Quality Assurance Project Plan

For:

Protecting the Strait of Juan de Fuca Nearshore Through Improved Understanding of Shoreline Erosion and Deposition Processes, Ecosystem Services Valuation, and Community Stewardship.

Nearshore Metrics of Benthic Invertebrate Communities and Fish Use.

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Quality Assurance Project Plan: Protecting the Strait of Juan de Fuca Nearshore Through Improved Understanding of Shoreline Erosion and Deposition Processes, Ecosystem Services Valuation, and Community Stewardship. I. Nearshore Metrics of Benthic Invertebrate Communities and Fish Use.

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1.0 Title Page/TOC/Distribution List

Quality Assurance Project Plan

Protecting the Strait of Juan de Fuca nearshore through Improved Understanding of Shoreline Erosion and Deposition Processes, Ecosystem Services Valuation, and Community Stewardship.

QAPP I. Nearshore metrics of benthic invertebrate communities and fish use.

April 10, 2012

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2.0 Abstract

This QAPP is for determining the ecological metrics to be incorporated into the ecosystem service valuation (ESV) study as part of the larger study funded through the Department of Fish and Wildlife (WDFW) grant (number 11-0034). Funds for the WDFW grant are provided by EPA. The ecological metrics and the ESV will be used to inform land owner communities on proper management of their properties. The ESV study will feed into an economic analysis of No Net Loss and present how to include ecosystem valuation in the Shoreline Master Program (SMP). The ecological metrics include long-term fish use, forage fish spawning and benthic invertebrate community data.

The fish use study will continue to use standardized and published methodologies to define the long-term fish use of the Elwha west estuary and the comparative Salt Creek estuary. These are the only data that implement the Before After Control Impact (BACI) scientific strategy (see Hewitt et al 2001 for a discussion) for defining the nearshore restoration response to the Elwha dam removals - a restoration project of national significance currently underway. The forage fish spawning study will compile the WDFW spawning information for the Dungeness and Elwha drift cells.

The benthic invertebrate study will continue to characterize the communities and document the invertebrate usage in the Elwha and Dungeness drift cells. The data will also, in combination with a study of sediment dynamics conducted by Dave Parks, Washington Department of Natural Resources (WDNR), provide important information on how sediment and sediment dynamics define habitat functions for the benthic community.

3.0 Background

The nearshore zone, which extends from the areas of tidal influence as well as the riparian zone along the tops of the coastal bluffs to 30 meters mean low low water (MLLW) and includes beaches, estuaries, and nearshore waters, is a critical component to the health of Puget Sound and has suffered extensive losses over the last one hundred years (Fresh, 2006; Shaffer et al. 2012, 2008; Simenstad et al. 2011). Recently, many shoreline and coastal bluff landowners in Clallam County have expressed an interest in protecting the nearshore environment while at the same time preserving their property and ensuring their safety. Understanding the ecological forming and function roles of nearshore is important for citizen land management. Metrics of ecological function are very important for citizens to understand the importance of nearshore habitats for marine systems. New tools are being developed to quantify efficiently bluff function. New tools quantifying the economic value of ecosystem services are emerging that will be extremely valuable for citizens to understand the value of their land, and natural resource management options. Our work, which includes four main elements, provides new data and improved tools to support Clallam County's SMP and related planning, implementation, administration, and monitoring efforts. New data such as high-precision bluff erosion rates will help to delineate hazardous areas and justify SMP measures. Through quantifying the economic values of ecosystem services of the nearshore and sharing the results with landowners, developers and other stakeholders, the project will enhance awareness and understanding of the regulatory framework needed to accomplish shared goals for the nearshore ecosystem and reduce long-standing barriers to its protection.

The primary project participants for the field elements of this project are the Coastal Watershed Institute (CWI), Department of Ecology (Ecology), Earth Economics, and WDNR, and the Clallam County. CWI will provide the overall project coordination, coordinate a series of citizen and student workshops and acquire the biological field metrics (fish and invertebrates) for the ESV (the focus of this QAPP). Ecology will conduct the light detection and ranging (LiDAR) surveys and develop the bluff erosion model (separate QAPP), and Earth Economics will develop the ESV (separate QAPP). As a partner that has been mapping the sediment characteristics of the Elwha and Dungeness nearshore the WDNR will collect sediment metrics for LiDAR collaboration that will also be utilized in the Ecology LiDAR modeling and Earth Economic ESV. There will therefore be separate QAPPS for this overall project: one for the ecological field metrics, written by CWI, one for the LiDAR and shoreline sediment mapping, written by Ecology, and possibly a third for the ESV modeling, written by Earth Economics.

This is the QAPP for the ecological metrics. The objectives of study elements in this QAPP are to:

1. Continue to define the intertidal benthic invertebrate communities of the Elwha and Dungeness drift cell utilizing standardized and published methodologies;
2. Compile the WDFDW forage fish spawning information for the Dungeness and Elwha drift cell, and;

3. Continue to define the long term fish use of the Elwha west estuary and comparative Salt Creek estuary utilizing standardized and published methodologies;
4. Conduct these field efforts as a series of citizen and college educational workshops.

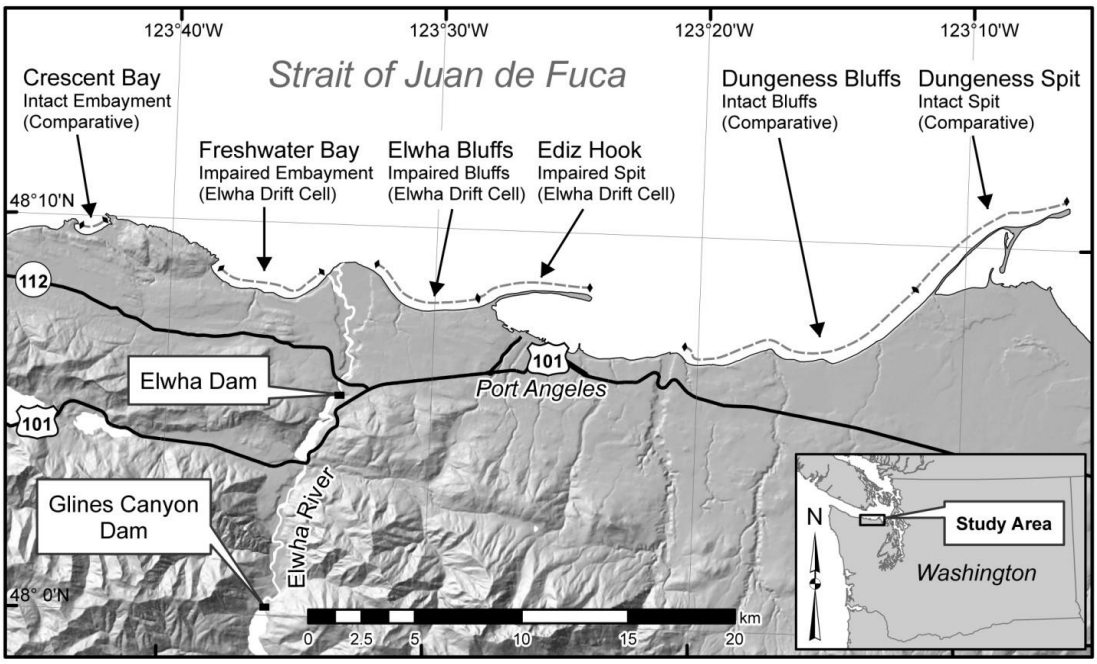

Figure 1. Study area (map provided by Parks et al in review).

The study area is located along the nearshore of the central Strait of Juan de Fuca on the north Olympic Peninsula (Figure 1). The history of the area and studies is summarized in three main publications: Shaffer et al. 2008; Shaffer et al. 2012, and Parks et al. in review. An overview of the strategy of the nearshore sampling is found in Shaffer et al. 2008, and Elwha Nearshore Proceedings (2012 Morrow and Black eds) and the Elwha Science Proceedings (in review, Morrow and Barbaro eds). The results of previous fish use and sediment dynamic studies are presented in Shaffer et al. 2009, Shaffer et al. 2012, and Parks et al. in review.

Two historical studies of the benthic invertebrate communities have been conducted in the Dungeness nearshore. In the 1970s, the U.S. EPA sponsored the Marine Ecosystems Analysis (MESA) Program because of the threat of oil pollution from large scale oil shipment through the Strait of Juan de Fuca (Nyblad 1979). Under MESA, studies involving biological characterizations including benthic invertebrate community assessment at 10 locations throughout the strait, physical oceanography, trajectory modeling, pollutant monitoring, and fate and effects of oil were implemented. Only two of the ten locations are within the current study area. These studies represent one of the most comprehensive baseline data sets ever gathered along the Strait. In 2008 Shreffler Environmental was contracted to develop a pilot field project to re-visit MESA sites sampled for intertidal and subtidal benthos (Sheffler 2008). Two of the MESA locations were sampled and the data was analyzed to assess changes or long-term trends in the intertidal benthic community over the last 30 years. One of these two locations is within the current study area.

4.0 Project Description

The studies in this QAPP include an assessment of long-term fish use and the benthic invertebrate communities in the Elwha and Dungeness nearshore. Detailed information on the two studies is provided in the following sections.

4.1 Project goals

The goal of the fish use and benthic invertebrate community studies is to provide ecological community information to landowners and local citizenry and ecological metrics of nearshore function to be incorporated into the ESV study. The ESV study will feed into an economic analysis of No Net Loss and will present how to include ecosystem valuation in the SMP. The field data and the ESV will be presented to the public through workshops to enhance public awareness, encourage ecological sound management of nearshore properties and thereby advance protection of the central Strait of Juan de Fuca nearshore.

4.2 Project objectives

Project objectives for the fish use and benthic invertebrate community studies are described in the following two subsections.

4.2.1. Fish Use

The project objectives for the fish study include 1.Continuing to define long term fish use of the Elwha west and a comparative estuary, 2. Compiling the forage fish use of the Elwha and Dungeness drift cell; 3. Imparting long term fish use and forage fish spawning ecological information to local landowners and interested local citizens, and; 4. Training the next set of managers on key topics and methods for assessing ecological metrics of nearshore fish use and identification. We will achieve these objects by:

- Sampling fish use of the Elwha and comparative Salt Creek estuary monthly using established beach seine techniques.
- Compiling existing forage fish spawn data from Salmonscape[1]
- Mentoring a set of upper level undergraduate and graduate student interns
- Holding a series of field and evening workshops for community

[1] SalmonScape, the Washington Department of Fish and Wildlife's interactive, computer mapping system, is one of the most important tools created thus far to deliver scientific information to those involved in on-the-ground salmon recovery projects. SalmonScape delivers the science that helps recovery planners identify and prioritize the restoration and protection activities that offer the greatest benefit to fish. The site also offers a significant environmental education tool for middle school and high school students. SalmonScape merges fish and habitat data collected by state, federal, tribal and local biologists and presents it in an integrated system that can be readily accessed by other agencies and citizens.

4.2.2. Benthic Invertebrate Communities

The project objectives for the benthic invertebrate community study include:

- Collect benthic invertebrate community data at 12 locations in the Elwha and Dungeness drift cells.
- Provide the benthic invertebrate community data to Earth Economics for inclusion in the ESV model.
- To the extent possible, assess changes in the benthic communities over time by comparison to the MESA program and Sheffler community data sets.
- Link the benthic invertebrate community structures with sediment dynamics in the Elwha and Dungeness drift cells.
- Provide a baseline data set of the benthic invertebrate community in the Elwha and Dungeness drift cells for future use by researchers and natural resource managers.
- Mentoring a set of upper level undergraduate and graduate student interns
- Holding a series of field and evening workshops for community

4.3 Information needed and sources

Information sources for the fish use and benthic invertebrate community studies are described in the following two subsections.

4.3.1 Fish Use

In addition to the new data collected as described above we will be compiling fish community information for the Elwha and comparative estuary for the past seven years, as well as surf smelt spawn data collected by the WDFW for the Dungeness and Elwha drift cells during the last decade. Forage fish spawn data are available through the WDFW GIS data bases which include Salmonscape.

4.3.2 Benthic Invertebrate Communities

The current benthic invertebrate data will to the extent possible be compared with the 1970s MESA program and the 2008 Shreffler Environmental data sets (Nyblad 1979; Sheffler 2008). As stated in the background section, only two locations sampled under the MESA program and one location sampled under the Sheffler Environmental study are within the current study area.

4.4 Target population

The natural resource target metrics are fish use and the benthic invertebrate community of the Elwha and Dungeness nearshore. The target metric is habitat function defined as species abundance and basic ecological metrics of species diversity and richness. The educational target populations are the community and landowners of the Elwha and Dungeness nearshore, and undergraduate college students of the Olympic Peninsula.

4.5 Study boundaries

The study area for the fish use includes the Elwha and Dungeness nearshore drift cells as well as comparative Crescent Bay and Salt Creek estuary (see Figure 1). The study area for the benthic community study covers approximately 25 shoreline miles between Dungeness Bluff (Dungeness Refuge trail at beach access point) and the western shore of Freshwater Bay (Figure 2).

Figure 2. The benthic community study area including sampling locations (note benthic invertebrate samples will not be collected at the DB-1, DB-2, Bluff-1, and Bluff 2 locations; these are sediment dynamics locations only). Historical assessment of the benthic communities was performed at DB-4 and BC-1 under the MESA program and at DB-4 under the Sheffler Environmental study.

4.6 Tasks required

Required tasks for the fish use and benthic invertebrate community studies are described in the following two subsections.

4.6.1. Fish Use

We will conduct monthly beach seines to measure abundance of fish within the Elwha west estuary and comparative Salt Creek estuary. Seining will follow standard fish use protocols published by the Puget Sound Water Quality Authority (PSWQA, 1996). Fish are identified to the lowest possible taxon and enumerated. Data are entered and qa/qc'ed each month. College students and citizen volunteers are trained in fish use identification and sampling techniques.

4.6.2 Benthic Invertebrate Communities

The following tasks are required to complete the benthic invertebrate community study:

- Collection of benthic community samples at 12 locations in the Elwha and Dungeness drift cells. Because of limited resources the sampling effort is conducted over three years

(2010 – 2013) with sampling occurring at selected locations each year (refer to Section 7.0 for further description of sampling design).

- Biannual field collection at selected locations of five community samples each at the MLLW, mean tidal level (MTL), and the wrack line.
- Sorting the samples and placing the invertebrate into four major taxonomical groups (annelids, crustaceans, mollusks, and miscellaneous taxa) while enumerating the organisms.
- QA/QC the samples sorted by the laboratory technicians.
- Store the invertebrate samples for future possible taxonomical identification.
- Compile the major taxonomical group data into a database.
- Format the database to suit the needs of the ESV study.

4.7 Practical constraints

The nearshore is a problematic area to sample for a number of reasons. The study area is geographically remote and weather, wind, tide, and seasonal length of day light make sampling challenging. In addition much of the sampling area requires access through private property, which we have obtained thru years of collaborative work. The fish use sampling requires daylight hours and moderate similar tide to produce a useable long-term data. We adjust for this by sampling on neap tides, and in the morning. The benthic community sampling is constrained by access to the lower intertidal areas and sampling can therefore only occur at minus tides during daylight hours. The biannual benthic community sampling events are conducted in March and July.

5.0 Organization and Schedule

The key individuals, their responsibilities, the schedules, and budget information for the two studies are provided in the following sections.

5.1 Key individuals and their responsibilities

CWI is the lead on both the fish use and benthic invertebrate community studies and makes all program decisions. The fish use study collaborates with WDFW and other fish managers including University of Washington, National Oceanic and Atmospheric Administration (NOAA), and US Fish & Wildlife Service (USFWS). Table 1 summarizes the key individuals and their responsibilities. The work is permitted by NOAA 4d, USFWS, and WDFW scientific collecting permits.

5.2 Project schedule and Limitations

The field data collection of fish use data will be performed monthly and invertebrate community data biannually. The sampling events for both studies under this QAPP are part of a larger continued effort; the fish use study was initiated in 2006 and the invertebrate community study in 2010. The QAPP will be applicable for the fish use study as soon as the document is finalized

and the grant contract is signed. The first invertebrate sampling event under this QAPP will be in July 2012. Key activities include:

- Monthly field collection of fish use in Elwha and Salt Creek estuaries (1 day per month)
- Monthly entry of fish use data into ongoing database (1/2 day per month)
- Biannual field collection of benthic invertebrate community samples (July and March)
- Laboratory process of invertebrate samples (2- 3 months per sampling event)
- Compilation of invertebrate data into ongoing database (concurrent with laboratory process)
- Compilation of forage fish spawning data
- Formatting the three data sets to fit into the ESV model

The target completion date for compilation of the ecological metrics is May 2013 at which point the data will be provided to Earth Economics to be incorporated into the ESV model.

Table 1. *Key individuals and their responsibilities.*

Name	Affiliation	Responsibilities
Anne Shaffer	CWI	Principal investigator for the fish use study, field coordinator, data analyst, CWI Executive Director and program coordinator. Student mentor, ecological communities, nearshore marine habitat ecosystem function.
Helle B. Andersen	CWI	Principal investigator for the invertebrate community study, field coordinator, laboratory manager, data analyst. Student mentor, ecological communities, nearshore marine habitat ecosystem function.
Dave Parks	WDNR	Principal investigator for the sediment dynamic study, field coordinator, data analyst. Student mentor, physical process and sediment characterization study
Students	Peninsula College and Western Washington University -Huxley	Student interns
David Batker	Earth Economics	ESV lead and SMP Accounting Review
Nahal Ghoghaie	Earth Economics	ESV modeler

5.4 Budget and funding

The ecological metrics work is funded by the WDFW grant (number 11-0034) and in-kind contributions from CWI, WDNR, Peninsula Colleges and Western Washington University -

Huxley. The WDFW grant provides funding for the two senior scientists (2*0.1 FTE per year) leading the fish use and benthic invertebrate community studies and workshops, $10,800 per year for student internships and approximately $5,000 in field equipment and consumables (e.g., gas).

6.0 Quality Objectives

Quality objectives for the fish use and benthic invertebrate community studies are described in the following subsections.

6.1 Fish Use Quality Objectives

This section summarizes the quality objectives for the fish use study.

6.1.1 Decision Quality Objectives N/A

6.1.2 Measurement Quality Objectives

Traditional indicators of data quality that are often used to establish MQOs include precision, accuracy/bias, representativeness, comparability, completeness, and sensitivity. Except as noted below, these have limited applicability to fish use surveys. Standard protocols emphasize the need for professional competence, accuracy of location data, ensuring seine or trawl nets are in good condition, and having criteria for judging acceptability of the seine or trawl sample. See PSWQA (1996) for more details.

Accuracy of fish identification is expected to be similar to that described in Shaffer et al (2008) where genetic analysis confirmed 82% of fish species identifications. This study will strive for 100% correct species identification, but will accept accuracy of least 82%. Bias will be minimized by sampling fish monthly throughout the year at the same locations, times of day, and using the same methods. Total length will be measured to the nearest full millimeter.

Representativeness. Fish use data will be collected monthly for one year (as part of a larger five-year monitoring effort) and therefore will capture basic seasonal trends. Fish will be collected from the Elwha, and from a comparative area.

Comparability. Standard protocols will be used to collect forage fish using seine nets (PSWQA, 1996). Data will be compiled by WDFW and included in Salmonscape.

Completeness. Targets for completeness are to collect samples of forage fish at all of the planned sites, to identify and measure total length of all specimens collected, and to record all results in an excel spreadsheet.

Sensitivity. Length of individual fish will be measured to the nearest full millimeter.

6.2 Benthic Invertebrate Communities Quality Objectives

This section summarizes the quality objectives for the benthic invertebrate community study.

6.2.1 Data Quality Objectives

Data Quality Objectives (DQOs) for benthic community assessments are that the collection effort will be in compliance with regional guidelines including PSEP and the MESA methodologies and that the samples will be representative of the in-situ benthic community present along the MLLW, MTL, and wrack line transects. The five field replicates collected from each transect at each location must be handled and prepared for future taxonomic analysis as described in Measurement Methods. Data quality will be assessed in terms of sorting accuracy, identification (to major taxonomical group), and enumeration processes.

6.2.2 Measurement Quality Objectives

Sorting of the benthic invertebrate samples will be conducted in accordance with the Puget Sound Estuary Program (PSEP) Protocols (PSEP, 1987). The measurement quality objective (MQO) is 95% sorting accuracy. A recount of the organisms per phyla will be performed on 10% of the samples processed y the lab technicians. If future funding is identified for taxonomical analysis of the invertebrate samples the MQOs will include agreement among two independent taxonomists on the identity of all organisms (verification of a voucher collection) and verification of final species count by a partial recount by the second taxonomist.

6.2.3 Comparability

To ensure data comparability with previous studies in the Strait of Juan de Fuca and other regional studies the benthic invertebrate samples will be collected in accordance with the PSEP protocols and MESA methodologies (PSEP 1987; Nyblad 1979). Two of the 12 locations were previously sampled during the MESA program.

6.2.4 Representativeness

The collection of benthic invertebrate samples will be conducted in accordance with the Puget PSEP Protocols and the MESA methodologies (PSEP, 1987; Nyblad 1979). The benthic invertebrate samples will be collected to represent the summer and winter communities. The sampling locations along the MLLW and MTL are identified using a stratified random sampling design. Sampling of the wrack line uses an opportunistic sampling design (sampling of algae matt(s) where present).

7.0 Sampling Process Design (Experimental Design)

The study design for the fish use and benthic invertebrate community studies are described in the following subsections.

7.1. Fish Use Study Design

This section summarizes the study design for the fish use study.

7.1.1 Sampling location and frequency

Long term fish use: seining has occurred monthly since 2006 along the Elwha and Salt Creek estuary at the same locations utilizing PSWQA beach seine techniques. Two seines will be used

at each site. We sample on neap tide during daylight, morning hours. Seine is deployed from a small boat and pulled to shore by a small team of students. The bag of the net it draped in a pvc yolk (Figure 3) and the fish sampled. All fish are identified to lowest possible taxa. Twenty of the fish for each species are measured to the nearest mm (both total and fork length for salmon, total length only for all other fish). Total counts for each species are recorded. Data are entered by two designated students within one week of sampling and the data reviewed for accuracy and completeness. The study area is shown is Figure 1.

Figure 3. Students and scientists sampling juvenile fish in the Elwha west estuary.
Note pvc yolk that net bag is draped over, allowing fish to be kept in the water at all times.

7.1.2 Assumptions underlying design

Long term fish use: We assume that the net we are using will result in an adequate and unbiased sampling of fish of the estuary.

7.1.3 Characteristics of existing data

This long term data study is an extension of the first time-ever-fish use assessment of the Elwha west estuary. The results of the first eighteen months were published in the journal Hydrobiologia (Shaffer et al. 2009). These are the only data that implement the Before After Control Impact (BACI) scientific strategy (see Hewitt et al 2001 for a discussion) for defining the nearshore restoration response to the Elwha dam removals - a restoration project of national significance currently underway.

7.2 Benthic Invertebrate Communities Study Design

The study is designed to link the benthic communities with sediment dynamics and the nearshore physical processes and, to the extent possible, to evaluate changes in the benthic communities over the last 30 years by using the same methodologies and revisiting previously sampled locations within the Dungeness drift cell (Nyblad 1979; Sheffler 2008).

The sediment dynamics study performed by Dave Parks characterizes the seasonal changes in beach particle size distribution and topographic profiles at 16 bluff locations in the Elwha and Dungeness drift cells. The study of the benthic invertebrates in the Elwha and the Dungeness drift cells will be conducted to define the current nearshore communities at 12 of the 16 sediment dynamics locations. The combined data set will provide important information on how sediment and sediment dynamics define habitat functions for the benthic community and address the following questions:

- Is there a difference in the benthic invertebrate community between the Elwha and Dungeness drift cells?
- Is there a seasonal effect on the benthic invertebrate community between the drift cells?
- Is there a relationship between grain size and the benthic invertebrate community associated with the Elwha and Dungeness drift cells?

In addition, the benthic community data will establish a present-day baseline of the nearshore benthic invertebrate communities.

7.2.1 Sampling location and frequency

The Elwha drift cell sampling locations include four locations in Freshwater Bay, two locations at Elwha bluff east of Dry Creek and two locations at the bluff west of Ediz Hook. The Dungeness drift cell sampling locations include two locations west of Bagley Creek and two locations at the bluff west of Dungeness Spit. One location west of Bagley Creek was previously sampled under the MESA program and one location at the west bluff of Dungeness Spit was previously sampled under the MESA program and the Sheffler Environmental study. The sampling locations are shown in Figure 2.

The WDFW grant funds the 2012/2013 sampling effort. Because of limited resources the sampling effort is conducted biannually over three years (2010 – 2013) with sampling occurring at selected locations each year (Table 2). The 2012/2013 sampling effort focuses on Freshwater Bay locations in the Elwha drift cell, in part because the Dungeness drift cell contains no suitable reference bay.

7.2.2 Assumptions underlying design

The study design includes stratified random collection of five benthic invertebrate samples along two transects (MLLW and MTL) and opportunistic collection of five samples in the wrack line. It is assumed that this sampling strategy, combined with following regional guidelines including PSEP and MESA methodologies for collection of benthic invertebrate samples, will produce representative samples of the in-situ benthic community present along the MLLW, MTL, and wrack line transects.

Table 2. Sampling locations per survey year.

Location	Survey Year (Summer/Winter)		
	2010/2011	**2011/2011**[c]	**2012/2013**
ID	FB-1[a], FB-3, EB-2, EB-4, BC-2, DB-4	FB-2[b], FB-3, EB-1, EB-3, BC-1, DB-3	FB-1, FB-3, FB-4
No. of Locations	6 (5)	6	3

[a] – sampled summer 2010 only
[b] – sampled winter 2011 and summer 2011
[c] – because of funding limitation (the contract for the DFWS grant had not been signed) only EB-1 was sampled in March 2012

7.2.3 Characteristics of existing data

Limited information is available on the benthic invertebrate communities in the Elwha and Dungeness nearshore. Two historical studies were conducted in the Dungeness nearshore in 1976-77 and 2008 by Nyblad (1979) and Sheffler Environmental (2008). The MESA program by Nyblad was a comprehensive baseline data set whereas the study by Sheffler was a pilot field project that re-sampled two of the MESA locations for intertidal and subtidal benthos. The current study of the benthic invertebrate communities in Dungeness and Elwha nearshore fills a data gap by providing a current description of the benthic communities in the Dungeness nearshore 35 years after the MESA program and by providing new information on benthic communities in the Elwha nearshore.

8.0 Sampling Procedures

The sampling procedures for the fish use and benthic invertebrate community studies are described in the following subsections.

8.1. Fish Use Sampling Procedures

This section summarizes the sampling procedures for the fish use study.

8.1.1 Field measurement and field sampling SOPs

Sampling location and frequency: Long term Fish use: seining occurs monthly along the Elwha and Salt Creek estuary utilizing Washington state PSWQA 1996 beach seine techniques. Two seines at each site. We sample on neap tide during daylight, morning hours. Seine is deployed from a small boat and pulled to shore by a small team of students.

8.1.2 Measurement and sample collection

Fish measurements are taken as specified by PSWQA 1996 and others (see Beamer 2003; Beamer et al 2003, 2005). The bag of the beach seine net it draped in a pvc yolk and the fish sampled. All fish are identified to the lowest possible taxa. Twenty of the fish for each species are measured to the nearest mm (both total and fork length for salmon, total length only for all

other fish). Total counts for each species are recorded. Data are entered by two designated students within one week of sampling and the data reviewed for accuracy and completeness.

8.1.3 Containers and preservation methods

Our fish are held in the net in the estuary and so never removed from the water, stored in buckets or other holding devices. They are identified, measured, enumerated, and released.

8.1.4 Field log requirements

We use a standard beach seine data sheet provided by NOAA (Appendix A).

8.2 Benthic Invertebrate Community Sampling Procedures

This section summarizes the field sampling procedures for the benthic invertebrate community study.

8.2.1 Field measurement and field sampling SOPs

Field collection of benthic community samples follows the standard operation procedures (SOPs) described in PSEP and MESA program (PSEP 1987; Nyblad 1979). Field collection is performed under WDFW scientific collection permit and with permission of private landowners.

8.2.2 Measurement and sample collection

The sampling locations are identified by survey monuments which have been mounted for the sediment dynamics study conducted by Dave Parks, WDNR. From the sediment dynamics study the MTL and MLLW have been identified at each location as a distance from the survey monument (Table 3). At each location five benthic community samples are collected along a 50-m transect parallel to the water at the MTL and MLLW. The five sampling sites along each transect are identified based on a stratified random approach. The 50-m transect is subdivided into 5 sections and the sampling site within each subsection is identified using a random number table to generate the distance from one end of the subsection.

Table 3. Distances (US ft) from survey monuments.

Location	MTL	MLLW
FB-1	30	180
FB-2	35	200
FB-3	35	122
FB-4	75	120
EB-1	45	90
EB-2	47	78
EB-3	65	125
EB-4	77	128
CB-1	45	150
CB-2	55	170
DB-3	75	115
DB-4	92	128

Two different substrate types, coarse sand and cobble, are present in the Elwha and Dungeness nearshore. Depending on the substrate type one of the following two methods is utilized.

Coarse Sand: A 0.05 m^2 (22.5 cm x 22.5 cm) PVC frame is placed at the sampling site and the sediment is removed to a depth of 15 cm using a hand trowel. The sediment is placed in a bucket and sieved through a 1 mm sieve in the field. The retained material is transferred into a double-bagged Ziploc bag and preserved with 10% buffered formalin (diluted with on-site saltwater).

A 0.25 m^2 (50 cm x 50 cm) PVC frame is placed at the sampling site adjacent to the smaller frame and the sediment is removed to a depth of 30 cm using a hand trowel and shovel. The sediment is placed in a large 11 mm screen and sieved in the field. Large retained invertebrates are transferred into a double-bagged Ziploc bag and preserved with 10% buffered formalin (diluted with on-site saltwater).

Cobble: A 0.25 m^2 (50 cm x 50 cm) PVC frame is placed at the sampling site and all algae, if present, are scraped off the rocks and transferred into a double-bagged Ziploc bag. Next epibenthos are collected within the frame and transferred into a double-bagged Ziploc bag. Larger easily identified benthos e.g., *Hemigrapsus nuda* are identified and counted in the field. Barnacles are counted in the field and if possible identified to species (small specimens (<2 mm) are identified as Balanoidae). In cases of large abundances of small specimens the abundance is estimated. When all epibenthos within the frame as been removed or identified the smaller 0.05 m^2 frame is placed within the larger frame and the sediment is removed to a depth of 15 cm using a hand trowel. The sediment is placed in a bucket, sieved through a 1 mm sieve in the field, and the retained material is transferred into a double-bagged Ziploc bag. All samples (algae, epibenthos, and sieved material) are preserved in 10% buffered formalin (diluted with on-site saltwater).

Five invertebrate samples are collected in the wrack line using an opportunistic sampling approach by sampling the algae matt(s) present within 50 m of the survey monument. Each sample is collected by pressing a plastic corer (10 cm diameter) through the algae matt and into the sediment to a depth of 2 cm. The retained material is transferred into a double-bagged Ziploc bag and preserved with 10% buffered formalin (diluted with on-site saltwater).

8.2.3 Containers and preservation methods

The benthic invertebrate samples will be double-bagged in zip-lock plastic bags and preserved in 10% buffered formalin (diluted with on-site saltwater). During the sorting process the invertebrates will be transferred into 70% denatured or isopropyl alcohol for long-term storage.

8.4 Sample ID

Each sampling area will be assigned a unique alpha-numeric location identification (ID) number. The first two characters represent the location ID:

FB – Freshwater Bay

EB – Elwha Bluff

BC – Bagley Creek Bluff

DB – Dungeness Bluff

The next character indicates the location number within each bluff area (ranging from 1 through 4). The next character will be either W or S for the winter or summer sampling event, respectively, and the last two characters indicate the sampling year (e.g., 12 for 2012 or 13 for 2013).

8.5 Field log requirements

All field activities will be recorded in a field logbook or data sheets maintained by the Project Manager. The field logbook/data sheets will provide a description of all sampling activities, sampling personnel, and weather conditions, plus a record of all modifications to the procedures and plans identified in this QAPP. The field logbook will consist of waterproof Rite-in-the-Rain notebook. All entries will be made in indelible pencil. The field logbook is intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the sampling period. The information will include:

- Date, time, location, ID
- Field personnel
- Sequence of events
- Any changes to plan
- Environmental conditions

9.0 Measurement Methods

The measurement methods for the fish use and benthic invertebrate community studies are described in the following subsections.

9.1 Fish Use Measurement Method

All captured fish will be counted. Length will be measured to the nearest mm for a maximum of 20 fish per species.

9.2 Benthic Invertebrate Community Laboratory Process

The laboratory processing of the benthic invertebrate samples follows the SOPs described in PSEP (PSEP 1987) and by Washington Department of Ecology (Ecology 2007), and is summarized below.

The benthic invertebrate samples are processed in the laboratory following this general description (further details are provided in the two cited SOPs):

- The laboratory technician selects a sample and removes all sampling bags from the storage container.
- Immediately prior to sorting, the 10% buffered formalin is decanted from the sample using a 860 um sieve and the sample is gently rinsed with freshwater and placed in freshwater for the duration of the workday.

- Sorting is performed using a dissecting light microscope with a minimum capacity of 10-power magnification.
- A small amount of the sample (e.g., teaspoonful) is placed in a grided Petri dish and suspended in freshwater.
- The sediment is examined systematically using the microscope and all organisms are removed. The technician examines each dish of sediment at least twice, swirling the dish gently between examinations, until one complete examination yields no organisms.
- To make sorting easier, the samples may be fractionated by using a set of nested sieves of diminishing mesh sizes to separate the sediment by particle size. The sample is washed through the nested sieves with a gentle stream of water to prevent loss or damage to organisms.
- The organisms are sorted into the following major phyla: Annelida, Arthropoda, Mollusca, and miscellaneous phyla. The technician is counting the organisms in each major phylum while sorting. To the best of their capability the technicians are identifying the organisms following the laboratory data sheet (see Appendix B). All organisms are sorted into vials containing 70% denatured or isopropyl alcohol and tightly sealed with Polyseal caps.
- The vials containing the organisms are stored by location and survey for future potential taxonomical identification.

10.0 Quality Control (QC) Procedures

QC procedures for collection and identification of fish and benthic invertebrates at the various sampling sites are described in the following subsections.

10.1 Fish Use Field QC Procedures

For comparability, fish will be collected at the same sites, at approximately the same time of day, and using the same sampling methods. Sampling will be conducted during neap tide. For accuracy, fish id in the field will be supervised by two professional biologists with a minimum of 10 years experience of juvenile fish id. Fish not easily identified in the field will be taken back to the lab for definitive identification.

10.2 Benthic Invertebrate Community Laboratory QC Procedures

To determine sorting efficiency, and ensure that all organisms are removed from the sediment, a quality control check is completed for every sample sorted by the laboratory technicians. Twenty-five to one hundred percent of each sample is re-examined by the laboratory manager to determine whether a sorting accuracy of 95% removal of organisms has been achieved.

All organisms found in the sample during the quality control check are counted, identified to major taxa group, and placed in the appropriate major taxa vial for that sample. The sample will passed the quality control check if the number (or estimated number) of organisms found during

the resort does not differ from the original count by greater than five percent. If the sample fails, then the entire sample is resorted by the laboratory manager.

11.0 Data Management Procedures

This section summarizes the data management procedures for the fish use and benthic invertebrate community studies.

11.1 Fish Use Data Management Procedures

Data are entered into a main excel data file by college student dedicated to the project. Data are then checked-100% by a second student. Each month of data entry the file is renamed so the previous months file is kept intact. Data analysis programs depend on question being answered. Primarily we use ecological metrics of species richness, diversity, and abundance of species per sampling effort as main indices.

11.2 Benthic Invertebrate Community Data Management Procedures

The information from each laboratory data sheet is compiled into Excel workbooks. Each workbook contains all the benthic invertebrate data for one survey and each spreadsheet within the workbook contains all the data from one transect and one sample type e.g., MTL infauna or MLLW algae. Data entries are reviewed for accuracy and completeness. Data will be formatted for uploading into Ecology's EIM.

12.0 Data Quality (Usability) Assessment

12.1 Process for determining whether project objectives have been met

This section summarizes the processes used to determine whether the study objectives have been met for the fish use and benthic invertebrate community studies.

12.1.1 Fish Use

The fish use data being collected are expected to address the stated objectives because this project is an extension of previous Elwha nearshore work (Shaffer et al 2008) and uses the same BACI sampling strategy and the sampling methods. The data will be provided in a series of workshops, thereby meeting the objectives of community outreach and college training. The data will be provided to the ESV analysis, meeting this study objective also.

12.1.2 Benthic Invertebrate Community

The benthic invertebrate data which have met the MQOs described in Section 6.2. will be used address the seven study objectives described in Section 4.2.2.

12.2 Data analysis and presentation methods

This section provides a brief summary of the data analysis and presentation methods for the fish use and benthic invertebrate community studies.

12.2.1 Fish Use

Fish use data are analyzed in a standard format of fish density and length by species and basic ecological metrics of species richness, and ecological diversity. Statistical analysis will depend on hypothesis being tested, and may include parametric and non-parametric analysis (see Shaffer et al. 2012 and Shaffer et al. 2009 for more recent fish use analyses).

12.2.2 Benthic Invertebrate Community

The benthic invertebrate dataset based on abundances of major phyla will be formatted to fit into the ESV model. To the extent possible the data will also be used to answer the following questions:

- Is there a difference in the benthic invertebrate community between the Elwha and Dungeness drift cells?
- Is there a seasonal effect on the benthic invertebrate community between the drift cells?
- Is there a relationship between grain size and the benthic invertebrate community associated with the Elwha and Dungeness drift cells?

If future funding is identified for taxonomical analysis of the samples the taxonomical data will be compiled and descriptive parameters such as species richness, abundances, and diversity indices will be derived. The benthic community data and the sediment data will be analyzed by comparing the data from Dungeness drift cell with Elwha drift cell to answer the following null hypotheses:

- There is no statistical difference in the benthic invertebrate community (species richness, diversity indices) between the Elwha and Dungeness drift cells;
- There is no statistical difference in seasonal effects on the benthic invertebrate community between the drift cells;
- There is no statistical relationship between grain size and benthic invertebrate communities associated with the Elwha and Dungeness drift cells; and
- There is no difference in assemblage structure between the tested communities.

In addition to standard statistical and graphical techniques, the data will be analyzed using multivariate analyses such as NMDS and associated ANOSIM, SIMPER and PERMANOVA tests in order to identify biologically meaningful patterns in the data (Cordell et al 2011). To the extent possible, the current benthic community data will be compared to historical benthic community data from two locations in the Dungeness drift cell assessed during the MESA Program (Nyblade 1979) and one location in the Dungeness drift cell assessed by Sheffler Environmental (Sheffler 2008) to evaluate any changes in the benthic community over time.

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14.0 Figures

15.0 Glossary, Acronyms, and Abbreviations

Analysis of Similarity (ANOSIM) – A statistical analysis to determine if significant difference(s) exist between two or more groups of sampling units.

Data Quality Objectives (DQO) - Data Quality Objectives are qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions. (USEPA, 2006)

Data verification - Examination of a dataset for errors or omissions, and assessment of the Data Quality Indicators related to that dataset for compliance with acceptance criteria (MQO's). Verification is a detailed quality review of a dataset. (Ecology, 2004)

Non-Metric Multidimensional Scaling (NMDS) - A set of related statistical techniques often used in information visualization for exploring similarities or dissimilarities in data. Non-metric MDS includes finding the non-parametric monotonic relationship between the dissimilarities.

Permutational Multivariate Analysis of Variance (PERMANOVA) - A computer program for testing the simultaneous response of one or more variables to one or more factors in an ANOVA experimental design on the basis of any distance measure, using permutation methods.

Quality Assurance (QA) - A set of activities designed to establish and document the reliability and usability of measurement data. (Kammin, 2010)

Quality Assurance Project Plan (QAPP) - A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives. (Kammin, 2010; Ecology, 2004)

Quality Control (QC) - The routine application of measurement and statistical procedures to assess the accuracy of measurement data. (Ecology, 2004)

Replicate samples - two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled. (USGS, 1998)

Representativeness - The degree to which a sample reflects the population from which it is taken; a data quality indicator. (USGS, 1998)

Sample (field) – A portion of a population (environmental entity) that is measured and assumed to represent the entire population. (USGS, 1998)

Sample (statistical) – A finite part or subset of a statistical population. (USEPA, 1997)

Similarity Percentage Analysis (SIMPER) - A non-parametric multivariate analysis

Standard Operating Procedure (SOP) – A document which describes in detail a reproducible and repeatable organized activity. (Kammin, 2010).

Acronyms and Abbreviations

Following are acronyms and abbreviations used in this QAPP.

e.g.	For example
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
GIS	Geographic Information System software
GPS	Global Positioning System
i.e.	In other words
MQO	Measurement quality objective
QA	Quality assurance
RSD	Relative standard deviation
SOP	Standard operating procedures
WDFW	Washington Department of Fish and Wildlife

Units of Measurement

cm	centimeter
ft	feet
m	meter

16.0 Appendices

Appendix A. Data sheet for fish use study. From NOAA and PSWQA 1996

Site Name: **Date:** **Time:** **Set # :**

Comments: (veg type, depth, substrate etc)

Water Quality:

Depth: Temp: Salinity: DO: Conduct:

Tide: *Height* *Time* *Stage*

Hi

Lo

Pink Tally **Total:**

Chum Tally **Total:**

Chinook	Ad/CWT	Fish #

Chinook	Ad/CWT	Fish #

Chinook	Ad/Cwt	Fish #

Chinook	Tally
Total:	

Coho	Ad/Cwt	Fish #

Coho	Ad/Cwt	Fish #

Coho	Tally
Total:	

Lengths:	Pink	Chum	Smelt (adult = >120)	Smelt (juv = 50-120)	Smelt (pl = <50)	Herring (adult = >120)	Herring (juv = 50-120)	Herring (pl = <50)	Sand lance (adult = >120)	Sand lance (juv = 50-120)	Sand Lance (pl = <50)	Sand sole	English sole	Starry Flounder	Crescent gunnel	Saddleback gunnel	Penpoint gunnel	Bay pipefish	Tubesnout	Snake prickleback	3-Spine stickleback	Shiner perch	Staghorn sculpin	Other:	Other:	Other:	Other:	Other:
1																												
2																												
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6																												
7																												
…																												
20																												
Tally																												
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Total																												

Appendix B. Laboratory Data Sheet for Invertebrate Samples

Date sorted: **Laboratory Technician:**

Benthic ID	
Tide Level	
Sample Type	
Sample Number	
Date	
Time	
Annelida	
Polychaeta	
Oligochaeta	
Crustacea	
Balanoidea (barnacles)	
Isopoda	
Amphipoda	
Decapoda	
Mollusca	
Polyplacophora (chitons)	
Patellogastropoda (limpets)	
Gastropoda (snails)	
Bivalvia (clams/mussels)	
Misc. Taxa	
Actiniaria (sea anemones)	
Nemertea (nemerteans)	