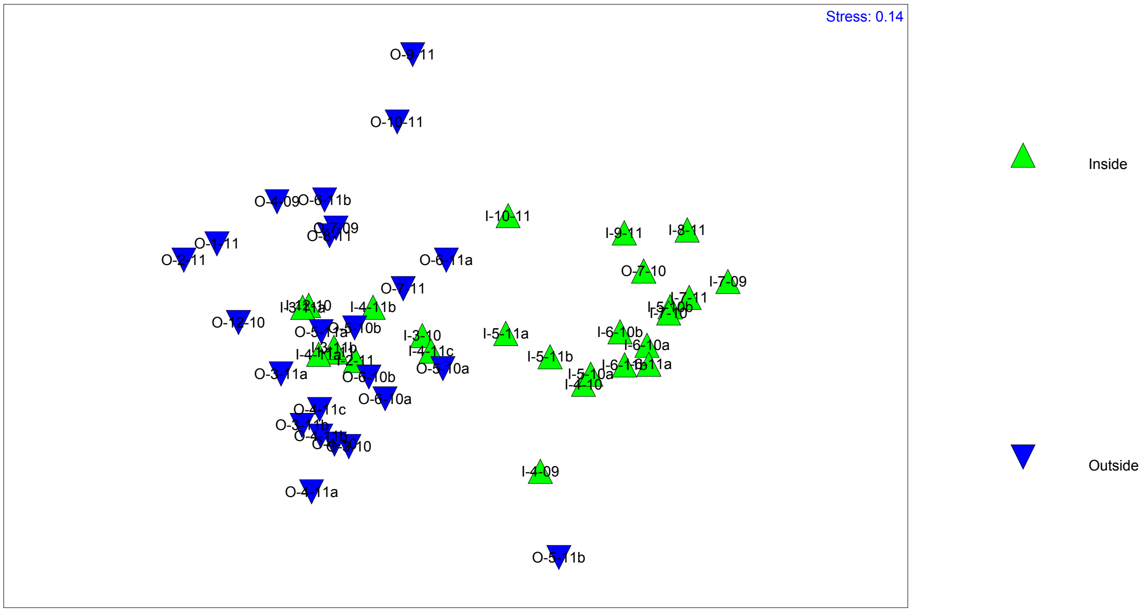

Figure 3.15. Multidimensional scaling plot (MDS) for Similarity Between Fish Populations Inside and Outside the Keyport Lagoon.

3.4.2 Salmonid Fish Trends

Salmon were caught both inside and outside the Keyport Lagoon, although their numbers were relatively small compared to some of the other species (Figure 3.13). Seasonally, salmon species were only captured when expected in the spring and early summer (i.e., March – June), although the “spikes” in abundance are largely attributable to one or two productive sampling times and most often a single seine haul (Figure 3.16). These patterns are demonstrated as more patchy when the different species are broken out. Inside the lagoon, only chum and pink salmon were captured, and of the latter, only two pink were caught (one each in April 2010 and May 2010; Table 3.14). All the rest of the salmon caught inside the lagoon were chum, and out of the 113 individuals caught, 41 were caught in March 2010. In addition to these two species, Chinook salmon were also found outside the lagoon, although 11 of the 13 caught were captured on the same date in June 2011. All but two (one was unnoted) had clipped adipose fins and were assumed to be local hatchery releases. Pink salmon on the outside of the lagoon were as rare as on the inside and all three individuals were caught in the same haul in April 2010. The rest of the salmonids outside the Lagoon were chum, and 68% were caught on the same day in April 2010. These data do not suggest that any salmon overwintered in the Keyport Lagoon or the adjacent nearshore habitat in Port Orchard Passage.

Size data on the different salmon species are presented in Table 3.14. The Chinook were generally larger than the other species, probably because they were hatchery-raised and released at a larger size. Chum showed the largest range in size (31 – 83 mm) and were similar inside and outside the lagoon. Pink salmon numbers were very limited and therefore not much can be said about the overall trends, but within this limited sample size, the individuals inside the lagoon were always larger than those outside.

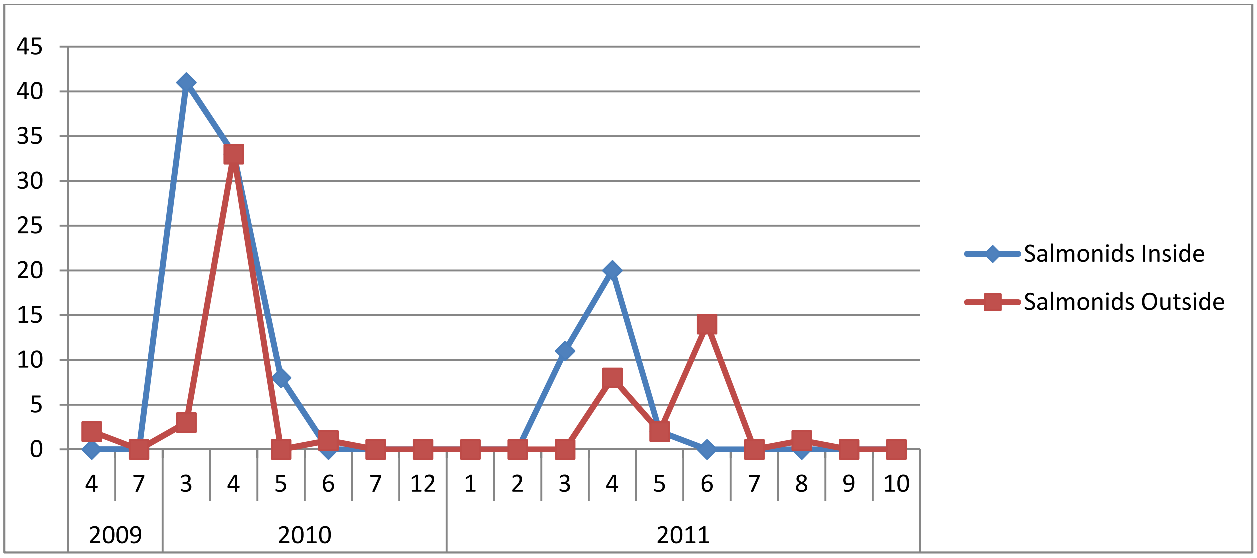

Figure 3.16. Seasonal Abundance of All Salmonid Fish Caught Inside and Outside the Keyport Lagoon from 2009 – 2011. Note the scale of x axis is not uniform and represents month of the year.

Table 3.14. Size Summary for Salmonids Caught Inside and Outside the Keyport Lagoon

INSIDE		Length (mm)				
Species	Total Caught	Median	Mean	Min	Max	SE
Chum	113	54.5	51.9	31	72	1.09
Pink	2	50	50	48	52	2.00
OUTSIDE						
Species	Total Caught	Median	Mean	Min	Max	SE
Chinook	13	92	90	67	135	5.00
Chum	44	50	54.4	35	83	2.28
Pink	3	35	37	33	43	3.05

3.5 NEI Results

This report consists only of before-restoration baseline data; therefore, a NEI assessment was not conducted. See Section 4.2 for pertinent results and implications relative to the NEI that will be calculated after weir removal.

4.0 Discussion

4.1 Adaptive Framework

Our baseline studies produced quantitative data on relevant ecosystem and fish parameters. In doing this, we learned where and how best to access and obtain samples from the sites. Further, we developed data sets on controlling factors such as elevation, season, and tide level that appear to have a large influence on the biological assemblages and water properties. This information allows us to refine predictions of the response of the biota and water properties to removal of the weir structure. Based on the data, we predict that the general system changes referred to in the RAMP will likely occur. The expansion of the marsh, which was speculative in previous studies, now appears more certain if sediment is allowed to enter the lagoon from the nearshore area. Water properties, particularly temperature, will improve dramatically for juvenile salmon. We also predict issues such as physical changes to the site (e.g., inundation of the beach inside the lagoon) based on new elevation data coupled with water levels following weir removal. This should trigger management actions to either adapt to this change or installation of structures to prevent possible erosion. The following sections provide more detail on some of these findings.

4.2 Pertinent Results and Implications

It was not appropriate to calculate the NEI for this baseline index report. However, the present data show that the lagoon ecosystem differs substantially from the outside or reference areas in terms of water properties, fish assemblages, and emergent marsh vegetation assemblage. Although this difference should not be surprising, the data indicate quantitatively how different the present diked lagoon ecosystem is from undiked natural systems nearby. Highlights of the potential changes are shown below: for example, water properties inside the lagoon were only 28 to 56% similar between the lagoon and the nearshore water outside of the lagoon, depending on the season sampled. The water was as much as 9˚C warmer during the summer in the lagoon. We expect this temperature differential to decrease after reconnection, which should improve the conditions for juvenile salmon. The magnitude of change in water temperature following reconnection will depend on the degree of unrestricted hydrology, duration and coupling between benthic and pelagic processes in the lagoon, time since reconnection, and several other factors. We fully expect fish assemblages to become more similar between the nearshore and lagoon sites. Vegetation assemblages should also become more similar over time depending on the rate of sediment accretion.

The RAMP outlines the performance metrics and the associated performance criteria that will be used to assess the overall goal for the project of improving salmonid access to the lagoon ecosystem. This goal includes restoration of natural estuarine water properties, water quality, and broader nearshore ecosystem support. The performance metrics include: fish assemblage access, salinity range within the lagoon, tidal water inundation and flushing, channel formation, stability of new culverts at mouth (not measured in this study), water properties, phytoplankton biomass, and organic matter. Below we summarize findings relative to these performance metrics.

Fish Assemblage:

- It is clear that fish assemblages differed significantly between the outside nearshore area and within the Keyport Lagoon. There were more species and greater abundances of salmonid in the outside samples. We predict that restoring hydrodynamic connections will offer much greater opportunities for salmonids to access the lagoon, and benefit from prey and refuge values associated with lagoon habitats.
- We predict a greater species richness within the lagoon following restoration, and we now have information on the range of species that should access the site.
- The lagoon will likely export organic matter that will supplement the food web base in the nearshore area.

Water Properties:

- Based on the temperature/depth sensor data from a two-year period, the lagoon is as much as 9°C warmer than the surrounding nearshore waters outside the lagoon during the summer. Temperatures are expected to decrease in the lagoon during the summer when effective tidal flushing is re-instated.
- Salinity range in the lagoon is expected to increase with tidal reconnectivity. Although the freshwater input will remain, the salinity difference between inside and outside of the lagoon will decrease with regular tidal flushing.
- The overall similarity in the suite of physical and biogeochemical water properties between the lagoon and the outside nearshore waters is expected to increase, supporting an overall increase in suitable habitat functions as refuge and potential feeding habitats for a variety of species.

Vegetation, Elevation, and Hydrology:

- Shift to more salt tolerant species such as *Salicornia virginica* and *Distichlis spicata* because salinity may become less variable with more consistent tidal flushing.
- Estimated changes at Keyport Lagoon after restoration based on bathymetry survey, outside water level sensor, and elevations at the reference marsh are shown in Table 4.1 and Figure 4.1and could result in the following:
  - Increase in marsh elevation range from 10 – 12 ft to approximately 9 – 13 ft, MLLW could result in an increase in area of 1.7 acres
  - Unvegetated flats would range from approximately 3 ft (the lowest elevation in the Lagoon) to 9 ft, MLLW covering an estimated area of 22.1 acres
  - A tidal channel will likely form in the 3 to 6 ft, MLLW elevation range and be inundated 60-80% of the time.
  - Potential periodic inundation of additional areas included wooded areas to the west of the lagoon, the fields by the pavilion on the north shore of the lagoon, and potentially by the building closest to the lagoon on the west side of the lagoon (see Figure 4.1).

Table 4.1. Elevations and Estimated Changes to Keyport Lagoon Post-restoration

Elevation Range (ft, MLLW)	Elevation Range (m, NAVD88)	Existing Strata	Estimated Strata	Estimated Inundation Frequency[a]	Area (acres)
12 - 13	2.88 - 3.18	Upland	High marsh/Shrubs	0.3%	0.6
11 - 12	2.57 - 2.88	High marsh	High marsh	1.9%	1.3
10 - 11	2.27 - 2.57	Marsh	Mid-marsh	8.5%	0.7
9 - 10	1.96 - 2.27	Open water	Low marsh	19.2%	1.1
8 - 9	1.66 - 1.96	Open water	Bare mud	31.6%	1.3
7 - 8	1.35 - 1.66	Open water	Bare mud	43.0%	1.8
6 - 7	1.05 - 1.35	Open water	Bare mud	54.5%	2.9
5 - 6	0.75 - 1.05	Open water	Bare mud/channel	63.3%	6.1
4 - 5	0.44 - 0.75	Open water	Bare mud/channel	70.2%	6.4
3 - 4	0.14 - 0.44	Open water	Bare mud/channel	76.2%	3.7
3 - 13	**0.14 – 3.18**	**All Strata**			**25.8**

(a) The inundation frequencies shown are for the upper elevation in the range (e.g., at 12 ft inundation frequency is 1.9%).

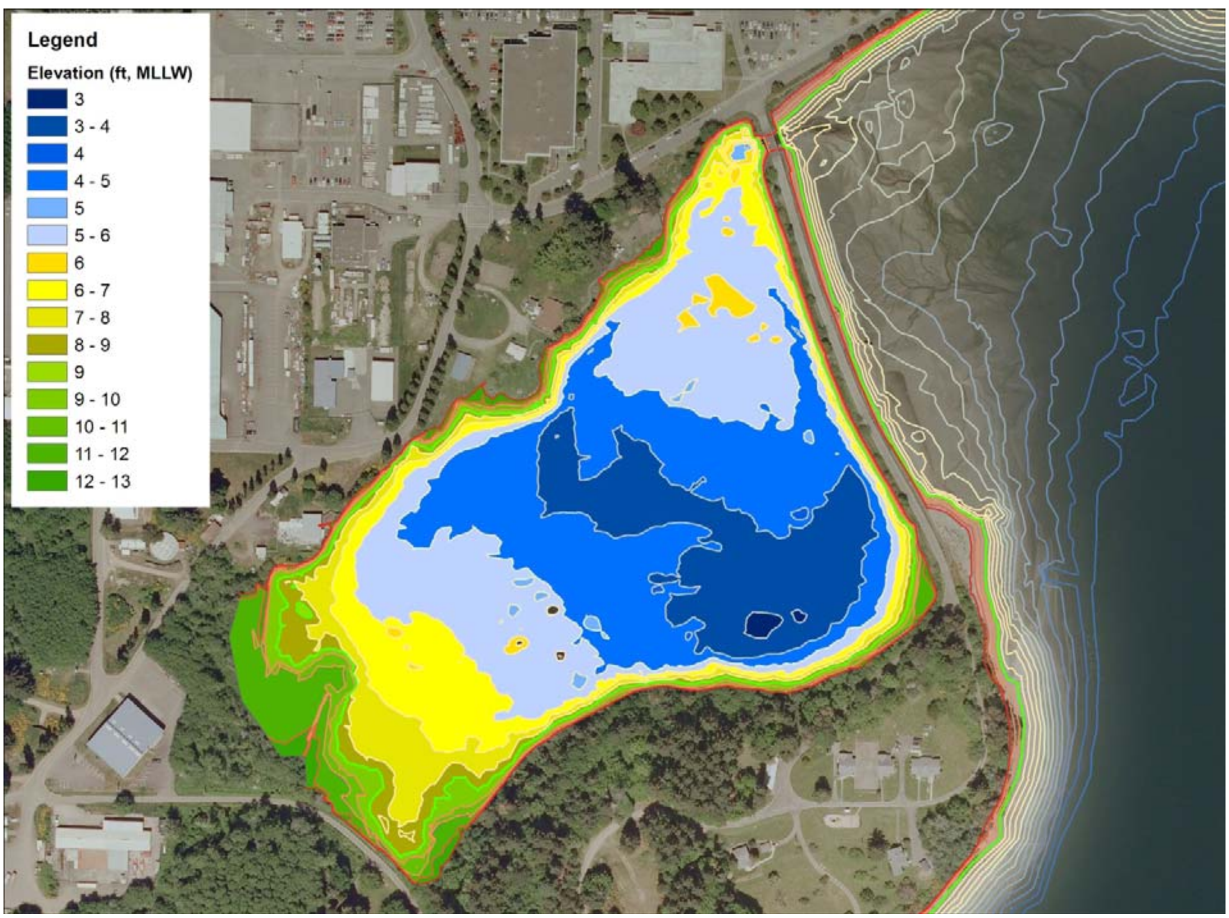

Figure 4.1. Map of Keyport Lagoon Showing Elevations Corresponding to Estimated Changes in Table 4.1

4.2.1 Sediment Chemistry Uncertainty

Sediment sampling was conducted within the Keyport Lagoon in July 2011. The sediment chemistry results were summarized by Anchor QEA, LLC (2011c). The sediment samples were collected to evaluate the quality of the biologically active zone (0 to 10 cm) and the sub-surface sediment anticipated to be removed from the lagoon once the tidal reconnection is complete. The quality of the sediment was identified in the RAMP as a significant uncertainty considered during the restoration planning. Selected sediment samples were analyzed per Sediment Management Standards (SMS) for a suite of metals, polycyclic aromatic hydrocarbons (PAHs), semi-volatile organics, polychlorinated biphenyl (PCBs; total arochlors), dioxins and furans, and explosives (Anchor QEA, LLC 2011b). The data were evaluated against Washington Sediment Quality Standards (SQS), Cleanup Screening Level (CSL) criteria, and/or against the marine Apparent Effects Thresholds (AET; LAET and 2LAET; PSEP 1988; Ecology 1996). Of the 33 surface sediment grabs, three different samples each exceeded one SQS: one for PCBs, one for Zn, and one for bis(2-ethylhexyl)phthalate. All three were collected near the northern shoreline where a majority of the outfalls enter the lagoon. Of the 13 sub-surface samples, no parameters were detected above the SQS.

Although the sediment chemistry had limited exceedences of sediment screening criteria, there are no such criteria available for dioxins and furans. Four surface sediment grabs were analyzed for dioxins and furans with concentrations detected above the method detection limit. Without available screening levels or threshold criteria establish for Washington, the potential ecological or human health risk associated with the detected concentration must be evaluated by using other published studies. Benchmarks for dioxin contamination are assessed by Toxic Equivalent (TEQ) value, not the concentration. The TEQ is calculated by concentration times toxic equivalence factor (TEF) for each individual dioxin and furan (PCDD/Fs). The TEQs are driven by the tetra-congeners of both the dioxin and furan groups. In the case of this site, the TEQs for the TCDD/Fs are rather low. They fall in the "good" or "background" category for Norwegian sediment criteria (Bakke et al. 2010).

The Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME) also provide a reference. The 2002 Interim Marine Sediment Quality Guidelines (ISQG) and Probable Effects Levels for TCDD/Fs are TEQ: 0.85 ng/Kg dry weight and 21.5 ng/Kg dw, respectively. Based on these guidelines, one of the sediment slightly exceeds the probable effects level. However, the bioavailability and flux of dioxins from the sediment should the weir be removed required additional information to adequately protect human and ecological risk.

The best approach to evaluating the uncertainty associated with the sediment chemistry would be to assess the potential "availability" of these contaminants to biota under the existing conditions in the lagoon and under modeled conditions following hydrologic reconnection. The availability is a function of many factors including the carbon content and type of carbon (e.g. activated carbon, black carbon, graphite, etc.). The sorption of dioxins and the kinetics of release will depend heavily on the type of carbon. The bioavailability could then be estimated using sorption models coupled with measurements of pore water concentrations using passive samplers to predict the concentrations of freely dissolved dioxins generated during sediment remobilization. The very slow kinetics of PCDD/Fs desorption should be considered when evaluating the bioavailability and potential risk of resuspending and remobilizing dioxins during hydrologic reconnection (Brandenberger et al. 2011).

In addition, total dioxin/furan TEQ were calculated for mammals, but could also be calculated for fish and birds to evaluate potential ecological risk. In addition, the TEQ for PCBs could be calculated to allow direct comparisons of PCBs and dioxins in the risk assessment for biota.

4.3 Suggested Actions

The suggested actions are broken out into two categories: 1) NEI Metrics and 2) Critical Uncertainties. For the NEI metrics the pre-restoration conditions have been documented and suggested actions resulting from these investigations include:

- Extend the survey data undertaken by Anchor QEA into the wooded area to the west of the lagoon and possibly into the swampy area across the road to better understand the implications of increased inundation.
- Continue with long-term sensor monitoring of temperature/depth and add salinity sensor for inside and outside lagoon.
- Increase frequency of water property sampling during short periods of the year to better understand the finer scale changes, such as the fall increase in DOC.
- Surveys of fish communities should also be conducted at the Battle Point reference area to provide a better habitat comparison for the Keyport Lagoon

The suggested actions for **Critical Uncertainties** were identified both in the RAMP and by the recent studies conducted within the lagoon on sediment chemistry and inundation frequencies. The suggested actions include:

- The potential for increased tidal inundation and subsequent errosion during higher tides may be beneficial for ecological function as more of the terrestrial-aquatic interface can be used as a resource, but could also potentially impact infrastructure at the base (e.g. the picnic area). These estimates and their implications should be investigated more thoroughly to make sure the potential threat to infrastructure is identified and understood.
- Schedule a spring 2012 Keyport Lagoon Stakeholder Meeting with the objective of addressing the uncertainties associated with the sediment chemistry in Keyport Lagoon and the potential human or ecological risks associated with the tidal resuspension and remobilization of the current surface sediment in Keyport Lagoon to surrounding nearshore environments.
- Collaborate with project ENVVEST Regional Mussel Watch sampling to optimize regional sampling that targets biological thresholds of concern and could be incorporated into risk modeling.
- Conduct risk modeling for dioxins and furans by coupling sorption models based on sediment concentrations of PCDD/F and TOC and then with PCBs and TOC (Cornelissen et al. 2008) and passive sampling within the lagoon. This would provide values of freely dissolved concentrations, which are then characterized based on the potential risk to biota (e.g. low, medium, high).
- Passive sampling could be conducted to assess the releases of bioavailable contaminants during the sediment remobilization after hydrologic reconnection.

- The background concentration of dioxins in sediment around Puget Sound should be defined to provide relative benchmarks for a regional comparison and regional considerations for the risk modeling. This includes determining dioxin concentrations in Liberty Bay, Port Orchard Passage, etc.

4.4 Actions during the Next Phase

4.4.1 Construction

Removal of the existing bridge and sill and construction of the new bridge was scheduled to begin in 2012, but there is uncertainty on the next steps of the construction schedule due to some findings with the sediment chemistry results (Anchor QEA, 2011c). As recommended above, the adaptive management process would require the stakeholder group to reach a consensus on the next steps with regard to the chemistry of the sediment and whether or not remobilization of the existing lagoon sediment, when the weir is removed, would result in unacceptable risk to the regional coastal zone. A winter/spring stakeholder meeting should be scheduled to evaluate the existing chemical benchmarks and propose recommended actions based on pertinent scientific information.

4.4.2 Monitoring

The collection of baseline data is scheduled to be completed with this report. The collection of additional data will wait until after the weir is breached and construction of the new culverts and bridge are complete. As that time, a new set of data will be collected to represent hydrologic reconnection and the progression of the system toward a new baseline. The NEI index would be calculated following the collection of post-weir removal data and begin the process of quantifying the net benefits to the regional coastal ecosystems.

4.5 Adaptive Management

At present, quantitative data on the effects of restoring pocket estuarine ecosystems are wanting in the region. This lack of information forces stakeholders and decision-makers to speculate on the compensatory values associated with restoring pocket estuaries. The quantitative changes attributed to the restoration of natural tidal hydrodynamics gathered under this project will provide rare and important information as to the effects of dike removal on pocket estuarine ecosystems in the region. We expect that the lessons learned from this project will allow better predictions as to the effects, including rates and patterns of development of the ecosystem, the ability for self-maintenance, and resilience of these types of sites to disturbances. Overall, the project will assist in refining the engineering design considerations of future projects of this type.

5.0 Conclusion

Over the past two years, we collected a quantitative data set on the performance metrics established within the RAMP for evaluating the performance of Keyport Lagoon restoration. This data set is unprecedented in scope and applicability to the restoration of a pocket estuary in the Pacific Northwest or globally. The data set also provided new information that allowed us to better predict the outcomes from the restoration actions. This both refines expectations and verifies that the restoration of the lagoon would have significant positive effects on fish, as well as, water properties in the region of the system. We now believe that the tidal marsh will expand in area and will become more diverse. Water temperature will improve significantly to the benefit of juvenile salmon. On the negative side, increased, but infrequent inundation may result in some erosion on the northern shorelines surrounding the lagoon. This unprecedented baseline data set, which when combined with the post-restoration monitoring, represents a unique quantification of the predicted effect of specific actions to restore what now are believed to be highly important ecological elements (pocket estuaries) in the Puget Sound landscape. Once the weir is removed, the application of the organizing Net Ecosystem Improvement index (applied using similarity analysis) should allow a systematic and quantitative measure of changes through time, and present the net change in a simple, scientifically sound method.

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Appendix A: Vegetation Species Cover

Appendix A

Vegetation Species Cover

Table A.1. Vegetation Species Codes, Descriptive Information, and Average Percent Cover for the Keyport Lagoon and Battle Point Sites. Non-native species are highlighted in yellow, and the cover for the top five species at each site are highlighted in red.

					Average Cover	
Species Code	Scientific Name	Common Name	Wetland Status	Native Status	Keyport	Battle Point
Vascular Plants						
ALRU	*Alnus rubra*	Red alder	FAC	yes	1.5	0.0
ATPA	*Atriplex patula*	spear saltbush	FACW	no	1.5	0.8
CACA	*Calamagrostis canadensis*	bluejoint	FACW+	yes	10.6	0.0
CAPA	*Caltha palustris*	Yellow marsh marigold	OBL	yes	1.0	0.0
COCO	*Cotula coronopifolia*	common brassbuttons	FACW+	no	3.5	0.0
CUSA	*Cuscuta salina*	saltmarsh dodder	NA	yes	0.0	0.0
DISP2	*Distichlis spicata*	saltgrass	FACW	yes	0.0	3.9
GRIN	*Grindelia integrifolia*	gumweed, Puget Sound gumweed	FACW	yes	0.0	0.1
HEHE	*Hedera helix*	English ivy	UPL	no	0.7	0.0
JUBU	*Juncus bufonius*	Toad rush	FACW	yes	0.5	0.0
LELA	*Lepidium latifolium*	broadleaved pepperweed	FAC	no	0.0	1.7
OESA	*Oenanthe sarmentosa*	Water parsley	OBL	yes	0.6	0.0
PHAR	*Phalaris arundinacea*	Reed canary grass	FACW	no	0.8	0.0
PLMA	*Plantago maritima*	goose tongue, seaside plantain	FACW+	yes	0.0	0.2
POAN	*Potentilla anserina ssp. Pacifica/Argentina egedii ssp. Egedii*	Pacific silverweed	OBL	yes	6.2	0.0
POCO	*Poa confinis*	coastline bluegrass	NA	yes	0.0	1.9
RONU	*Rosa nutkana*	Nootka rose	FAC	yes	0.0	0.0
ROPI	*Rosa pisocarpa*	Clustered wild rose, peafruit rose, swamp rose	FAC	yes	0.1	0.0
RUSP	*Rubus spectabilis*	Salmonberry	FAC+	yes	1.5	0.0
SAVI	*Salicornia virginica*	pickleweed	OBL	yes	0.0	23.1
SCMA	*Schoenoplectus maritimus*	Seacoast bulrush	OBL	yes	12.8	0.0
SODU	*Solanum dulcamara*	Bittersweet nightshade	FAC+	no	1.8	0.0
SPSA	*Spergularia salina*	salt sandspurry	OBL	yes	0.3	1.4

					Average Cover	
Species Code	Scientific Name	Common Name	Wetland Status	Native Status	Keyport	Battle Point
SYSU	*Symphyotrichum subspicatum*	Douglas aster	FACW	yes	1.2	0.0
TRMA	*Triglochin maritima*	Seaside arrowgrass	OBL	yes	1.6	0.0
TYLA	*Typha latifolia*	Common cattail	OBL	yes	8.8	0.0
VEAM	*Veronica americana*	American speedwell	OBL	yes	0.2	0.0
Other Observations						
BARN		Barnicles			0.0	3.1
BG		Bare Ground			31.0	28.3
DW		Drift Wrack			0.9	6.7
Litter		Litter			1.3	11.9
LWD		Large Woody Debris			1.5	15.3
Mytilus		Mussels			0.9	0.0
OM		Organic Matter			5.1	0.0
OW		Open Water			41.8	26.6
SH		Shell Hash			0.0	3.2
Algae		Unspecified Algae			0.0	3.4
ULVA	*Ulva spp.*	Sea lettuce			0.1	5.2
FGA		Filamentous green algae			0.7	10.5
FUDI	*Fucus distichus*	Rockweed			0.0	0.6

Appendix B: Water Property Data Summary

Appendix B

Water Property Data Summary

Date	Site		Surface water temp. (°C)	Salinity (psu)	D.O. (mg/L)	chl a (ug/L)	DOC (mg C/L)	POC (mg C/L)	TOC (mg/C L)	Total Suspended solids (mg/L)	Organic suspended Solids (mg/L)	Inorganic Suspended Solids (mg/L)	TP (ug/L)	TN (ug/L)	PO4 (ug/L)	SiO4 (ug/L)	NO3 (ug/L)	NO2 (ug/L)	NH4 (ug/L)
4/28/2009	KI	n=8	15.53	11.58	12.36	1.66	-	-	-	4.64	2.32	2.32	-	-	11.14	3064.18	30.45	2.08	50.37
			(0.95)	(0.12)	(1.03)	(1.10)	-	-	-	(0.61)	(0.31)	(0.41)	-	-	(4.97)	(331.13)	(7.46)	(0.38)	(17.24)
	KO	n=3	11.50	29.03	13.29	0.65	-	-	-	20.62	5.88	14.74	-	-	46.66	1218.53	63.27	3.53	81.60
			(1.49)	(0.46)	(2.29)	(0.11)	-	-	-	(14.65)	(3.59)	(11.07)	-	-	(9.29)	(225.96)	(29.66)	(0.62)	(18.30)
8/6/2009	KI	n=9	23.36	27.01	6.46	2.85	2.94	1.16	4.09	16.00	5.25	10.75	157.93	582.41	107.12	2451.31	2.62	0.74	36.48
			(0.31)	(0.31)	(0.75)	(0.40)	(0.61)	(0.10)	(0.58)	(5.09)	(1.00)	(4.16)	(4.02)	(47.93)	(9.53)	(101.95)	(5.71)	(0.43)	(23.99)
	KO	n=9	17.36	29.69	10.68	12.41	1.16	1.68	2.84	16.63	5.06	11.57	117.08	443.49	64.76	1401.94	7.05	1.20	43.31
			(0.59)	(0.08)	(1.24)	(10.03)	(0.46)	(1.23)	(1.59)	(3.59)	(0.84)	(3.27)	(15.77)	(77.10)	(3.42)	(58.82)	(2.54)	(0.23)	(26.99)
12/8/2009	KI	n=8	5.19	23.21	6.55	1.24	2.15	0.53	2.69	6.35	2.52	3.83	96.38	1305.40	63.51	3369.20	329.38	13.66	169.48
			(1.39)	(2.38)	(1.23)	(0.44)	(0.28)	(0.34)	(0.47)	(2.62)	(2.58)	(0.73)	(3.28)	(88.67)	(5.35)	(515.16)	(14.75)	(1.82)	(32.86)
	KO	n=8	7.61	29.48	7.18	0.87	0.97	0.24	1.21	4.65	1.66	2.99	93.70	775.28	86.68	1840.71	381.57	7.59	56.55
			(0.38)	(0.24)	(0.77)	(0.38)	(0.09)	(0.09)	(0.14)	(1.05)	(1.20)	(0.82)	(3.90)	(57.37)	(1.80)	(28.70)	(7.02)	(0.10)	(7.38)
6/2/2010	KI	n=8	19.97	22.34	7.78	3.12	2.90	0.87	3.36	2.97	1.54	1.43	50.90	328.55	24.69	2128.36	12.31	1.13	28.08
			(0.87)	(0.91)	(0.68)	(1.42)	(0.20)	(0.35)	(1.37)	(0.62)	(0.42)	(0.28)	(2.98)	(28.22)	(8.45)	(158.77)	(10.42)	(0.79)	(22.84)
	KO	n=8	13.68	28.75	10.49	12.28	1.66	1.89	3.31	24.69	4.26	20.43	105.78	360.92	70.27	298.30	21.52	2.10	78.09
			(0.71)	(0.11)	(0.42)	(7.38)	(0.09)	(1.32)	(1.44)	(19.05)	(2.22)	(16.87)	(16.54)	(84.86)	(7.14)	(85.13)	(4.53)	(0.62)	(22.26)
2/9/2011	KI	n=8	5.98	15.82	11.48	0.67	2.89	0.48	3.36	4.64	1.73	2.91	77.09	1167.62	45.01	6090.62	703.13	9.30	97.64
			(1.82)	(2.02)	(0.96)	(0.14)	(0.23)	(0.07)	(0.23)	(1.43)	(0.40)	(1.06)	(4.21)	(69.80)	(2.18)	(799.25)	(97.75)	(0.58)	(11.81)
	KO	n=8	7.79	27.20	11.09	0.70	1.26	0.39	1.65	10.76	2.42	8.34	87.42	605.32	77.29	1884.46	433.50	5.29	28.24
			(0.44)	(0.29)	(0.64)	(0.16)	(0.14)	(0.12)	(0.24)	(7.63)	(1.15)	(6.49)	(4.31)	(72.63)	(1.28)	(41.56)	(22.04)	(0.93)	(9.13)
4/21/2011	KI	n=8	16.49	22.87	12.89	5.21	2.86	1.01	3.87	4.70	1.88	2.82	40.53	406.90	13.41	2398.13	43.66	1.62	39.85
			(2.44)	(2.15)	(1.54)	(1.68)	(0.40)	(0.23)	(0.37)	(1.42)	(0.46)	(1.01)	(6.52)	(60.97)	(7.37)	(702.20)	(49.93)	(1.06)	(24.97)
	KO	n=8	11.89	26.83	12.22	2.10	1.70	0.89	2.59	15.39	3.98	11.41	71.79	446.25	60.61	1682.86	244.04	3.90	40.58
			(2.60)	(1.66)	(1.18)	(0.55)	(0.48)	(0.41)	(0.73)	(17.49)	(4.81)	(12.71)	(3.53)	(40.44)	(5.42)	(38.90)	(85.37)	(1.20)	(5.52)
7/19/2011	KI	n=6	23.36	25.57	7.52	5.57	3.73	0.93	4.66	8.32	3.42	4.90	90.50	405.36	55.29	3270.90	6.71	1.36	18.83
			(1.24)	(1.14)	(1.16)	(3.03)	(0.19)	(0.31)	(0.45)	(4.21)	(1.29)	(3.13)	(8.08)	(44.80)	(15.66)	(543.86)	(5.27)	(0.48)	(12.96)
	KO	n=7	15.75	33.27	8.12	2.79	1.84	0.74	2.59	13.82	4.05	9.77	177.39	783.68	66.37	1462.17	53.45	3.02	80.94
			(2.46)	(0.70)	(0.94)	(1.94)	(0.73)	(0.37)	(0.77)	(10.44)	(2.28)	(8.20)	(42.66)	(198.53)	(11.69)	(714.82)	(25.59)	(0.91)	(34.76)
10/6/2011	KI	n=8	17.88	23.13	-	5.11	7.80	0.89	8.69	10.98	3.93	7.06	101.51	571.94	81.08	3355.29	104.01	3.50	64.47
			(0.33)	(1.81)	-	(2.03)	(0.87)	(0.16)	(0.90)	(5.01)	(1.06)	(4.01)	(5.41)	(101.58)	(9.78)	(540.84)	(76.93)	(0.87)	(27.04)
	KO	n=8	13.51	30.19	-	4.66	7.91	1.11	9.02	13.36	3.96	9.41	82.82	482.30	61.09	1950.42	140.51	11.46	60.23
			(0.35)	(0.65)	-	(3.90)	(1.93)	(0.51)	(1.79)	(8.58)	(1.78)	(6.97)	(7.10)	(42.37)	(8.08)	(54.39)	(10.38)	(6.98)	(33.98)

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